VERHANDELINGEN

DER

KONINKLIJKE AKADEMIE VAN WETENSCHAPPEN

AFDEELING NATUURKUNDE

TWEEDE SECTIE

(Geologie - Delfstofkunde - Dierkunde - Gezondheidsleer - Ontleedkunde - Plantkunde - Physiologie en Zielkunde)

DEEL XXX

MET 6 PLATEN EN 45 TEKSTFIGUREN

UITGAVE VAN DE N.V. NOORD-HOLLANDSCHE
UITGEVERS-MAATSCHAPPIJ, AMSTERDAM 1932—'33

INHOUD

MICROTINAE (ROD.) IN THE NETHERLANDS, EXTINCT AND RECENT

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EXTINCT VOLES.

The Microtinae are a remarkable group of Muridae by reason of their value for the stratigraphy of the Plio-Pleistocene of Western and Central Europe.

From the abundant fossil material found in English deposits it is evident that each species of vole had a short range in time. Since remains of Microtinae have occasionally been obtained from borings in the Netherlands, they may be of considerable help in correlating the various deposits with each other and with the horizons of neighbouring countries.

In the determination of the Dutch material I have been greatly aided by the accurate investigations on the Microtinae by Mr. MARTIN A. C. HINTON, and especially by those published in his valuable "Monograph of Voles and Lemmings, living and extinct", the first volume of which was published in 1926.

Where, as a rule, only one molar of the three in each jaw half shows some characters which render a specific determination possible, it is obvious that most of the preserved teeth are of little value for our purpose. In comparison to the many thousands of British fossil specimens examined by HINTON, the Dutch material, consisting of some lower jaws, about twenty teeth, some fragments of incisors and the distal half of a femur, is very scanty indeed.

Of the geologically oldest vole known in Britain, represented by the genus *Mimomys*, three species have been obtained in the Netherlands, viz. *M. pliocaenicus* FORSYTH MAJOR, *M. newtoni* F. M. and *M. intermedius* NEWTON. Besides these I have recorded the species *Microtus malei* HINTON.

Some of the remains of *Mimomys*, including four teeth, from a boring at Gorkum, which are preserved in the Rijks Geologisch Museum at Leiden, have been described and figured by RUTTEN (1909) and discussed by HINTON (1926). Four other teeth of this genus were found at Tegelen; these have been studied by NEWTON (1907, 1910) and by HINTON (1926), and presented by Mr. REID to the British Museum in London.

I take pleasure in expressing here my sincere thanks to Dr. P. TESCH at Haarlem, to Prof. Dr. B. G. ESCHER at Leiden, to Prof. J. VAN BAREN at Wageningen and to the Rev. JOS. CREMERS at Maestricht, who entrusted the fossil remains to me for examination. For the recent specimens I am greatly indebted to Prof. Dr. E. D. VAN OORT, Director of the Natural

History Museum at Leiden and to Prof. Dr. L. F. DE BEAUFORT, Director of the Zoölogical Museum at Amsterdam.

Mimomys pliocaenicus FORSYTH MAJOR [1]).

The collections of the Rijks Geologische Dienst (State Geological Survey) at Haarlem include a right mandibular ramus of a vole, with the incisor and the two anterior teeth in place (Plate, fig. 1*a*). It was obtained from a boring at Etten (in the western part of the Dutch province of Noord-Brabant) at a depth of 80—100 m. The colour of the jaw and of the enamel of the teeth is a lustrous black; where the surface is rough the small pits are filled up with a limonitic substance.

The ascending ramus is lacking, the jaw being broken off through the alveole of the posterior root of m_3. Only a small portion of the coronoid process has been preserved. The length of the fragment, measured to the point of the incisor, is 21.5 mm., the height of the jaw, perpendicular to the trituration surface of the teeth, is 7.6 mm. That two roots occur on each tooth is distinctly to be seen, since in m_1 and m_2 of this very old jaw their bases protrude slightly out of the alveolar border and the alveoles of the missing m_3 lie open. Without doubt the incisor passes beneath the posterior root of m_2 in its course backwards from the inner to the outer side of the mandible; I could not bring myself, however, to break open this beautiful object to obtain the convincing proof.

The crown surface of m_1 (Pl., fig. 1*c*) consists of a posterior loop, three substantially closed triangles and an anterior loop with a deep fourth inner infold, filled like the other folds with a large quantity of cement. On none of the many figures of this species given by HINTON (1926) does m_1 show this anterior inner fold to be so deep. The specimen from Béremend in Hungary (MÉHELY 1914) bears a striking resemblance in this respect to the Etten tooth. On the front loop, just before the third outer angle, lies a shallow infold (HINTON's prismfold). Anterior to it another shallow infold can be observed, much narrower than the prismfold. This must be the reduced third outer valley (KORMOS' Inselfalte). Both small infolds would be very soon worn away in this senile tooth. The enamel islet, derived from the islet fold by isolation, has undoubtedly been worn out. In front of the islet fold still another infold is present in this specimen, making a similar shallow bend in the border of the crown. This one, in my opinion, is due to a crenulation of the enamel; when a tooth is nearly worn out variations of this kind are common in the enamel pattern. On the anterior point of the tooth a similar shallow infold can be observed.

The salient angles of both teeth are rather blunt. The enamel of the second inner fold almost touches that of the opposite side; that of the first inner fold pushes it even somewhat out of its course. The same feature is

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[1]) See addendum p. 35.

Fig. 1*a*. Fig. 1*b*. Fig. 1*c*. Fig. 1*d*.

Fig. 1. *Mimomys pliocaenicus* F. M., from Etten (Noord-Brabant). *a*: Right mandibula with m_1-m_2 and incisor, inner view; *b*: outer, *c*: crown view of m_1; *d*: crown view of m_2.

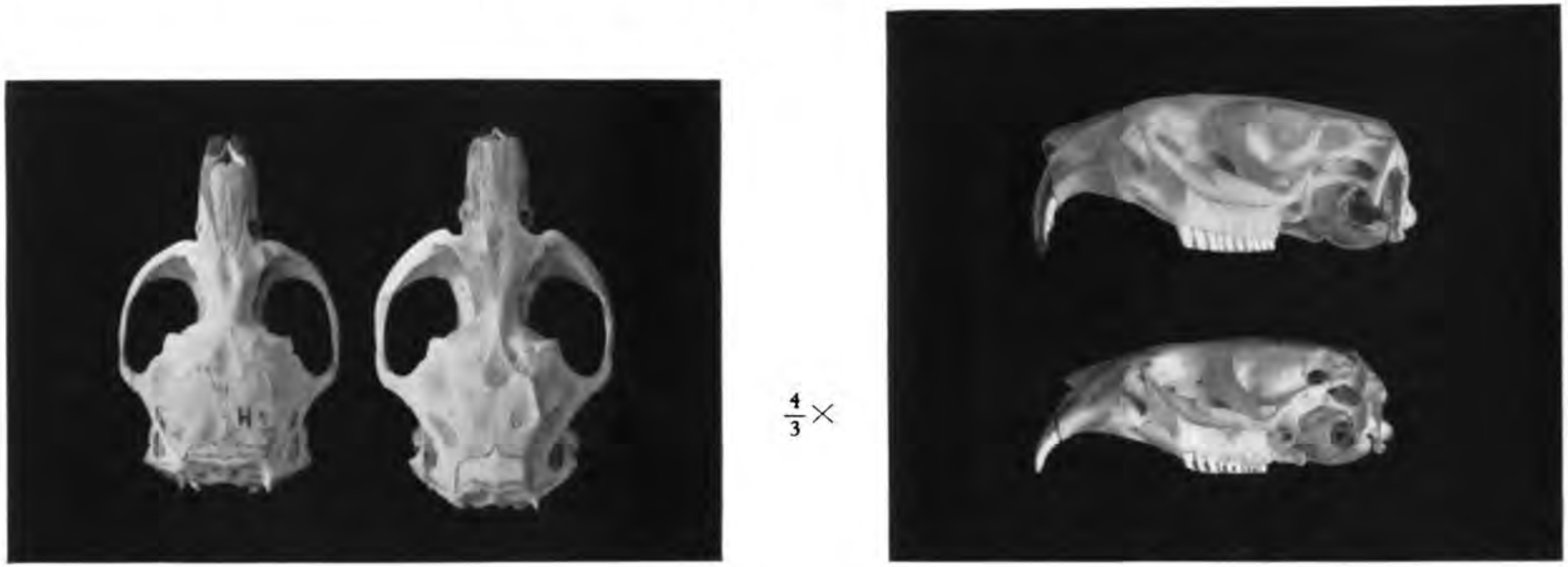

Fig. 2*a* Fig 2*b*

Fig. 2. *a*: Skulls of: *Arvicola scherman* SHAW ♀ from Heerlen (left) and of *Arvicola terrestris* L. ♀ from Best (right); *b*: same skulls in side view, above *A. terrestris*, below *A. scherman*.

seen on the m_1 from the Norwich Crag, figured by HINTON on his text-fig. 100, fig. 6. The enamel layer is thicker on the convex than on the concave side of the triangles. The fossilisation of the teeth is such that it is quite impossible to distinguish the cores of osteodentine from the surrounding dentine, for which reason I have not drawn them on the figures 1*c* and 1*d* of the Plate.

The pattern of m_2 (Pl., fig. 1*d*) shows nothing particular. The length of m_1 is 3.7 mm, that of $m_1 + m_2$ is 6.0 mm. The whole toothrow must have measured 8.0 mm. This is a fairly great size, exceeding that of the largest West-European species of recent *Microtus*, viz. *M. ratticeps*, but equal to that of some adult specimens of *Arvicola scherman* from Heerlen (see table). HINTON mentions among the characters of *Mimomys pliocaenicus*: tooth-row measuring 7—8 mm. MÉHELY (1914) did not meet with any m_1 of this species larger than 3.5 mm, but according to KORMOS (1931) the teeth from Béremend, described by MÉHELY, are exceeded in size by those from Senèze (Haute Loire).

Although the characteristic islet on the front loop is lacking on the old m_1 from Etten, the jaw must undoubtedly be referred to *Mimomys pliocaenicus* F.M.

The collection at Haarlem contains another microtine remain which has been obtained from a boring at Raamsdonkveer, north-east of Etten in the Dutch province of Noord-Brabant. The depth at which it was found was 82—88 m.

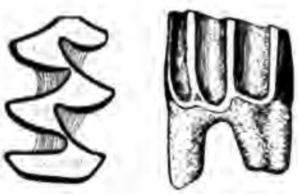

Fig. 1. *Mimomys* cf. *pliocaenicus* F. M., from Raamsdonkveer. Inner ($7^1/_2$ × nat. s.) and crown view (10 × nat. s.) of right m_2.

This specimen is a right m_2 (fig. 1), and can be referred to the species *M. pliocaenicus* too. The enamel is strong and of a lustrous black colour, thicker on the convex than on the concave sides of the triangles. The cement is abundant in the valleys. The osteodentine cores are rendered very distinct by a yellowish brown crack which separates them from the surrounding dentine. The resemblance in the form of the pattern with that of the m_2 from Etten is striking. The length of the crown is slightly less, being 2.2 mm; the breadth is 1.4 mm in both. Two distinct roots are present; with them the height of the tooth is 3.2 mm. Both roots are undamaged; the anterior one is the longest and oval in cross section; the posterior one is shorter and its form in cross section is heart-shaped; the point of the heart is directed outwards and forms a rather sharp angle owing to both enclosing sides being slightly concave. The form and shortness of this root is caused by the peculiar position of the tooth, whereby this root stands upon the incisor (MÉHELY 1914, Pl. III, fig. 6).

In a boring at Breda (Noord-Brabant) at a depth of 52—55 m a right m^1 (fig. 2) was found and deposited in the Haarlem-collection. Although a specific determination of an m^1 cannot be decisive either, I feel but little doubt that this tooth, which is still in place in a small fragment of jaw, may be referred to the same species. It can be seen on the outer side of the tooth, that the cement spaces are closed; the number of the roots cannot be stated since they are hidden in the alveole. The length of the crown is 3.0 mm; this measurement is 2.9 and 3.1 on two first upper molars from Senèze (KORMOS 1931). The width is 1.8 mm like that of the m^2 from Eindhoven. The triangles are blunt and much broader than the infolds. In the pattern I could not find any difference between it and the French tooth shown on fig. 2 of KORMOS; the quantity of cement is slightly greater in the Dutch one.

Fig. 2. *Mimomys* cf. *pliocaenicus* F. M., from Breda. Right m^1, crown view (10×).

Another microtine tooth is preserved in the Haarlem collection from a depth of 152—158 m at a boring near Eindhoven, in the east of Noord-Brabant. It is a large left m^2, the anterior enamel plate of which is lacking (fig. 3). The length of the tooth (restored) is about 2.4 mm, its breadth 1.8 mm. According to KORMOS (1931) the length of the m^2 from Senèze is 2.3 mm. The enamel sheet is strong, especially at the convex sides of the triangles. The cement spaces are closed below, the cement is much corroded as also the greater part of the roots. Their bases are clearly to be distinguished. One round root occurs at the posterior extremity; supporting the anterior loop two roots, both slightly compressed laterally, stand close side by side. The m^2 from Senèze shows two roots, as do most specimens of m^2 from Béremend; MÉHELY, however, observed one specimen with three roots.

Fig. 3. *Mimomys* cf. *pliocaenicus* F. M., from Eindhoven. Left m^2, crown view (10×).

Judging from the size of the tooth the thickness of the enamel and the presence of three fangs, this m^2 from Eindhoven may also be referred with a fair degree of probability to *Mimomys pliocaenicus* F.M.

The fifth record of the species in the Netherlands is a left m^3, preserved in the Geological Museum at Leiden, and obtained at a depth of 165.5 m ? from a boring at Gorkum, in the province of Zuid-Holland. This tooth has been referred by HARTING (1853) with other microtine remains from the same boring to *Hypudaeus terrestris*. RUTTEN (1909) determined it rightly to be *Mimomys pliocaenicus* F.M. and gave a good figure of this tooth.

The enamel is partly dark blue and partly horn-coloured. The cement in the re-entrant folds is fairly strong. The line between the dentine and the core of osteodentine is not distinguishable. The enamel infolds of the opposite sides never meet. The reduced second inner fold is seen on the inner surface as a distinct vertical furrow with a very little cement at its deepest part only. Three roots are developed; the posterior root is cylindrical, the two anterior roots stand side by side and support the front loop just as on the m^2 from Eindhoven. The inner of these two roots is also cylindrical, the outer one is thicker, its cross section is a triangle with obtuse angles. The anterior side of this root is slightly concave laterally. HINTON mentions among the characters of the species: m^3 with two roots. There is no doubt, however, that this m^3 from Gorkum is provided with three, as is that from Senèze (KORMOS 1931).

TEGELEN [1] (near Venlo in the province of Limburg) is another locality in the south of the Netherlands from which a tooth of this species has been mentioned. NEWTON (1907) described and figured a left m_1 found by CLEMENT REID among the many seeds he washed out of a quantity of Tegelen clay, and presented by the latter to the British Museum. Here HINTON examined it again and termed it (1926) "a very characteristic tooth of the species".

Besides the Dutch localities mentioned above, *Mimomys pliocaenicus* F.M. is known from:

1. the Norwich, Weybourn and Shelly Crag in England (NEWTON 1882, F. MAJOR 1889, HINTON 1910 and 1926),
2. the Upper Pliocene deposits of the Val d'Arno in Italy (TUCCIMEI 1897 and FORSYTH MAJOR 1902),
3. the Late Pliocene (Lower Cromerian according to KORMOS 1930) of Béremend (MÉHELY 1914) and of Villány (Kalkberg) in Hungary.
4. the Preglacial (Middle Cromerian according to KORMOS 1930) of Püspökfürdő in Rumania (former Hungary) (KORMOS 1930),
5. the Upper Pliocene of Senèze (Haute Loire) in France (KORMOS 1931) (Villafranchian according to DEPÉRET).

The shore deposits having yielded the Dutch remains described above of 85—100 m beneath the soil of Etten, those of 82—88 m beneath Raamsdonkveer, as also those of 165.5 ? m beneath Gorkum, of 152—158 m beneath Eindhoven and of 52—55 m beneath Breda are, according to Dr. P. TESCH (1928) all of Icenian age (Günz Glacial and Günz-Mindel Interglacial) and stratigraphically equivalent to the Norwich-Weybourn Crag.

The Tegelen Clay, too, is synchronous with the Lower and Middle Cromerian, as is evident from the occurrence of *M. pliocaenicus*, a species never found among the large quantity of fossil voles known from the Upper Freshwater Bed (Upper Cromerian) of West Runton, etc.

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[1] HINTON (1926), HELLER (1930*b*) and KORMOS (1931) are mistaken in mentioning Belgium among the countries where *M. pliocaenicus* and *M. newtoni* have been found: "Tegelen-sur-Meuse" is a village in the Netherlands.

Mimomys newtoni FORSYTH MAJOR.

It is to this species that HINTON (1926, p. 377) refers three microtine teeth from TEGELEN, formerly (1910) termed *M. intermedius* by NEWTON. After a careful examination of the objects in the British Museum, HINTON bases his opinion on the smallness of the teeth and on the fact that the very young left m_1, which lacks the posterior loop, has a distinct persistent third outer valley filled with cement, a feature not occurring in *M. intermedius*. The crown of m_1 cannot have been longer than 2.5 mm. The two other teeth are an m^2 and an m^3 of small size. Together with the tooth of *M. pliocaenicus* from the same locality they were found by REID and presented by him to the British Museum.

This small species is further known:

1. in England from the Norwich Crag and from deposits ranging in age between this horizon and the Lower Freshwater Bed (FORSYTH MAJOR 1902, HINTON 1926),
2. in Hungary from Villány (Kalkberg) and from Béremend (Lower Cromerian) (MÉHELY 1914),
3. in France from the Upper Pliocene of Senèze (Haute Loire) (KORMOS 1931 *a*), according to DEPÉRET a deposit of Villafranchian age.

The occurrence of this species in the Tegelen Clay is in entire accordance with the Lower-Middle Cromerian age of these deposits.

Mimomys intermedius NEWTON.

Besides the above-mentioned tooth of *M. pliocaenicus* from 165.5 m depth, three other microtine teeth have been obtained from the boring at Gorkum at a somewhat higher level, mentioned by HARTING and described by RUTTEN (1908). They are also preserved in the Leiden Museum. Two of them (from a depth of 127.3 m), a left m_1 and a right m^1, have been referred by RUTTEN to *Mimomys intermedius* NEWTON; a tooth from 129.9 m to *"Microtus (Arvicola) amphibius auct."*.

HINTON in his Monograph (p. 358) expresses some doubt as to the correctness of RUTTEN's determination of the m_1 and of the last-mentioned tooth.


Fig. 4. *Mimomys intermedius* NEWTON, from Gorkum. Left m_1, outer (6 ×) and crown view (10×).

The m_1 has been referred by RUTTEN to *M. intermedius* on account of its resemblance to that from the Forest Bed of West-Runton, figured by FORSYTH MAJOR on p. 106, fig. 22, of his "Note on pliocene voles" in the Proc. Zool. Soc., vol. I, 1902. As regards the general form of RUTTEN's figure of the crown, HINTON thought it had closer affinities with *M. pliocaenicus* and asked for a further study of this specimen and for a good figure of the external side.

In my opinion it is apparent from our fig. 4 that RUTTEN was right in his determination. I fail, however, to see the resemblance observed by this author to F. MAJOR's figure 22. The tooth from West Runton shows on its outer aspect a distinct vertical furrow along the third salient angle and on its crown view a shallow fold of the enamel on the corresponding place. Figure 21 on the same page and fig. 12 on the preceding one, respectively the crown and the outer view of a left m_1 from the same locality, bear more resemblance to the Dutch tooth owing to the absence of any furrow or fold on the third outer angle. It is just this character of one wide shallow outer fold on the anterior loop, occurring on a tooth with newly closed cement spaces, which leads me to refer it, as RUTTEN does, to *M. intermedius* NEWTON.

Comparing the tooth with all the figures of this species given by HINTON in text-figure 102, it struck me that the fourth inner fold on all is more reduced than in the Dutch tooth. The resemblance, however, to the young specimens in text-fig. 61, fig. *d* and in text-fig. 99, fig. 10, is greater in this respect, but, in my opinion, no isolated enamel islet occurs on the anterior loop of the Gorkum tooth. It is improbable that the dark spot just in the middle of the loop could be an indication of a worn-out islet, as it is not rounded, but angular. The height of the tooth is 3.9 mm, the crown is 3.1 mm long and 1.3 mm broad. The m_1 from Val d'Arno lacks the hind-loop, but according to KORMOS (1931*a*), this crown must have measured 3.0—3.1 mm, and those from Hungary vary between 2.9 and 3.5 mm.

No roots are to be seen; the cement spaces are closed below. On the crown side the enamel layer is sharply defined from the dentine by its hardness and dark colour; anterior to the shallow third outer fold it is lacking along the whole height of the tooth. The outline of the osteodentine is not clearly distinguishable in the object. Nowhere is the osteodentine of one triangle confluent with that of another.

The other tooth from the same level is a right m^1 (RUTTEN's fig. 17). In *Mimomys intermedius* the m^1 agrees in the form of its pattern with that of other normal voles, and thus a specific determination must always be doubtful. This tooth (fig. 5) is a young one, the enamel layer at the posterior end is still intact. The cement spaces are closed below, but there are no roots formed yet. The quantity of cement is small.

The manner of conservation of the tooth is the same as that of the m_1. Some of the salient angles are partially broken off at the crown surface, but lower down they are undamaged and the pattern could therefore be completed.

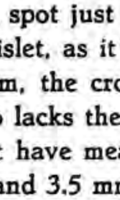

Fig. 5. *Mimomys* cf. *intermedius* N., from Gorkum. Right m^1, crown view (10×).

The height of the tooth is 4.5 mm, the length of the crown is 2.7 mm, the breadth is 1.4 mm. (The m^1 of this species from Senèze is 2.5 mm long (KORMOS 1931 *a*).) These measurements agree with those of the m_1. As in the latter the enamel of the infolds never touches that of the opposite side. The osteodentine cannot be distinguished from the dentine. As the only figure of an m^1 of *M. intermedius* which I met with in literature is that of the decidedly older tooth of Senèze, I can make no comparison. I think, however, that there is every reason to refer this tooth, as RUTTEN did, to *Mimomys intermedius* NEWTON.

The tooth from a depth of 129.9 m beneath the soil of Gorkum, referred by RUTTEN "mit ziemlicher Sicherheit" to *Microtus (Arvicola) amphibius auct.*, is probably a left m_2, the hind loop of which is broken off (fig. 6). An examination of this tooth showed me, that it cannot be referred to the genus *Arvicola*, since the cement spaces are closed below, a feature never occurring in the persistently growing teeth of this genus. The fossil is a tooth of *Mimomys*, as are the three other teeth from the same boring. Cement occurs in the outer as well as in the inner infolds.

Fig. 6. *Mimomys* cf. *intermedius* N., from Gorkum. Left m_2, crown view (10 ×).

The conservation differs from that of both the teeth from 127.3 m. The enamel is hardly distinguishable from the dentine (probably the enamel in on our fig. 6 has been drawn somewhat too thick). It is therefore conceivable that RUTTEN thought the enamel of the re-entrant inner folds came into cóntact with that of the outer side, a suppositional feature which led him to distinguish this tooth generically from those referred to *Mimomys*. The line between the osteodentine and the dentine is very distinct by reason of a narrow crack which isolates two cores of osteodentine (corroded and partly fallen out) each formed by two widely confluent triangles.

Precisely the same pattern of the crown is to be seen in HINTON's text-figure 102, figs. 5 and 10, both of which show m_2 of *Mimomys intermedius* NEWTON from West-Runton. I believe there is no objection to refer the tooth, under reservation, to this species, together with those from 127.3 m depth.

The height of the tooth is 4.5 mm, the breadth of the crown is 1.3 mm, the length of the fragment is 1.4 mm. The total length must have been about 2.0 mm. The ratio between the length in m_1 and m_2 in HINTON's text-figure 102 is about 3 : 2, so this comports very well with the length of m_1 and this m_2 from Gorkum, being 3.1 and 2.0 mm respectively.

A boring beneath the soil of Zaandam (Noord-Holland) has yielded at a depth of 64.20—65.50 m a microtine m_2 (fig. 7) which might be referred with a fair degree of probability to *M. intermedius* too. Though size and pattern of this species agree with those of the same tooth in *M. pliocaenicus*, the absence of roots and the open pulp cavity on the former rather high tooth (4.1 mm) point to a toothform geologically somewhat younger than the latter.

Fig. 7. *Mimomys* cf. *intermedius* N., from Zaandam. Left m_2, crown view (10 ×

The cement spaces are closed below and the cement is in an uncorroded condition. The lustrous black enamel is distinctly thickest on the convex sides of the triangles, the hinder two of which are substantially closed, the anterior one is slightly confluent with the front loop. The cores of osteodentine are distinct. The length of the crown surface is 2.0 mm, the width is 1.3 mm.

The *Mimomys* character of this fossil specimen points to deposits formed before the major glaciation (Risz-) of the Netherlands. This is in complete agreement with the fact that in the same boring at a depth of 41.20—41.8 m boulder-clay has been met with. Thus the layers which yielded the tooth must probably be reckoned as belonging to the end of the Mindel-Risz Interglacial Period (Dr. P. TESCH in litt.).

In the Netherlands *Mimomys intermedius* NEWTON is thus only known with certainty from the boring at Gorkum, where it has been found at a higher level than *M. pliocaenicus.*

NEWTON (1910) referred three microtine teeth from the Tegelen Clay to *M. intermedius,* but HINTON (1926, p. 377), after making a careful examination in the British Museum, perceived their identity with *M. newtoni* F.M. The species *intermedius* being abundant in the Upper Freshwater Bed, HINTON was able to study several hundreds of teeth belonging to it, we can therefore rely upon his opinion. The species rarely occurs in the somewhat older Shelly Crag.

Besides beneath the soil of Gorkum *Mimomys intermedius* NEWTON has been found in:

1. The Shelly Crag and Upper Freshwater Bed in England (NEWTON 1881 and 1882, FORSYTH MAJOR 1902, HINTON 1910 and 1926),
2. the Lower Cromerian of Béremend in Hungary (MÉHELY 1914) where it lived, somewhat later than *M. pliocaenicus,* in preglacial forests,
3. the Middle Cromerian of Püspökfürdö in Rumania (KORMOS 1930), in deposits equivalent to the Shelly Crag.
4. the Upper Cromerian of Villány (Nagyharsányberg) in Hungary (MÉHELY 1914), in layers synchronous with the Upper Freshwater Bed,
5. the Upper Pliocene of Val d'Arno (KORMOS 1931 *a*) in Italy,
6. the Upper Cromerian of Podumci in Dalmatia (KORMOS 1931 *b*), deposits being synchronous with 4.

As can be seen from the table (p. 12), the three species of *Mimomys* found in the Netherlands are undoubtedly confined to the English Cromerian. Both the species found in Tegelen occur in the older deposits of the series, viz. in the Lower and Middle Cromerian, existing in Norwich Crag — Lower Freshwater Bed. The question of the geological age of the Tegelen Clay has given rise to a very extensive literature, treated exhaustively by BERNSEN (1927). These clay-layers are classed in the Upper-Pliocene by many geologists, by others they are termed Earliest

	Italy	England	Netherlands	Hungary	Rumania	France	Dalmatia
Mimomys intermedius NEWTON	Val d'Arno	Upper Freshwater Bed and Shelly Crag	127—130 m beneath the soil of Gorkum; ± 65 m beneath Zaandam (?)	Villány (Nagyharsányberg) and Béremend	Püspökfürdö		Podumci
Mimomys pliocaenicus F. MAJOR	Val d'Arno	Shelly Crag, Weybourn and Norwich Crag	50—168 m beneath the soil of Zuid-Holland and of Noord-Brabant and at Tegelen	Béremend Villány (Kalkberg)	Püspökfürdö	Senèze	
Mimomys newtoni F. MAJOR		Weybourn and Norwich Crag	Tegelen	Villány (Kalkberg)		Senèze	
Mimomys pusillus MÉHELY		Norwich Crag?	152—158 m beneath the soil of Eindhoven?	Villány (Kalkberg)	Püspökfürdö	Senèze	

Pleistocene. If we assume with Penck-Brückner the existence of a Günz Glacial Period this clay has been deposited in the First Interglacial Period. The bone breccia of Püspökfürdö are classed by MÉHELY (1914) in the same interglacial period, but KORMOS (1930) considers them to be of preglacial age. The character of the mammalian fauna of Tegelen is decidedly Upper Pliocene, viz. Villafranchian (BERNSEN 1930—1932).

Mimomys pusillus MÉHELY ?

From the same depth (152—158 m) beneath Eindhoven as that from which the m^2 of *M. cf. pliocaenicus* has been obtained, there is also an anterior upper molar preserved in the Haarlem collection. This small m^1 (fig. 8) with a crown length of 2.2 mm cannot be referred to the latter species. The posterior extremity of the crown surface forms a rather sharp angle owing to the concaveness of the two enclosing sides. I could not find any cement in the cement spaces, which are closed below. Their bulging ends are clearly to be seen, separating the hollow prisms, since the pulp-cavity is still widely open. MÉHELY (1914), Pl. I) has given beautiful figures of quite similar "Schmelzblasen" at the rootside of young lower teeth of *Mimomys (Microtomys) pusillus* from the Middle Cromerian of Püspökfürdö in Rumania. This structure of the crown base, however, is common to all rooted voles.

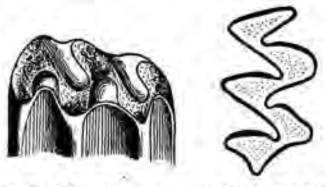

Fig. 8. *Mimomys pusillus* MÉHELY? from Eindhoven. Right m^1, crown and root side (10 ×).

It is remarkable that in the Norwich Crag at Thorpe, besides some teeth of *M. pliocaenicus*, a small tooth, perfectly similar to the m^1 from Eindhoven, has been found. HINTON (1926, text-fig. 100, fig. 21) has given a drawing of it which cannot be distinguished from our fig. 8; here also the size is small, the posterior end is pointed and the cement is lacking. HINTON has termed it: *Mimomys spec.*

Possibly both small m^1 may be referred to the species *Mimomys pusillus* MÉHELY. According to this author the length of the m^1 of this species from Püspökfürdö varies between 2.1 and 2.3 mm. That from Senèze is 2.15 mm long (KORMOS 1913*a*). On MÉHELY's Plate VII the m^1 shows a rather large quantity of cement. Regarding the occurrence of cement, however, KORMOS, after the examination of more than a hundred specimens of *M. pusillus* stated that in those from Püspökfürdö the cement is always present to a more or less degree, while in the geologically somewhat older form from Villâny(Kalkberg)cement is rarely to be seen.

Besides from the two localities just mentioned the species is also known from Senèze in France. In all these strata it is accompanied by *Mim. pliocaenicus* and by *M. newtoni*. It would thus in no wise be strange if in the Dutch Icenian this small species also occurred, together with the other two.

Microtus malei HINTON.

A boring beneath the soil of Velzen, north of Haarlem in the province of Noord-Holland, at a depth of 68—77 m, has yielded another microtine tooth, which is also preserved in the Haarlem collection. It is a young left m_1; the juvenile enamel cap is not yet worn away from the anterior portion of the front-loop, nor from the points of the salient angles. The enamel is a lustrous black on the object and clearly distinguishable from the cores of dull black osteodentine, of the dark brown dentine and the light brown cement. The enamel sheet is present all round the frontloop, along the whole height of the tooth. Its size is rather large, the height being 4.6 mm, and the length 3.1 mm. The cement spaces are open to the base. Of the five closed triangles the three inner ones are larger and more sharply pointed than the two outer ones.

Fig. 9. *Microtus malei* HINTON, from Velzen. Left m_1, crown side (10 ×).

There can be no doubt that we have to do here with a representative of the genus *Microtus*.

The tooth is far too large to belong to any of the four species of this genus from the Upper Freshwater Bed, mentioned by HINTON (1923) and figured later in his Monograph (1926).

In the Early Middle Terrace of the Thames there has lived a species which can neither come into consideration by reason of its small size (HINTON 1926, p. 130, fig. 5).

From the Late Middle Terrace of the Thames three forms of *Microtus* have been recognized, namely: *M. nivalis* group, *M. malei* HINTON (and allied forms) and *M. ratticeps*. The latter does not come into consideration here on account of the confluency of its fourth inner prism with the frontloop.

The size of both other groups agree with that of the tooth from Velzen. *Microtus malei* is distinguished from the *nivalis* group by the greater development of the inner side of the anterior portion of the frontloop, so that a slight sixth inner angle is formed. This angulation is clearly present in the Dutch tooth; in the so-formed fifth re-entrant fold some cement can be seen. Another feature of *M. malei* is seen in the distinct projection of the fourth outer angle, caused by the slight concavity of the outline anterior to it. In our tooth also the fifth outer angle is apparent. Both angles, the sixth inner and the fourth outer, continue as distinct ridges along the entire height of the tooth.

The crownlength of four teeth of *M. malei* from the Clevedon Cave, measured by HINTON (1907, p. 50) varies between 2.98 and 3.22 mm.

Thus we come to the conclusion that the tooth from Velzen must undoubtedly be referred to *Microtus malei* HINTON, a vole of the size of the recent *M. ratticeps*. The species is known only from the Late Middle Terrace of the Thames, the fauna of which is entirely new as compared to that of the High and the Early Middle Terrace. According to HINTON (1926) the *M. nivalis* group and *M. malei* and allies are strongly marked and especially characteristic of this Late Middle Terrace horizon.

The layers of 68—77 m beneath Velzen, which yielded the Dutch tooth, are considered by Dr. TESCH (in litt.) to have been formed in the beginning of the Riss-Würm Interglacial Period, i.e. after the greatest expansion of the ice sheet which then covered the whole province of Noord-Holland. Just as in England, the fauna of these strata must have shown a different character from that of the earlier interglacial periods.

VOLES IN LOESS DEPOSITS.

In the south of the Dutch province of Limburg, the Meuse and its confluents the Jeker and the Geul excavate their valleys in the Upper Senonian Chalk (fig. 10). In the slopes of the "mountains" so-formed, surface erosion has caused a number of more or less deep cavities. On the bottom of some of these pits on the St. Pietersberg we find, besides some cretaceous marine fossils, weathered out of the chalk wall, and some small pebbles fallen in from the Meuse gravel overlying the chalk, an enormous quantity of toad-bones. These are mixed with, and often clotted into lumps as large as a man's fist by, brownish yellow loess, which covers the slopes (helling-loess) and formerly also the tops of most hills in the entire southern part of the province. This loess has been washed, just like the gravel, into the cavities by rainwater, which has also caused the disappearance of the loess from many hilltops and from the abrupter sides.

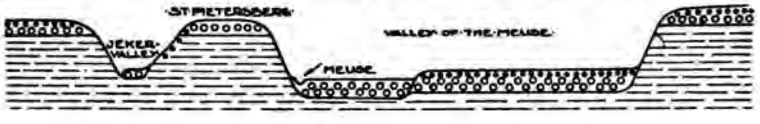

Fig. 10. Structure of the "mountains" in Zuid-Limburg.
— — — Senonian chalk; o o o gravel of the Meuse Terraces; . . . . loess.

Among these bones gathered in the Jeker valley on the slope of the St. Pietersberg near Maestricht I found, preserved in the collections of the Natural History Museum at Maestricht, some fragments of lower and upper jaws, some incisors and a dozen teeth of Microtinae. The lower jaws all lack the ascending ramus, except one, which shows distinctly its identity with an *Evotomys* jaw by the form and place of the coronoid and the condylar processes and of the foramen in the basis of the latter. Since the toothless jaw of *Microtus* and of young specimens of *Evotomys* shows no difference with regard to the alveoles it cannot be made out as to which genus the other jaw fragments, without teeth, belong.

Evotomys cfr. glareolus SCHREB 1).

Four teeth, two of which are shown in figure 11 *a*, can be recognized at once as belonging to the genus *Evotomys*, since a basal ring already partly shuts off the pulpcavity of the young teeth. A quantity of cement is present in the re-entrant folds. The length of the m_1 and of the m_2 is 2.3 and 1.5 mm respectively. I did not observe any difference in size nor in pattern between these teeth from the loess and those of *Evotomys glareolus* occurring nowadays in these regions. The resemblance of the Dutch teeth to those of the Forestbed-fauna from the Sackdillinger Cave in Bavaria, figured by HELLER (1930 *a*, fig. 21), is striking.

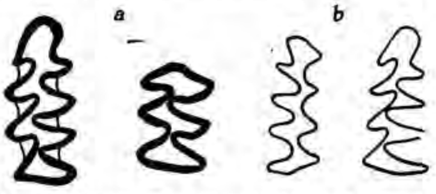

Fig. 11. *Evotomys* cf. *glareolus* SCHREB. from Maestricht. *a*: Left m_1 and m_2: *b*: crown side and rootside of right m_1 juv. (all 10×).

The other teeth belonging to this form have been scarcely worn.

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1) Since the generic name of *Clethrionomys* TILESIUS (Isis 1850, p. 28) has the priority, it ought to replace the so accustomed name of *Evotomys*.

In the toad-bone lumps from the same locality, preserved in the Geological Institute of Wageningen, I found two germs of microtine teeth; one of them is a right m_1 of *Evotomys* (fig. 11 *b*). The length of the crownside is 1.8 mm, that of the rootside is 2.0 mm; the height of this germ is only 1.2 mm. They show, just like all young teeth of voles, small and narrow salient angles and wide U-shaped re-entrant folds. No complications of the pattern occur on the front loop.

The geologically oldest specimens of the *Evotomys glareolus* group have been recognized by NEWTON (1882) and by HINTON (1910) among the remains of the Upper Freshwater Bed. They have exactly the same pattern as the recent form; perhaps they are a trifle smaller (HINTON 1926). In the synchronous deposits near Villány (Nagyharsányberg) the species has also been found (KORMOS 1930, p. 59).

Microtus cfr. agrestis DE SÉLYS.

Some other microtine remains have been yielded by this loess, among which three undamaged m_1, which bear a strong resemblance as regards size and pattern to *M. agestris*, occurring nowadays in this region. One of them is very young (fig. 12 *a*); the length of this tooth at the crownsurface is 2.0 mm, but at the base it is already 2.3 mm. Both other teeth are full grown. The largest (fig. 12 *b*) is 2.8 mm long and the other (fig. 12 c) 2.6 mm; quite the same measurements I found on recent teeth in pellets of owls. The front-loop is distinguished by its great size. In the largest tooth a distinct sixth inner salient angle occurs with a shallow sixth infold anterior to it. I met with this feature only in some of the most robust among the numerous recent teeth of *M. agrestis bailloni* which I examined with regard to this character. Also the fourth outer infold is rather deep.

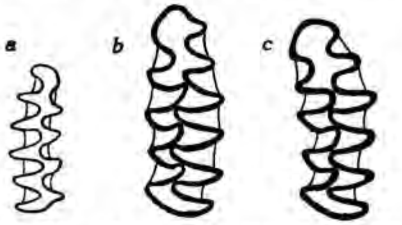

Fig. 12. *Microtus* cf. *agrestis* L., from Maestricht. *a*: right m_1, juv., *b*: and *c*: left m_1 (all 10×).

The remains of Microtinae are extremely rare among the enormous quantity of toad-bones (*Bufo vulgaris*) among which the presence of some frog-bones (*Rana esculenta*) could be determined (SCHAEFER 1932). The voles and frogs may have fallen into the pits by accident, just like the toads, whose awkwardness is often known to be the cause of their tumbling into cellars, pits, etc. from which they cannot escape again.

RANGE AND RELATIONSHIPS.

It is evident that the Dutch remains of Microtinae are far too scanty to venture on any suppositions as to their phylogenetic relationship or to their swarming in from other regions. Since, however, Britain was connected with the Continent, sometimes for a rather considerable extent in Plioand Pleistocene times, it may not be too hazardous to expect that the spread of the voles in the Netherlands was dependent on almost the same factors as it was in England. In both countries the northern portion of the land was covered by the ice-sheet for long periods. In England the limits reached by the ice lay as far south as close to the Thames Valley; in the Netherlands they reached the Valley of the Rhine south of Nimeguen.

I will consider here only the species met with in our country up till now, and will rely on HINTON's thorough investigations, which have clearly shown that MÉHELY's phylogenetic relationships of the rooted voles (1914, p. 237) cannot be maintained.

Mimomys pliocaenicus is the oldest species of the genus and bears some primitive characters: early development of molar roots and occurrence of three roots in m^1, m^2 and m^3 (at least in those from Senèze and from Gorkum). The great complexity of the crown in the young m_1 and the long persistence of the insulated portion of the third outer fold of this tooth are primitive characters too. These features might lead to the conclusion that the species may be ancestral to the later species of the genus, where the roots develop gradually later in life, where only two roots occur on all the teeth and the third outer infold of m_1 becomes more and more reduced. But in one respect *M. pliocaenicus* possesses the highest specialization of all the other species, namely, in the reduction of the second inner fold of m^3, as is obvious also on this tooth from Gorkum (RUTTEN 1909).

Mimomys newtoni is a primitive vole too, in which the roots develop early. In respect of the persistence of the third outer valley in m_1 it is still more primitive than *M. pliocaenicus*, where this fold is reduced by insulation.

Mimomys pusillus MÉHELY is closely related to *M. reidi* HINTON and is a primitive vole by reason of the confluency of the dentinal spaces. In other features it is more specialised than *M. pliocaenicus* and *M. newtoni*, namely, in the absence of complications in young m_1 and of an enamel islet in m^3, in the formation of roots at a more advanced age, etc.

Mimomys intermedius is a newer form, as is evident from the fact that the roots develop later in life, in other words, the teeth become more hypsodont. Another feature is that the islet, originating from the reduced third outer valley of m_1 is worn out very early. In this species however, m^3 is more primitive than in *M. pliocaenicus* while the second inner fold is not reduced by insulation.

It is probable that it is from the younger forms of *Mimomys* that *Arvicola* has descended. According to HINTON (1926) so far as pattern, structure and size are concerned, there is nothing to distinguish the teeth of *Mimomys intermedius* from the Upper Freshwater Bed from those of *Arvicola bactonensis* from the somewhat later "gravel pan" at Bacton. Only the total absence of roots and of closed cement spaces on the adult teeth shows that we have to do here with a true *Arvicola*, where extreme hypsodonty has been acquired.

Evotomys, with its rather short mandibular incisors, stands near to the Lemni, which are to be considered as the oldest and most primitive voles. Also the presence of roots on the adult molars points to a primitive form. Unchanged it is known from the Upper Freshwater Bed and from synchronous layers in Bavaria up till the present time.

The genus *Microtus* makes its first appearance in England together with *Evotomys* and *Pitymys* as a rather small species. Like *Mimomys* they must have come (HINTON 1908) to these regions from southern Europe. Afterwards, in the Later Middle Terrace of the Thames a new fauna was met with, which swarmed in from Siberia and Eastern Europe. Some old forms, such as *Mimomys* and *Trogontherium*, have totally disappeared, but others continue to flourish. Among the latter the genus *Microtus* must be mentioned, with the species *nivalis, malei*, etc. *Microtus malei* is a vole with a rather generalized pattern of the teeth. It was known only from England but now also from Velzen (province of Noord-Holland). When HINTON in the second volume of his Monograph has treated the genus *Microtus*, represented in England by a wealth of material, we shall certainly know more of the interrelationships of the different species living and extinct, and of their probable geographical origin.

RECENT VOLES IN THE NETHERLANDS.

Evotomys glareolus glareolus SCHREBER [1]).

This slender vole is met with in the dune regions of the coast (in the environs of the Hague and of Haarlem) as well as in the extreme south (environs of Maestricht and Roermond), in the Naardermeer (a marsh south-east of Amsterdam) and in the sandy portions of the central, southern and eastern provinces of the country.

I have examined in the Amsterdam Museum about thirty skins and skulls from specimens caught by Dr. G. BARENDRECHT from May till October in 1927 and 1928 in the Naardermeer. Their rufous mantle is not very bright. Their dimensions quite agree with those given by MILLER of the subspecies. In nine of the largest adult specimens the length of the tail varies between 41 and 50 mm; that of the hindfoot between 16 and 18 mm. I cannot give the measurement of body and head, as the skins have been much stretched in the process of preparation. The average condylo-basal length is 23.4 mm, the max. length 24.1 mm, the min. 22.2 mm. For the zygomatic breadth these figures are 14.2 mm, 14.4 mm and 14.1 mm; for the length of the max. teeth-row 5.1 mm, 5.4 mm and 4.9 mm.

From *Evotomys gl. glareolus* SCHREB. STEIN has separated three skins and skulls from Houthem (Zuid-Limburg) presented to the Berlin Museum by Mr. P. HENS. The rufous mantle, namely, is distinctly brighter here than in the normal specimens of *E. gl. glareolus* from the neighbourhood

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[1]) See foot-note p. 15.

of Frankfurt a. Oder and from Saxony, preserved in that Museum.

The general Dutch form agrees with the latter specimens and with HINTON's definition (p. 218) of *E. gl. glareolus*: "colour of upper parts rather bright, though dark-toned." This tone is produced by a dense sprinkling of black-tipped hairs. The older the animals from the Naardermeer are, the brighter the mantle; the young skins are very dark, nearly slate-gray by reason of the shortness of the rufous ends of the hairs, which do not yet conceal much of the under-colour. In autumn these dark young animals are by far the most numerous; the older specimens are conspicuous then by their brighter rufous mantle, which does not differ distinctly from the general colour of all animals in spring and of the older specimens in summer. Their sides are yellowish rufour and the under surface whitish-grey, strongly darkened by the slate-grey underfur. Especially in older males a light yellowish-brown wash replaces the white hairs of chest and belly.

Exactly one-half of the Naardermeer skulls show on the m^3 two inner-folds; the others have three.

Not only in Zuid-Limburg, but also on the Veluwe (Eerbeek, Barneveld) conspicuously brighter coloured animals have been caught, whose mantle-colour cannot be distinguished from that of the Swedish *Evotomys rufocanus*; also the upper-side of their tail is more reddish-brown than in the Naardermeer specimens.

The colour will be in particular correlation with the soil upon which the animals live. In the Naardermeer this is a marshy peat-moor, in Houthem and in Eerbeek the soil is dry.

Microtus agrestis bailloni DE SÉLYS-LONGCHAMPS.

In the north (province of Friesland) as well as in the south (Zeeland, Noord-Brabant and Limburg), east (Denekamp) and centre of the country (Naardermeer, etc.), this vole is known. In Limburg and Noord-Brabant it is one of the chiefest elements in pellets of owls. In the environs of the Naardermeer several of these animals, too, have been caught by Dr. BARENDRECHT. Their colour and size agree with the diagnosis of the sub-species, given by MILLER. Of two adult specimens from there (♀ and ♂), the length of the tail is 34 and 30 mm, the condylo-basal length of the skull is 24.6 and 25.0 mm, the zygomatic breadth 14.8 and 14.5 mm, the occipital breadth 11.2 and 11.8 mm, the length of the maxillary teeth-rows 6.4 and 6.2 mm. Young animals are somewhat darker than adults.

Microtus arvalis arvalis PALLAS.

This vole is common throughout the country. The brown colour of the upper part is slightly more yellowish than that of the former species; in size it is somewhat smaller. Of two adult animals, one from Leusden (prov.

of Utrecht), the other from Denekamp (prov. of Overijsel), the length of the tails is 29 and 30 mm respectively, the condylobasal length of the skulls is 24 and 24.3 mm, the length of the maxillary teeth-rows 6.2 and 6.1 mm; the zygomatic breadth of the first is 14.2 mm. The specimen from Leusden has a tinge on its upper parts decidedly more rusty than the other.

It may be mentioned that in the Amsterdam Museum a specimen from Noord-Holland is preserved which is entirely white, and another whose upper parts are quite black, the underside very dark brownish-grey, with the snout, feet and tail hair-brown. The latter is a strong male specimen, and was caught in the month of June in Nieuwkoop (Zuid-Holland). Length of body and head is 116 mm, length of tail 34 mm and of hind-foot 16 mm. At first sight the animal looks like a young black waterrat (*Arvicola*).

My attention having been drawn by STEIN (1931) to the occurrence of his new subspecies *Microtus arvalis cimbricus*, replacing *M. arv. arvalis* in Schleswig-Holstein and Mecklenburg, I made a closer scrutiny of the pattern of m^3 in the Dutch skulls. The only character by which this new subspecies has been distinguished by STEIN from *M. arv. arvalis*, is the absence of the fourth inner salient angle of m^3 in 88 % of the skulls. It struck me that the first skull, from Breukelen (Utrecht), which I examined on this point might be a *cimbricus* by reason of the occurrence of only three distinct salient angles, alternating with two inner infolds. When looking through the *arvalis* remains in pellets of owls from the neighbourhood of Breukelen and 's Graveland near the Naardermeer, I found 16 skulls in which the m^3 was still in its place. Among these teeth all kinds of transitional forms, from the *M. a. arvalis* pattern with four distinct salient angles to the new subspecial form where, as a rule, three angles occur, can be observed (fig. 13); the latter are by far in the minority (± 25 %). In a hundred teeth from the Hague ('s-Gravenhage) I found

Fig. 13. *Microtus arv. arvalis* PALLAS from Holland and Utrecht. Some hind-loops of right m^3, much enlarged.

12 specimens with three angles. Some stages are shown in fig. 13. In the jaws I saw from Zuid-Limburg the m^3 has always four inner angles; the

form of the hind-loop varies between 4 and 10 of our form types in fig. 13. Of nineteen m^3 from Denekamp, half of the specimens could be classified among our form type 3; five among 5, and among each of the form types 1, 2, 4, 7 and 8 one specimen. Sometimes, however, both teeth in the same skull are different: on one side the third infold may be distinct, while it is absent on the other. It would be interesting, however, to know by what criterium STEIN has arrived at the presence or absence of the fourth angle. Is the hind-loop in the 88 % of the skulls of *M. a. cimbricus* really minus any concavity (vestige of the third infold) between the third inner angle and a low ridge indicating the reduced fourth angle? In nearly all the Dutch m^3 from different localities I was able to recognise the fourth angle, though sometimes reduced to a very low ridge. Only in a few exceptional cases was there really no trace of the fourth angle.

Microtus ratticeps KEYSERLING and BLASIUS.

This rather large vole occurs in the northern and central provinces of the Netherlands: Friesland, Noord-Holland (Texel Island, environs of Zaandam, Velzen, 's Graveland, etc.), Zuid-Holland (environs of Leiden). Guelderland. Dr. N. TINBERGEN, ornithologist at the Hague, examined a large quantity of pellets of 25 owls (*Asio otus*), gathered on the island of Texel during last winter. Among 1500 skulls of voles *Microtus ratticeps* was the only representative.

The species is identical with *Arvicola arenicola* DE SÉLYS LONGCHAMPS, four co-types of which I saw in the Natural History Museum at Leiden.

MILLER has given the measurements of a specimen from Texel Island. I was able to measure many skulls from there, a skull from Leiden, one from 's Graveland and fragments of a skull from Wartena (Friesland). All agree in size with those in MILLER's table and with the measurements given by STEIN (1931) of the "grössten märkischen Rattenköpfe". The specimen from Wartena is a large, old male, and measurements could be taken before preparation. The length of the body and head was 135 mm, that of the tail 55 mm. The upper parts (winter pelage) are a mixture of wood-brown and black, without any tinge of russet on the sides; the underside is pale grey with cream buff; the feet are the hair-brown of RIDGWAY. The m^3 of the skull from Leiden bears the typical pattern with four outer salient angles, the m^3 in the specimens from Texel, 's Graveland and Wartena show only three angles on the outer side, three closed triangles thus, two outer and one inner (MILLER p. 710). The name of Northern vole (Nordische Wühlratte in Germany, Noordsche woelmuis in Holland) has been given to the species by KEYSERLING and BLASIUS, because for a long time it was known only in northern Russia (the type locality), Scandinavia and Siberia. It is, however, by no means restricted to such high latitudes, since typical specimens have been found in northern Hungary (Pressburg) and in Bavaria (Isar valley). The name of Rattenkopf (rat's head), generally used in Germany, is therefore to be preferred.

Pitymys subterraneus subterraneus DE SÉLYS LONGCHAMPS.

This vole was recorded for the Netherlands some years ago by Mr. F. H. VAN DEN BRINK (1930) who found many skull fragments and mandibles in pellets of owls, first in those from Epen, near the southern boundary of Zuid-Limburg, later from many other localities in the southern half of the province of Limburg. Professor EUGÈNE DUBOIS sent last summer from Haelen, west of Roermond, a specimen to the Museum of Amsterdam which was measured before preparing. The total length was 130 mm, tail length 30 mm, and hindfoot 13.5 mm. The condylo-basal length of the skull is 21.0 mm, zygm. breadth 13.4 mm, max. tooth-row 5.7 mm. In a specimen from Houthem, near Maestricht, measured also in a fresh condition, these figures were as follows: total length 129 mm, tail 29 mm, hindfoot 13 mm. The condylo-basal length of the skull is 22.8 mm, the zyg. breadth 13.5 mm, the maxillary tooth-row 5.4 mm.

WETTSTEIN mentions the variability of pattern in 11 specimens from the same locality in Austria; I have examined 12 first lower molars out of pellets of owls from Haelen. Here the front-loop is always broad and the anterior inner and outer-infold are strongly developed, so much so that in one object they came into contact and thus a second pair of widely confluent triangles is formed. The m^3 of one specimen shows a distinct fourth outer salient angle, opposite to the third inner infold; in the others it is more or less observable, or it may be absent. Just as in the pattern of this tooth in *M. arv. arvalis* the variability of the hind-loop is so great that the right and the left tooth of one and the same skull differ. In the jaws I saw, m^3 has three deep inner folds.

MILLER could not yet include the Netherlands, nor Germany in the geographical distribution of the subspecies. In the latter country it has been gathered in Saxony (MATSCHIE, Pallasia 1923, UTTENDÖRFER 1931), in the Lausitz, in Schlesia and in the Rhine province (UTTENDÖRFER 1931). Haelen in Limburg (at lat. 51° 14′), the neighbourhood of Meiszen (51° 10′) in Saxony, and Görlitz (51° 9′) in Schlesia were the most northerly localities from which *Pitymys* could be recorded, until I recently found the species in pellets from the environs of Nuland near the Meuse in Noord-Brabant, situated at lat. 51° 44′.

ARVICOLA

(Dutch: woelrat, waterrat, molmuis, hamster, aardwolf, vreetwolf)

Besides upwards of twenty specimens, in formaline, from Heerlen (Zuid-Limburg), I have been able to examine skins and skulls of about forty animals from different localities throughout the Netherlands, preserved in the collections of the musea at Amsterdam and Leiden and of Mr. F. H. VAN DEN BRINK at Utrecht.

Moreover, during the past year more than thirty freshly killed animals have been sent to the Amsterdam Zoological Museum, thus the measurements could be taken by myself previous to their being prepared, which is a great advantage. By far the majority of them had been caught in the nursery gardens at Aalsmeer (south-west of Amsterdam) and some in those of Mr. RUYS, at Dedemsvaart. Other specimens e.g. those from Denekamp, had been killed in gardens, potato-fields and orchards. I take pleasure in here thanking Mr. C. J. AUGUSTIJN, at Aalsmeer, Mr. B. RUIJS, at Dedemsvaart, Mr. B. J. BERNINK, at Denekamp and Mr. M. KRAMER at Leeuwarden for the trouble they took for this purpose.

Arvicola scherman SHAW.

According to MILLER (1912) *Arvicola scherman scherman* SHAW is widely spread in continental Europe from the Baltic southwards into France and southern Germany, and thus the Netherlands would fall within this range.

MILLER and HINTON (1926) have studied specimens from Waremme, near Liège, from Thüringia, Hesse and Brunswick, etc. together with a locotypical specimen from Straszburg, and have classified them among *A. sch. scherman* SHAW. The name *scherman* is derived from the popular name of Schermaus, which is given to this form in Germany. BUFFON saw this name on the label of the type specimen from Straszburg sent to him by the German zoologist HERMANN, but as BUFFON could not read it aright, he named the animal *Arvicola scherman* (BLASIUS 1857).

We will consider in which regions of the Netherlands the species *scherman*, as defined by MILLER and HINTON, really occurs, and we shall begin with the extreme south of the country, viz. Zuid-Limburg. Here the animal is called "molmuis", by reason of its mole-like habits. In these hilly regions they lead a strictly terrestrial life and sometimes (1924, 1929) are a real plague by reason of their great numbers. They dig their tunnels through the upper layer of the ground in potato-fields, orchards and gardens, etc., where they feed on the subterraneous parts of the plants and fruit-trees.

In the autumn of 1929, in the course of a few weeks, large numbers of these animals were caught in traps, by night as well as by day, in an orchard in Heerlen. They had penetrated into the houses and cupboards and were so tame that they could be captured with the hand. Among these were some very young individuals, and there is no doubt but that there were nests in the soil of the orchard. Here the animals live during the whole year, far removed from any water. They have been captured in Zuid-Limburg in May as well as in October and December in the potato-fields on the hills.

Mr. P. HENS, at Valkenburg, informed me that he had seen specimens of *Arvicola* on the banks of the Geul, the right confluent of the Meuse, in Zuid-Limburg, but that he had not managed to catch one. It would be interesting to know whether, and if so, by which features, these riparian animals differ from the so well-known terrestrial form.

This race caught from Heerlen to Maestricht (Heerlen, Schinnen, Houthem, Heer, Mheer, etc.) conforms well to the diagnosis of *A. scherman* as regards the colour and size. The latter is obvious from a comparison of the external and cranial measurements of three of the largest skins and skulls among them given in our table, with those published by MILLER (p. 750) and by HINTON (p. 450). They are characterised by a short tail: in none of the adult specimens I saw was its length more than 77 mm; in one specimen only did it attain to half the body-length, which is neither great. Among 20 specimens caught in the orchard in Heerlen and preserved in formaline, there are 8 adults, 4 of which are females. The latter have swollen mammae, but no embryos in the uterus; probably it was too late in the year for this. The length of head + body varies in these 8 specimens between 138 and 160 mm; the length of the tail between 70 and 77 mm, that of the hindfeet between 25 and 27 mm; three of them occur in the table. The other 12 animals are juveniles, and are of all sizes, down to a body + head length of 76 mm, a tail of 38 mm and a hindfoot of 19 mm. The measurements show a great resemblance to those of *Arvicola scherman exitus* MILLER from the Alps and the Vosges (MILLER p. 748, HINTON p. 450, WETTSTEIN p. 103). Some specimens show that reproductive activity begins in males as well as in females before the interorbital ridges are joined.

The colour of the upper parts varies between darker broccoli- and paler wood-brown; some specimens are rusty brown. No black or very dark animals were among them. The overlying with longer black hairs is weakly present, generally only distinct at the lumbar region; the spine is not marked by darker colour. The cheeks are but indistinctly brighter than the sides. Chest and belly show a mixture of slate-grey and often rather dull ochraceous buff; in the objects where the upper parts are rusty this colour replaces the ochraceous buff of the underside. In the dark animals the slate-grey is in excess of the hardly discernible ochraceous buff. Generally the upper side of the tail is distinctly darker brown than its underside, which may be écru in the lighter specimens, just as the hindfeet. Sometimes, however, the tail is dark throughout and not sprinkled with lighter hairs on the underside. A similar variability of tail colour was observed by WETTSTEIN (1926) in the *Arv. sch. scherman* in Austria. The pencil of the tail is short and rather dark. The lips on nearly all skins are white. One object shows a white spot on the crown and white-haired digits on the fore and hind feet; some have a white spot on the tail.

The tail is shortly but densely haired by reason of which the annulations, about 15 of which go to the centimetre in the middle, are concealed.

Young rats are somewhat darker than the adults; the colour is independent of sex.

The skull form is typically fossorial: the occipital plane is pressed foreward above at the expense of the interparietal (fig. 14), and the incisors are strongly protruding, more so than in HINTON's fig. 110 of the species.

The proödonty of some specimens (plate, fig. 2) exceeds even that of Miller's fig. 154 of *Arv. scherman exitus.* Measuring according to the method of Thomas (1918, 1919), I found incisive index numbers varying between 101° and 106°. In *exitus* these numbers are 103°—104° and in the fossil *Arv. abotti* 105° (Thomas 1928).

Also the forward inclination of the occipital bone is great. Both characters are in distinct correlation here, just as in *exitus* and in *abotti.* That this correlation need not always exist is obvious from the description given by Thomas (1928) of *Arv. amphibius brigantium* Thomas in England, where a distinct proödonty (96°—102°) occurs together with an occipital plane as upright as in *Arv. amph. amphibius.*

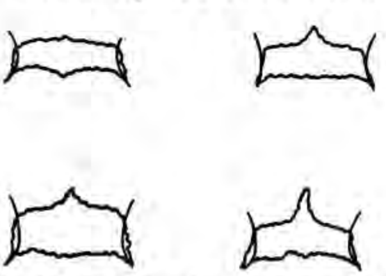

Fig. 14. *Arvicola scherman* Shaw; some outlines of interparietals (2 × nat. size); above: from Heerlen, below: from Denekamp.

The antero-posterior diameter of the interparietal is small and differs somewhat in length: very short bones (Plate, fig. 2 *a*, left side) occur, as well as slightly longer ones (fig. 14).

The *Arvicola* in Zuid-Limburg must undoubtedly be classified among the species *Arvicola scherman* Shaw. If an existing subspecial name must be chosen, the small size of body and tail, the high degree of proödonty and the strongly fossorial form of the skull in these strictly terrestrial animals, would make the subspecial name of *exitus* preferable to that of *scherman.* Since, however, a form as plastic as *Arvicola* would make it necessary to establish a new subspecial name for nearly every geographical region studied, (see p. 34) I prefer to define the animals in Zuid-Limburg as a highly fossorial race of *Arvicola scherman* Shaw.

The second region which is inhabited by *Arvicola scherman* is situated in the provinces of Overijsel and Guelderland, east of the north branch of the Rhine, called the IJsel. From Denekamp, in Overijsel, near the German frontier, several brown specimens have been sent to the Amsterdam Museum, caught in the gardens and fields where they live both winter and summer. That they are well known to the country-people by reason of their depredations among the vegetables, is apparent from the names by which they are popularly known there. Ritsema Bos (1913) mentioned the following names he had heard in the east of Guelderland: hamster, vreetwolf (glutton) and aardwolf (earth-wolf). Also in Holstein and Mecklenburg, in Germany, they are called Hamster and Hamstermus (Mohr 1931). Since the real hamster, *Cricetus cricetus* L., occurs in the Netherlands only in Zuid-Limburg, the country-people in Guelderland do not know it, and apply the name to the terrestrial *Arvicola*, which is a similar diligent hoarder of winter-store. But also the name of water-rat is used in those regions when the animals live on the banks of the small rivers. According to Mr. J. B. BERNINK, Director of the Natural History Museum at Denekamp, there lives at the Dinkel near that village a black race, of which two skins and skulls were sent by him to the Museum at Amsterdam last year.

This melanism is not known yet in Zuid-Limburg; it may perhaps occur in the riparian form living on the banks of the Geul.

The fully adult brown specimens from Denekamp are of *Arv. sch. scherman* size. The tail is generally larger than in the Heerlen race and varies between 70 and 95 mm, agreeing with the measurements of the subspecies given by MILLER (p. 746), by HINTON (p. 450) and by

WETTSTEIN (p. 101). Also, relative to the body length, the tail is longer in the Denekamp animals which represent a more normal form of *Arvicola scherman* than the Heerlen race. The fur of the brown Denekamp specimens is distinctly more lustrous and brighter than in the latter; the overlying black hairs are longer, especially so along the spine in the lumbar regions. The tinges of brown differ slightly: some skins have a faint tinge of russet, others are more woody, or more prout's brown. On the whole, wood-brown is more characteristic of the Heerlen race, and prout's brown of the Denekamp rats and of the Dutch *terrestris*. The underside is slate-grey, with more or less ochraceous buff. The tail may be distinctly bicolour and sometimes sprinkled with long whitish hairs on the underside; in darker specimens, however, the tail is unicolour. The hair is denser on the bicoloured tails where the annulations are quite concealed.

Comparing a skin of *Arv. terrestris* from Sweden with the brown Denekamp skins, I was struck by the complete agreement. The size, as a matter of course, is larger in the former and the hairs of the tail and pencil are decidedly longer, but in the colour of the fur I could find no difference between the Swedish object and some of the Denekamp specimens, either on the upper parts, the under parts, or on the sides. The cheeks are tinged somewhat more brightly than the sides in both. Also from the *Arvicola terrestris* living in the greater part of the Netherlands, the Denekamp form cannot be distinguished by the colour; this applies to the brown animals as well as to the black ones.

The fossorial character of the skull is not so marked as in the Heerlen race, although the proödonty of the two skulls of brown rats where it could be measured is evident (101° and 104°) as is also the forward inclination of the occiput in both. Unfortunately the other skulls are broken. Extremely short interparietals, as occur in the Heerlen race, I did not meet with here.

The black Dinkel race at Denekamp is unsufficiently known. It is noteworthy that one (1932) of the two specimens mentioned above exceeds considerably the size of the brown rats and matches that of an average *A. terrestris* (see table). And so does the slight protrusion (98°) of the incisors.

Two fullgrown skulls in pellets from Zevenaar (Guelderland) may as well belong to *terrestris* as to *scherman* and thus demonstrate again that the limit between the two species of MILLER can not be drawn sharply. Moreover, it is possible that intermixing of the two forms will take place at the meeting of their ranges.

A skull from Varseveld (Guelderland) shows the same size, proödonty (103°), etc., as the common Denekamp skulls, and so do the skull fragments from Winterswijk (Guelderland), which I saw in the Leiden Museum.

I regret not to have succeeded in collecting fresh specimens of *Arvicola* from the Veluwe, the dry sandy region in the centre of the country, west of the IJsel. In the Amsterdam Museum, however, I saw three specimens from there in alcohol, caught years ago in Eerbeek, Nunspeet and Worth-

Rheden, situated respectively in the east, north and south-east of this region. Most unfortunately the skulls have been broken to pieces, except the one from Worth-Rheden, which belongs to a fully adult specimen of small size (see table); the aspect of the skull is conspicuously little like the fossorial type and the hindfoot is remarkably long. A skull from Amersfoort is but slightly larger (see table) and nearly orthodont. The measurements which could be taken on the object from Nunspeet indicate an equally small animal, the tooth-rows being 8.2 and 8.1 mm long. The specimen from Eerbeek, although somewhat larger than the former, does not exceed the animals from Denekamp in size of body, tail and skull. The colour is dark. Long black hairs occur in the lumbar region, and the tail is unicolour and scantily haired, as in some specimens from Denekamp and in the one from Winterswijk.

Relying on these few objects it seems to be probable that at least the eastern half of the Veluwe is inhabited by the same form as the region east of the IJsel, viz. *Arvicola scherman.*

This may apply also to the northern and greater portion of the province of Limburg, judging from an old skull obtained from the environs of Roermond.

The reduction of the plantar tubercles in *A. scherman* and the lesser inflation of the auditory bullae, as compared with *A. terrestris,* are hardly distinguishable and subject to considerable variation in both species. Also the front-loop of m_1 does not show any invariable difference.

As we shall proceed to prove, the greater part of the Netherlands is inhabited by a form of *Arvicola* which cannot be classified among MILLER's *scherman.* STEIN (1931) has established quite the same fact for the large vole living on the plains of northern Germany.

Thus, the range of his *A. scherman* is more limited than MILLER thought it to be, when he wrote: "West-central continental Europe, from the Pyrenees and Alps to the Baltic". HINTON speaks of *A. sch. scherman* as "the typical form with a wide range over the lowlands of West-Central Europe", but he adds: "it is not improbable that this subspecies will be found to intergrade to the north, probably in the neighbourhood of the Baltic, with *A. terrestris*".

Arvicola terrestris L.

Besides *Arvicola scherman* another form of "waterrat" is present in the Netherlands, which must be referred to *Arvicola terrestris* L. This animal is as clever a swimmer as it is a digger, and inhabits the whole country except probably the regions treated above. An exact limit between the ranges of the two species cannot be drawn. The farthest south locality from which I saw a typical specimen of *A terrestris* is Eindhoven, in the south-east of Noord-Brabant. Without doubt animals of this species have been caught in the following localities, arranged in an arc from the east, over the north and the west, to the south of the country: Dedemsvaart (Overijsel), Joure, Wartena, Lieve Vrouwenparochie, Veenklooster and Engelum (Friesland), Langendijk, St. Pancras, Amsterdam and Aalsmeer (Noord-Holland); environs of Leiden and the Hague (Zuid-Holland); Breukelen (Utrecht); Best, Tongelre and Eindhoven (Noord-Brabant). From the island of Texel a very young specimen is preserved in alcohol, and from the island of Terschelling I saw some remains in pellets of owls; these objects do not permit of judging about their specific identity.

During last summer and winter I measured many newly killed animals sent to the Amsterdam Zoological Museum, mainly by Mr. C. J. AUGUSTIJN of the Phytopathological Service at Aalsmeer. Of four of the largest specimens I have given the measurements in the table; of the object from Best I found the skull, and skin minus the tail, in the collection. The external measurements of the animals have all been taken before the skinning, with the exception of the object from Best, of which the skin was measured.

On the whole the rats are larger, and their tail, also relatively, is longer than in *A. scherman* (see table). Both measurements are very variable: in 1. 9. 1931 of the table the length of the tail is about half the length of the body, in 11. 9. 1931 from the same locality it is two-thirds. In adult specimens the length varies between 85 and 120 mm, and is on an average (see table) longer than in the Dutch *A. scherman*, where it does not exceed 95 mm for aught I know, with the exception of the black riparian rat from the Dinkel.

As regards the colour, the lighter specimens fully agree with *A. scherman* from Denekamp, and can thus be distinguished from the Heerlen race by the brighter gloss on the fur, caused by the greater length (up to 40 mm) and lustre of the overlying hairs, and by a darker tinge along the spine region. I have looked eagerly for the "distinct difference" in the fur between the two species, mentioned by STEIN (1931). According to this author, the fur of *A. scherman* is soft to the touch, while that of *terrestris* is rougher. The many skins of both species (all prepared by the same person and the same method) which I examined with regard to this point did not show the slightest difference.

The under-parts of the brown specimens of *terrestris* perfectly agree with those of *scherman* by a bright ochraceous-buff, everywhere dulled by the slate-grey undercolour and fading on the throat to yellowish grey. Often both lips are white as is, though less often, the pencil or only some terminal hairs of the tail, which is bicolour. However, this is more apparent in winter when the tail-hair is dense, and the greyish or buffy hairs predominate on the under side, while the upper-side is almost black and shorter haired (4—5 mm) and the rings are fairly concealed. In summer the hair of the tail is generally less dense and does not conceal the annulations, which can be seen to be 9—13 to the centimetre in the middle; the older the animals, the broader the rings.

The brownish black and quite black rats, together with the brown specimens just mentioned, form one population. The darker are in the minority, although black animals are by no means rare in the Netherlands. The general colour shows less resemblance to the English *A. amph. amphibius*, where melanism is rare, than to the somewhat smaller Scottish *A. amph. reta*, a darker form in which melanism is frequent, the brown being often replaced by black upon the upper surface, while black and brown individuals may occur in the same litter (HINTON, p. 40).

I found all the transitional shades between brown and quite black upper parts among the rats from Aalsmeer. Going from the black to the brown specimens, the black colour recedes from the sides to the spine, where especially the lumbar region remains marked by the long overlying black hairs. On the sides the black passes gradually into the ground-colour which is caused by the blackish or brownish tips of the slate-grey hairs covering the whole body in all forms of *Arvicola*. The cheeks are nearly concolour with the sides, and never form a distinct contrast.

On the underside of the darkest rats the ochraceous buff of the brown skins is totally absent. The slate-grey of the under-fur is intimately blended with the brownish black hair-tips. In a series of a dozen skins, ranging from brown to black, the buff of the underside disappears earlier in the series than does the brown on the upper. In the five darkest skins of this set the buffy tips of the hairs are absent and replaced by a slight tinge of "light seal brown" (RIDGWAY, Pl. XXXIX), partially overlying the slate-grey, but the brown colour above is absent only in the two darkest. A reddish-black tinge sometimes lies over the entire black skin, suggestive of the colour of an old black cat.

The darkest skins also have a white-haired area on the lips, larger or smaller, but always present. A short white pencil, or some white hairs at the end of the tail, may often be observed. The rats from Dedemsvaart which I saw had all a white pencil; in one specimen the white colour extended about 15 millimetres along the tail.

As far as I can judge, the colour of the animals is fairly independent of sex and of age. I saw old brown rats and old black ones, as well as young black and young brown animals. Perhaps the younger adult brown rats darken slightly in growing older, because on the whole there are more dark specimens among the larger rats than among the smaller ones. The relative length of the tail is independent of colour and sex.

Especially in old individuals a short swimming fringe is formed by the somewhat longer hairs along the external margin of hands and feet and along both sides of each digit. The latter hairs are very light in colour, almost white, even in black animals.

Regarding the two characters of the skull which merit more particular attention, the form of the interparietal and the degree of protrusion of the incisors, we will cite MILLER's description of the form of this skullbone in

"*A. amphibius*: interparietal large, somewhat variable in form, usually ligulate with obliquely truncate outer extremities and slight anterior median projection, but sometimes almost a perfect parallelogram about twice as wide as long.

A. terrestris: interparietal tending to be sub-quadrate in outline.

A. scherman: interparietal tending to be somewhat ligulate in outline."

The slight median projection mentioned of *amphibius* is also common in *scherman* and in *terrestris* (HINTON, fig. 110 and our figs. 14 and 15).

The tendency of the bone in *terrestris* to be subquadrate in outline may actually be very faint, as is shown in our fig. 15 *S*, a drawing of the skull-bone in a Swedish specimen presented to the Amsterdam Museum by Professor LÖNNBERG. I presume it is on account of the great variability of the interparietal that HINTON, in his Monograph, nowhere mentions the form of this bone in his diagnoses of the different species of *Arvicola*.

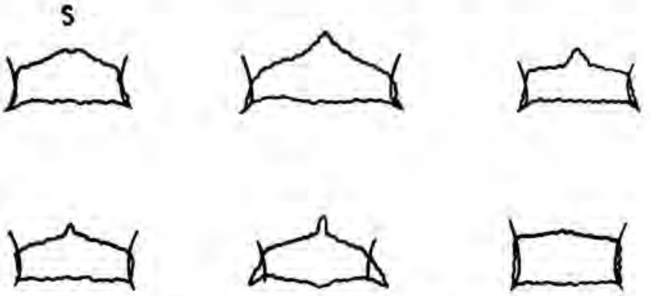

Fig. 15. *Arvicola terrestris* L.; some outlines of interparietals (2 × nat. size): S from Dalsland in Sweden; the others from the Netherlands.

In the Dutch skulls of *A. terrestris* (fig. 15) the antero-posterior diameter of the interparietal bone is greater than in the strictly fossorial *A. scherman* (fig. 14 above), where the occiput is strongly pressed forwards above. I did not see a single form of the bone among *terrestris* which did not fit into the diagnosis given by MILLER for *amphibius*.

The degree of protrusion of the incisors is, *on the whole*, a serviceable criterium by which to distinguish the Dutch *A. scherman* from *terrestris*. The difference will be seen at a glance from fig. 2 on the plate, which shows a specimen from Heerlen side by side with one from Best (Noord-Brabant). However, the incisive index number varies considerably; in the skulls from Aalsmeer it lies between 90° and 103°, and thus reaches that of the Denekamp race. Youth does not play a significant rôle in the degree of proödonty, as far as I can judge. Also in all six stages of growth in *A. amphibius*, drawn in HINTON's figures 5—7, the incisors are distinctly orthodont. Yet, the most proödont incisors I did not see in the larger, strongly ridged skulls from Aalsmeer, but in the smaller, which thus are undistinguishable from *A. scherman* from Denekamp.

Nevertheless, the Dutch *terrestris* is generally characterised by a slightly slanting occipital plane and rather orthodont incisors, the average of all the skulls measured being nearly 94°.

The persistent growth of teeth and skeleton in *Arvicola* is emphasized by HINTON (p. 48) as follows: "in the oldest individuals examined, among the enormous amount of fossil and recent material at my disposal, not only are the molars still in vigorous growth but the epiphyses of the limb bones are still unfused with their shafts." This fact is illustrated on his Pl. III and IV by photos of limb bones of a very old specimen of *A. amphibius* L. and of *A. terrestris* L., from Denmark. As regards *A. terrestris* in the Netherlands, some epiphyses evidently fuse earlier in the life of the animal. I saw but few skeleton bones, some of them being macerated, others found in pellets of owls. But of the 6 femora, the epiphyses of 4 were fused, viz. 2 out of an owl's pellet and 2 macerated. Of 4 humeri this was the case in 2. It is only the upper epiphysis of the tibia and the lower of the ulna and the radius which seem here to remain free till a great age. This feature, also met with in the family of the Castoridae (SCHREUDER 1929, p. 210 etc.) need not be correlated with permanent growth of the teeth, and is probably the consequence of an adaptation to aquatic life; DEPÉRET observed it also in the skeleton of otters.

The nursery-gardeners call the *Arvicola* "waterratten", or "zwarte ratjes" (little black rats), the latter name in contrast to the larger, lighter coloured, brown rat (*Epimys norvegicus*), also an excellent swimmer.

The water-rats do great damage to the nurseries, since they feed on the roots of trees and plants, and on young bark. In Aalsmeer they are caught in summer and winter in traps, at the same places. There can be no question here of a "trek" from the water to potato-fields, market-gardens, etc., as has been recorded by REINWALDT (p. 22) and by STEIN (p. 292) regarding Estland and German rats. Neither do they retire from the land to the water when they are quite adult, as has been suggested by WETTSTEIN (p. 100). The nursery-plots in Aalsmeer and surrounding district lie so low that each is surrounded by water. Indeed, the soil of the greater portion of the provinces of Noord-Holland and Zuid-Holland lies below sea-level, and is intersected by a dense network of canals and ditches, for which reason retreat from the water would be an impossibility.

Fig. 16. Hind-foot of *Arv. terrestris* ♂ from Aalsmeer, with its five plantar tubercles.

The contention sometimes met with in the literature, that only *Arvicola* males are caught in winter will probably be an error which has arisen from the fact that in winter the females closely resemble the males owing to the absence of perceptible mammae and the strongly developed clitoris. I have noticed more than once a newly-acquired specimen with ♂, which had later to be changed to ♀

after the object had been opened. At all events, in December 1931 three females were sent in two days from Aalsmeer.

If, with MILLER, we restrict the name of *A. amphibius* to the robust English water-rat, we must call this Dutch form *A. terrestris*, and the geographical distribution of this species, as given by MILLER in 1912: "Scandinavian Peninsula, eastwards to Finland" must be altered to: *Scandinavia and the lowlands east and south of the Baltic and North Sea.* Specimens of water-rat of the size of *terrestris*, namely, have been captured later in Estland (REINWALDT 1927), in the environs of Berlin (ZEDTWITZ 1929), of Frankfurt am Oder (STEIN 1931), in Denmark (HINTON p. 474) and in the Netherlands.

It remains, however, an open question whether the separation of *Arvicola* into the two species, *amphibius* and *terrestris*, is necessary. "Aside from the somewhat less robust general form correlated with the animal's smaller size there appear to be no tangible external characters to distinguish *A. terrestris* from *A. amphibius*" (MILLER p. 738). "The skull of *terrestris* shows a tendency in the occiput to be a little more obliquely truncate, in the upper incisors to be a little more protruding" (HINTON p. 404). The roots of m_1 and m_2 form no protuberances on the lower surface of the mandible in *terrestris*. The latter character is of course in strong correlation with the less robust teeth. The other features point to a slight modification towards terrestrial and fossorial habits which, however, will be of little significance in the chiefly aquatic form in the watery lowlands of the Netherlands, Germany, etc.

STEIN (1931 p. 292) is quite right, in my opinion, when he emphasizes the close relation between *terrestris* and *amphibius*. The Dutch form of *terrestris* points to *amphibius* by the, in general, scantily haired tail and by the form of the interparietal; the size, however, is that of MILLER's *terrestris*, as is also the less robust build.

Thus we arrive at the conclusion: *Arvicola terrestris L. inhabits the greater part of the Netherlands, where it is found as far south as Eindhoven, in the province Noord-Brabant. Arvicola scherman* SHAW *is the "woelrat" of the dry regions in the east and probably in the centre of the country, where it may form a chiefly terrestrial race, with quite the same colour as the lighter specimens of the Dutch A. terrestris, and a black, probably larger, aquatic race (Dinkel, near Denekamp). In Zuid-Limburg the A. scherman is strictly fossorial, and exhibits the short tail, the degree of proödonty and the size of the teeth-rows of* MILLER's *A. scherman exitus, and thus represents an extremely specialized race of A. scherman.*

Long series of specimens, however, must still be collected from many localities throughout the land, before it can be made out whether there remains satisfactory ground for differentiating *A. scherman* from *A. terrestris* here, or whether both forms are bridged over by some local races whose characters partly agree with those of the former, partly with those of the latter. The more the *Arvicola* is studied, the more "subspecies" arise by which the gaps between the different species become bridged over. For example, in England, *A. amph. reta* MILLER is less robust than *A. amph. amphibius*, and *A. amph. brigantium* THOMAS (1928) in Northumbria, is distinctly more proödont than they are. Both features point to *A. terrestris*, just as the form of the interparietal and the scantily haired tail of the Dutch *terrestris* to *A. amphibius*. Further, *A. terrestris abrukensis* REINWALDT (1927), in Estland, exceeds by far in size MILLER's *terrestris* in Scandinavia and the German (STEIN) and the Dutch water-rat; moreover, *abrukensis* is more proödont, in which character it agrees with *A. amph. brigantium* and with the majority of the Dutch *terrestris*.

According to STEIN, *A. scherman* is sharply distinguished from the coarser *terrestris* by the softness of the fur. In the case of the Dutch *Arvicola*, this difference does not exist, as we saw; even the colour of the Denekamp race of *scherman* is quite the same as that of the lighter specimens of *terrestris* in Holland, and the degree of proödonty reaches that of MILLER's *exitus* of the Alps and the Vosges.

WETTSTEIN (1926) mentioned an *Arvicola* from the Austrian Voralps and from the valleys of the Lieser and the Danube, of the size of *A. sch. scherman*, the colour of *A. s. exitus* and the length of teeth-rows and diastema agreeing with that of *terrestris* [1]). In the Heerlen race of *scherman* the body size and colour agree with that of MILLER's *scherman scherman*, but the degree of proödonty and the length of the tail and of the teeth-rows are those of *exitus*.

Blood-mixing is often presumed in cases where the characters of two or more species or subspecies occur in a race: STEIN's *A. s. scherman* × *A. s. exitus* and WETTSTEIN's "nicht typische" specimens of *A. s. exitus* from Salzburg.

From all this it is apparent than an infinite number of local races ("subspecies") of *Arvicola* will be found to exist, forming together one "Formenkreis", which it will become more and more difficult, if not impossible, to separate into distinct species. In my opinion it will become more and more evident that everywhere the water-rats leading a riparian life are the stronger, resembling most the chiefly aquatic *Arvicola amphibius*. The smaller form is the fossorial rat of the dryer regions of which MILLER's *Arv. scherman exitus* is the extreme type. Between these two forms an infinite number of oecological races will prove to exist in close connection

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[1]) WETTSTEIN also emphasizes the great size of the hindfoot, but WETTSTEIN (p. 64) measured it *with*, MILLER and HINTON *without*, the claws (HINTON p. 419). Whereas the latter are about 3 mm long, the average length of the hindfoot is 27.9 — 3 = 24.9 mm, a number not exceeding those of *A. s. scherman* given by MILLER (26—27 mm), by HINTON (24—26 mm) and in our table (25—29 mm).

with the qualities of the soil and the local food. *Arvicola* appears to be a highly plastic animal possessing strongly the quality of adaptation to the environment.

For this reason I have abstained from establishing new names for the three races I tried to distinguish in the Netherlands; I prefer to refer them, though with some reservation, to two of the species founded by MILLER, viz. *scherman* and *terrestris*.

July 5, 1932.

ADDENDUM

After this treatise had gone to press Dr. TESCH sent another specimen of microtine tooth lately obtained in a boring at a depth of 78—85 m beneath the soil of Wassenaar, near 's-Gravenhage (the Hague), in Icenian layers (see p. 7). This left m_1 shows an enamel islet on the front loop. The tooth is very young: the mastication surface has not yet quite reached its definitive extension at the anterior end and the cement in the infolds is perceptible only at some distance from the upper surface of the tooth; the enamel is not yet strong. Both roots are formed, however, but are not yet fullgrown. The length of the crownsurface is 3.3 mm, the breadth is 1.5 mm; the height of the tooth between the roots is 4.0 mm. In view of the early development of the roots, the presence of an enamel islet on the frontloop and of a typical shallow concavity along the outer side of the tooth immediately before the third salient angle, the specimen can unreservedly be referred to *Mimomys pliocaenicus* F.M. This object is a normal representative of the species, more so than the very old tooth in the lower jaw from Etten (Plate, fig. 1 c).

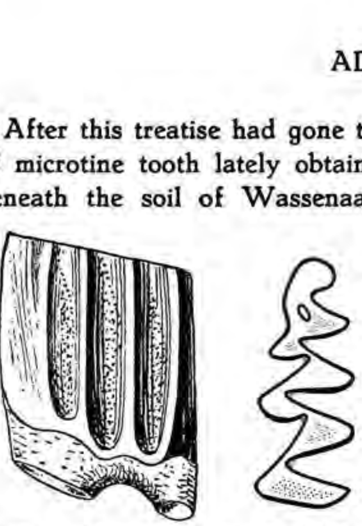

Fig. 17. *Mimomys pliocaenicus* F.M. from Wassenaar. Left m_1: outer ($7^1/_2\times$) and crown view ($10\times$).

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BODILY BUILD

PHYSIOLOGICAL AND PSYCHOLOGICAL FUNCTIONS

BY

PROF. DR. E. D. WIERSMA

VERHANDELINGEN DER KONINKLIJKE AKADEMIE
VAN WETENSCHAPPEN TE AMSTERDAM
AFDEELING NATUURKUNDE
(TWEEDE SECTIE)
DEEL XXX, No. 2

UITGAVE VAN DE N.V. NOORD-HOLLANDSCHE
UITGEVERS-MAATSCHAPPIJ, AMSTERDAM 1933

The term personality is employed in such divergent meanings that it is necessary, before discussing it, accurately to state what one intends by its use. Every person is judged by his behaviour and by his appearance. He is as he shows himself to us in bearing, shape, expression, and movement, as he conducts himself, acts, and reacts to the external world, and as he deals with and inwardly experiences psychical contents. Personality thus defined displays itself in two directions. It is characterized, that is, by external phenomena which are objectively cognizable, and by inward experiences which are subjective; in other words, we distinguish between a person's outward and inward aspect, both of which are accessible to close investigation. In order to comprehend the subjective experiences, the inward aspect, that is, of patients and healthy persons, we endeavour to call up in ourselves the feelings aroused in them by dealing with the psychical contents. If this is to be done it is essential that the investigator should be able to put himself into the state of mind of the subject of the investigation. This inward-feeling is achieved by imitating the expressive movements e.g. of depression, fear, anger, distrust etc., and then seeing what emotions are aroused, or by following in oneself the line of thought of the person to be examined, and observing what thoughts, emotions, arise in consequence. For the success of this method it is necessary that the psychic states to be investigated shall not be strange to the investigator, that he shall have experienced them himself, be it only in a rudimentary form, so that at all events traces of them are present in his consciousness. A second condition is that he shall have a close acquaintance with the expressive phenomena of the inward experiences. Subjective psychology therefore requires the aid of objective, but on the other hand it must not be forgotten that the cognizable expressive phenomena of which the investigator makes use are nothing but the objective signs by means of which the inward experiences make themselves known. In order to sum up the personality it is therefore necessary to employ both the objective and the subjective methods of investigation. Either method alone is insufficient. The objective method is inadequate owing to its giving no insight into the inward experiences; the subjective method is impossible if a knowledge of the cognizable expressive phenomena is lacking. The objective and the subjective symptoms both give us an aspect of the same reality, of which the former show us the outward side and the latter the inner side. Both groups of phenomena are subject to the same laws.

The exterior of the personality, which is objectively cognizable, is characterized by somatic and psychic phenomena. The somatic ones are related to physiological operations and to the anatomical structure, to the shape of the body as a whole and in all its parts. These forms owe their origin to centrifugal growth-impulses. They are thus the result of physiological operations. The psychological phenomena of the interior are related to observations, memory, orientation, practice, fatigue, associations, line of thought, judgment, affections, volitions, etc. Like the somatic operations, they are accurately measurable. There is so intimate a correlation between the somatic and the objectively cognizable psychical processes, that form and function imply in the domain of somatology a definite psychical constellation and that psychical processes make themselves evident through accompanying physical phenomena. Every psychical operation is immediately reflected in a measurable modification of the plethysmogram, in the respiration curve, in the secretion of perspiration, in the resistance of the skin to electric currents, etc. The strength, but not the nature, of the psychical symptoms can thereby be measured. This investigation is moreover of great importance owing to the fact that the rapidity with which and the extent to which the functions are developed by practice give a reliable insight into the disposition in various spheres. The strength and the direction of the disposition, which differ for each individual, can be accurately measured. For the investigation of the internal aspect of the personality, of the subjective experiences, that is, an accurate knowledge of the objective phenomena is also necessary.

The connection between somatic and psychic phenomena may be determined in various ways. Experimental investigation enables us to determine the correlations between the psychological and the physical phenomena in the anatomical and in the physiological sphere. The biographical method is also very useful for this purpose. Where reliable biographies are not available, we can make these ourselves. A third method is that of the somato-psychological inquiry 1), by which the desired anatomical, physiological, and psychological data are furnished, so that it is possible to see, in the case of the same individual, the anatomical, the physiological, and the psychological person, between which the connection may be sought. But the differences which exist between the somatic and psychological qualities of the individuals also enable us to distinguish between the races and the types of constitution. The races may be distinguished from one another somatically by means of height, shape of skull, and pigmentation, psychologically by means of difference in psychical after-effect. The types of constitution likewise differ from one another in physical, physiological, and psychological characteristics. In medical science the term constitution is used in connection with an increased or decreased susceptibility and resistance to diseases. This view is one-sided, for the individual difference in the degree of reaction to innocuous stimuli is also due to the constitution. These differences may be either of a somatic or of a psychological nature.

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1) E. D. WIERSMA. Lectures on psychiatry, 1932, p. 78.

Fig. 1.

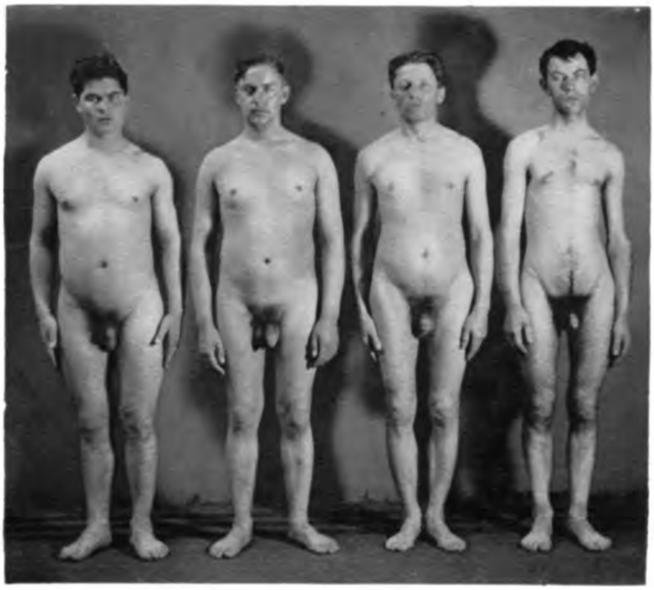

Fig. 2.

Bodily Build.

HIPPOCRATES, BENEKE, STILLER, and others have tried to find a connection between physical build and susceptibility to particular diseases. They speak of an innate predisposition, whereas the French school, SIGAUD and his disciples, ascribe a great influence to the action of the environment. KRETSCHMER was the first to seek a connection between physique and mental condition. The marked inclination which exists constantly to find new names for the same conceptions, is due to the desire to indicate the principle from which one has started. There is on the one hand a close resemblance between the phthisical habit of HIPPOCRATES, the scrofulous-phthisical constitution of BENEKE, the asthenic type of STILLER, the habitus microsplanchnicus of VIOLA, the type respiratoire of SIGAUD and others, the leptosomic type of KRETSCHMER, the linear type of STOCKARD, and the slender type of the somato-psychological inquiry; and on the other hand between the habitus apoplecticus of HIPPOCRATES, the carcinomatous constitution of BENEKE, the apoplectic type of STILLER, the habitus macrosplanchnicus of VIOLA, the type digestif of SIGAUD and others, the pycnic type of KRETSCHMER, the lateral type of STOCKARD, the thick-set of the somato-psychological inquiry, eurysomia of WEIDENREICH. All these divisions are based on the length and breadth of the persons, for which reason WEIDENREICH suggests distinguishing only between eurysomics and leptosomics. It is to my mind advisable to speak only of broader and narrower individuals when these measurements are regarded not as absolute values, but in relation to the length. This is also implied by the above terms, for eurysomic means broad, leptosomic narrow or slender of build. Eurysomia may occur both in tall and short persons, leptosomia in both short and tall ones.

The classification of human beings according to the relative breadth of the body and its parts is evidently not difficult, for so great is the harmony between the build of the parts of the body that the shape of the face suffices to indicate eurysomia or leptosomia of the entire body. This was pointed out by KRETSCHMER, and WEIDENREICH [1]) gives a number of instances. This is also evident from fig. 1, taken in the Groningen clinic.

There may, however, be objections, for there is not invariably entire agreement between the shapes of the parts of the body. There are sometimes discrepancies, whilst there are also gradual transitions between the broad and the narrow type, such as those mentioned above, and which are not infrequently met with in the case of the coarse and robust. Accurate measurements, however, usually enable us to determine in which category the individual is to be placed. In the following fig. 2 the gradual transition

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[1]) F. WEIDENREICH. Rasse und Körperbau. 1927.

from eurysomia to leptosomia is plainly visible. From left to right the figures gain in slenderness and narrowness.

A second objection is to be found in the asymmetrical construction of the body, which is especially noticeable in the face. The two right-hand halves of the face, joined together to form one whole, often give quite a different picture from the real portrait and form the two left-hand halves joined together. I have made photographs of this kind of many persons. When doing so it is necessary to fix the head in such a position that the photographs are as truly full-face as possible. The difference between the two halves of the face is often that the juxtaposed right-hand halves show the eurysomic physique, the two juxtaposed left-hand halves the leptosomic (fig. 3).

Not only is asymmetry in build shown by this investigation, but there is also often a great difference in emotional expression, so that the right-hand halves express an entirely different state of mind from the left-hand ones (figs. 4 and 5).

It is further known that considerable alterations may take place in build during the life of the person. Children who are eurysomic in the first few years of their life not infrequently become leptosomic later on. In the case of adults, also, changes in the bodily build may occur at the various periods of life.

Connection between build and function.

The somato-psychological inquiry, which puts us in possession of 415 biograms, which furnish us with information as the anatomical build, the physiological operations, and the psychological constitution, enables us to trace the physiological and psychological characters by which eurysomia is distinguished from leptosomia.

The eurysomics or thick-set are characterized by a relatively smaller length and greater breadth of body, face, nose, neck, and thorax, by relatively short, rounded arms and legs, by small, broad hands and feet, by relatively short, thick fingers and toes, and by an obtuse angulus epigastricus. The leptosomics are slender; their face, nose, neck, thorax, and shoulders are narrow. The arms are relatively long, thin, and slender, the hands, feet, fingers, and toes are long and thin. The face is oval, the chest is flat, the angulus epigastricus is acute. Still another type may be isolated from the material furnished by the somato-psychological inquiry, viz., the coarsely-built and robust, identical with the muscular type of SIGAUD and the athletic type of KRETSCHMER. They are characterized by greater length, a coarsely-built skeleton, and pronounced muscular development. The relative breadth of the body and its parts may be slight, in which case they approach the leptosomics; they may also be greater, forming a transition to the eurysomics. According to their bodily build the coarse and robust sometimes, therefore, belong to the leptosomics and sometimes to the euryso-

E. D. WIERSMA: BODILY BUILD, PHYSIOLOGICAL AND PSYCHOLOGICAL FUNCTIONS.

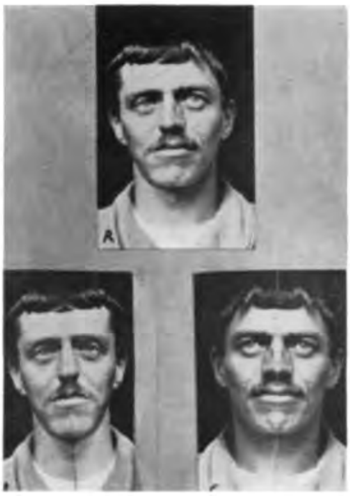

Fig. 3.

Fig. 4.

Fig. 5.

mics. Although of the same height, they may sometimes be leptosomics and sometimes eurysomics. An independent type of physique is not discoverable in the muscular, the athletic, the coarse and robust.

The somato-psychological inquiry further shows us that euryblastia is accompanied by the development of particular psychological and physiological phenomena.

The thick-set, the stocky, who are characterized physically by lateral growth, display at the same time a particular state of mind and special physiological properties. Psychologically they evince a more than average activity (73—67). [Of the figures between brackets the first refers to the percentage in which the quality mentioned is found in the type under discussion, the second to the percentage in which this quality is found in all the persons covered by the inquiry.], a secondary function stronger than the average (53—46), and a less than average emotionality (57—65), so that they conform to the phlegmatic type of temperament. They make a calm (28—20), levelheaded, and thoughtful impression (62—49). Physiologically they belong to the rapid, sure, and quiet type. They give the impression of reacting quickly, efficiently, quietly, and without undue haste: movements rapid (55—51), walking quick (71—58): they make straight for their goal (83—79), speak loudly (48—39) and articulate well (64—58); their movements are quiet (69—62). With respect to the autonomous functions the thick-set belong to the hypo-autonomous type: pulse slow (50—33), respiration slow (41—38), temperature low (33—28).

The slender, belonging, so far as their physique is concerned, to the slight and narrow-built, are distinguished psychologically by a greater emotionality (69—65), increased irritability (39—35), and further by a greater interest in new impressions (19—17), in languages (20—18), in drawing (12—10), in the stage (8—7), in imitating others (12—10), but less in mathematics. (13—17). Physiologically the narrower and slenderer belong to the quick and more or less uncertain and restless tempotype. They give the impression of carrying out the movements of walking, writing, and speaking quickly, but with some haste, agitation, and uncertainty: movements rapid (59—51), walking quick (63—58), speech rapid (51—42); movements of the hands restless (16—13); writing irregular (31—25), changeable (26—25). With respect to the autonomous functions the slender and narrow must be placed in the hyperautonomous type: pulse rapid (29—25), respiration rapid (10—8), temperature high (9—7).

Physiological and psychological functions separately and in connection with one another.

There is, as is seen from the above, a great degree of harmony in the build of the parts of the body, so that from the shape of the face the build of the other parts of the body may be deduced, not, it is true, with absolute certainty, but with a great degree of probability. Moreover the types of build, of which we have distinguished the eurysomics and the leptosomics, are characterized by certain physiological and psychological qualities. The question now arises whether as strong a correlation can be shown to exist between the phenomena of the various physiological types, and also between the various psychological types as between the build of the parts of the body, and furthermore which correlation can be marked between the physiological and the psychological types and between these and the types of physique.

Interconnection of the separate physiological functions.

Of the physiological operations two groups may be distinguished, viz., the automatic and the autonomic. The former evolve from voluntary movements. They (e.g. walking, speaking, cycling, in short all acts of daily routine) are gradually learned by practice, and are finally performed without or with only very little intervention of the consciousness. They have then become automatic. The operations of the second group (e.g. the action of the heart, the respiration, the secretion of perspiration, the movements of the stomach and intestines, etc.) are not under the direct influence of the will. They obey laws of their own, they are autonomic.

Just as between the shape of the parts of the body, so also is there a harmony between the automatic operations. Of these functions the rapidity of reaction of the movements is the most striking, since it displays a marked correlation more especially with the rapidity, but also with the sureness and calmness, with which all actions are performed. According to the somato-psychological inquiry the rapid tempotype is characterized by the great rapidity of the movements, of walking, of speaking (66—50) by the greater energy, decision, and sureness of the actions, of writing, of speaking, of the facial expressions (64—55) and by greater restlessness of the movements and of the face (39—30). With the slow tempotype all these actions are performed in greater number less-rapidly (42—17), less-energetically, less-decidedly, and less-surely (24—16) and more calmly (65—53).

This inquiry also shows that there is a correlation between the autonomic operations. The hyperautonomic type, which is most easily recognizable by the more rapid action of the heart (100—25), also shows a more superficial (37—23) and quicker (24—8) respiration, a higher body-temperature (23—8), and a restless and short sleep (23—17). The hypo-autonomic type, with a slow heart-action (100—33), is also characterized by a deep (51—30), slow (68—38) respiration, a low body-temperature (57—28), a calm, long sleep (71—61), which quickly begins (74—66).

Correlation between automatic and autonomic operations.

Correlation also exists between these two groups of physiological phenomena, between the automatic and the autonomic operations. The rapid tempotype is distinguished from the average with respect to the autonomic phenomena by a higher temperature (11—8), a quicker pulse (31—25), a more rapid and superficial respiration (20—15), a reduced secretion of perspiration: dry hands (84—82). — The slow tempotype is characterized with respect to the autonomic phenomena by a lower temperature (34—28), by a slower pulse (45—33), by a deeper and slower respiration (42—34), by an increased secretion of perspiration: hands damp (30—10). — The hyper-autonomic type is marked with respect to the automatic operations by a greater rapidity of the movements of the body, of walking, of speaking, and of writing (56—50), by uncertainty and irregularity (19—17) and restlessness of these movements (30—23). The hypo-autonomic type, on the other hand, displays a greater slowness of the bodily movements, of walking and speech (26—17), a greater regularity in gait and writing (69—61), less decision and energy in the movements and in the writing (49—54), and more calmness in movements and mimicry. (62—54).

Correlation between the physiological types, the psychological (temperamental) types, and the types of physique.

The relations of interdependence of the psychical phenomena (temperament, intellect, tendencies, volitions) have already been discussed in detail.[1]). The somatopsychological inquiry further showed that the automatic operations are influenced to a very great extent by the qualities of temperament. Inactivity reduces the energy of the bearing: slouching carriage, round shoulders (40—25)); increases the slowness of the bodily movements, of walking and of speech (39—25), promotes uncertainty in walking, writing, and speaking (41—25), aggravates the restlessness of the bodily movements, the expression of the face, the movements of the eyes (30—25); whereas activity exercises a contrary influence on all these operations; emotionality increases the rapidity (77—71), the uncertainty (80—71), and the restlessness (86—71); the primary function likewise increases the rapidity (37—31), the uncertainty (36—31), and the restlessness (43—31). The autonomic functions are modified less by the activity and the psychical after-effect than by the emotionality. It is true that with active persons the temperature is somewhat higher, the pulse and the respiration are rather quicker, and with the secondary functioners the secretion of perspiration is somewhat increased, but with emotionality all these functions are strengthened to a very great extent, so that this heightened activity may be regarded as a sign of increased emotionality.

There is therefore an intimate interaction of the physiological and psychical operations, whilst it has also been shown (see p. 7) that types of physique such as the thick-set and the slender and narrow-built also correspond to particular physiological and psychological phenomena. Are,

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[1]) G. HEYMANS u. E. D. WIERSMA. Beiträge zur speziellen Psychologie auf Grund einer Massenuntersuchung. Zeitschr. f. Psychol. Band 51, 1909.

then, these physiological types (tempo- and autonomic types) likewise characterized by particular psychological phenomena and connected with particular kinds of physique?

Psychological and anatomical characteristics of the physiological types (tempotypes and autonomic types).

The rapid tempotype (254 persons), which is marked by rapid reaction, displays a strong motoric disposition, so that the attention is especially directed to the act to be performed. This type bears the psychological signs of the choleric temperament-type: the activity (70—67), the emotionality (74—65), the primary function (28—25) are above the average. The enhanced sensitiveness of reaction reveals itself in every psychical sphere. In intellectual matters the persons of this tempotype are seen to be more intelligent (76—69), more positive in their opinions (52—47), wittier (47—40), readier in conversation (71—62), more practical (83—74), more skilful (72—64), better observers (70—60). With regard to their tendencies, they are on the one hand more altruistic: taking an interest in the lot of others (65—60), helpful (81—77), courageous in danger (45—38), always wide awake (55—49), but on the other hand they display increased vital tendencies: fond of good living (47—42), vain (23—17), sensitive to appreciation (73—68), ambitious (29—24), fond amusements (26—16).

Physically leptoblastia is very prominent. The persons of this type are thin (32—14), slim-built (36—33), slender (37—31). The eyes are large (41—35), the neck (29—26), the thorax (20—16), the ribs (8—6), the shoulders (24—21) are narrow, the pelvis is narrow (23—20) and slender (35—30), the arms are long (46—41) and slender (54—47), the legs are long (41—39) and slender (50—44), the hands are narrow (40—37), the fingers thin (54—49), the feet small and thin (51—47), the toes long and thin (39—32). — The susceptibility to infections such as nasal catarrh, affections of the throat and bronchitis (18—16), to exaltation (7—5), to urticaria (13—12), to reactions to cutaneous stimuli (15—13) is enhanced.

Summing up, the quick tempotype is seen to be distinguished physiologically and psychologically by greater mobility, and anatomically by leptoblastia.

The slow tempotype (64 persons), which has not a motoric disposition, is, so far as temperament is concerned, characterized by an enhanced non-activity (37—23), an increased non-emotionality (25—17) and a stronger secondary function (51—43). The persons of this tempotype display, that is, some resemblance to the apathetic temperament-type. In every psychical region there is a slighter mobility. They are quieter (86—51), of a tranquil nature (83—63), less persistent (33—49), more thoughtful (62—49), more irresolute (47—21), cooler (52—32) and less hurried (11—21).

In intellectual matters they are less intelligent (52—69), more superficial (11—7), more unpractical (20—9), less decided (31—44), more cautious (41—28), less witty (27—40), less ready in conversation (41—62), more poor-observers (20—11), more clumsy (29—16). In their vital tendencies they are not exigent: not fond of good living (39—29), sexually continent (72—66), not satisfied with their own performances (52—45), caring little about their appearance (63—41), not ambitious (19—16), inclined to keep in the background (38—27), easily manageable (11—6); on the other hand the egotistical tendencies are increased: they are more avaricious (16—14), less disinterested in money matters (41—48), less kind to their subordinates (75—85), they have less feeling for others (47—60), are more occupied with themselves (23—10), less willing to help (64—77), more egotistical (16—7), not-loved by children (20—12). Furthermore, they are indifferent to politics (44—38) and religion (39—31), more reserved (64—40), timid in danger (47—35), less domesticated (50—59), self-contained (20—9), distrait (41—27), speak less essentially (13—25), laugh little (59—37), display little courage in sickness (22—32).

Physically they are more thick-set than the average (52—47), much more coarsely (27—16) but not more robustly built (27—31), less strong (6—12), but more angular (11—7). The skin is thick (20—13) and rough (9—4). The face is short (31—24), broad (42—31), round (41—29), and fat (9—4), with indistinct nasolabial folds (50—38), the complexion is pale (34—27). The nose is short (34—26) and blunt (36—33), the lips are thicker than the average (34—27), the skull is short (36—27). The neck is short (45—37) and inclined forward (36—20). The shoulders are sloping (29—18) and bent forward (27—14). The arms are short (27—20) and coarsely-formed (39—28), the arm-muscles are weak (16—10), the pelvis is coarsely built (41—28), the legs are short (29—28) and coarsely-built (41—28), the leg-muscles are weak (16—7), the back-muscles (16—13) and the abdominal muscles are weak (25—19). The fingers are short and thick (38—28). The feet are thick (23—17), the toes are short and thick (30—23).

Summing up, the slow tempo-type, which physiologically is characterized by greater calmness but less quickness, decreased energy, decision, and sureness of movement, psychologically, as a result of the slighter activity and emotionality and of the stronger but less varied secondary function, displays a monotonous psychic life, of which the slight perseverance, the indecision, the irresolution, the decreased wittiness, the unpractical sense, the slight interest, the reduced altruism and the increased egotism are the consequence. Physically this type shows a coarse build of body and extremities, a thick skin and thick lips, a short, broad, round, fat, and pale face, the nose being short and blunt. The short growthform reveals itself also in the skull, the neck, the arms, fingers, and toes. Microblastia is thus not always coupled with euryblastia. These persons cannot be classed with the eurysomics. They are distinguished from these by the weak muscles of the back, abdomen, arms, and legs, by the bearing bent forward and by their sloping shoulders.

The hyper-autonomic type (102 persons), which, as we have seen above, is characterized by a more rapid heart-action, more superficial and more frequent respiration, a higher body-temperature, and in which also the automatic movements have become more rapid, but also more uncertain, is distinguished psychologically with respect to the qualities of temperament only by the increased emotionality of the average individual. The activity (68—67), the secondary function (45—43), and the primary function (26—26) show no deviation worth mentioning. The emotionality, on the other hand, is greatly increased (80—65). In agreement with this is the greater mobility (52—39), the increased impulsivity (51—38), the greater vehemence (59—44), the increased irritability (47—31), the reduced calmness (54—63), the more marked agitation (32—21), the greater fear of (30—22) and impatience during sickness (30—25) and the greater readiness to call in the aid of the doctor (34—29). In intellectual matters the intelligence (75—69), the wittiness (47—40), the loquaxity (68—62), the skill (73—64), the tendency to express a positive opinion on everything (52—44), the aptitude for accomplishments such as mathematics, languages, music, drawing, the stage, imitating people, (16—13) are increased, whilst the common sence (49—55), the breadth of view (74—79) and the independence (64—69) are reduced. The vital and egotistical tendencies are in general stronger than the average, being less inhibited by the higher tendencies: fond of good living (49—42), dissolute in sexual matters (12—9), satisfied with their own performances (32—22), vain (23—17), ambitious (30—24), money-loving (17—14), egotistical (13—7), constrained in deportment (25—17), given to exaggeration and embellishment (21—15), fond of amusement (26—16). There is an increased tendency towards melancholia (6—2), to hysteria (4—3), to neurasthenia (17—13), to hypochondria (3—1) and phobias (8—7).

Physically the persons of this type are lean (17—14), slender (38—33), slightly-built (42—31); the skin is thin (70—63), the face is narrow (36—24), the eyes are large (39—35), the neck is less rounded (40—61), less broad (27—35), the thorax is narrow (20—16), the intercostal spaces are narrow (9—5), the build of the thorax is paralytic (10—5), the shoulders are narrow (26—20), the pelvis is narrow (28—20) and slender (39—30), the arms are long (44—41) and slender (60—47), the legs are slender (54—44), the hands are small (62—51), the fingers are thin (55—49) and tapering (36—32), the feet are small (55—49), the toes are thin (42—39). There is a greater susceptibility to infections such as nasal catarrh, affections of the throat and bronchitis (22—16), to exaltation (9—5), to depression (22—16), to palpitation of the heart (21—12), to urticaria (15—11), to reactions to cutaneous stimuli (21—12).

Summing up, it is therefore seen that the hyper-autonomic type, both with respect to the psychological and physiological phenomena and to the anatomical structure, bear a great resemblance to the rapid tempo-type, so that the composition of the two types is found very largely in the same persons. The hyper-autonomic type is marked by a greatly increased psychological and physiological activity. Anatomically speaking, leptoblastia of the entire body and of most of the parts is found.

The hypo-autonomic type (136 persons),which is characterized by a slow heartbeat, by a deep and slow respiration, a low temperature, a quiet and long sleep, evinces less rapidity, greater regularity and tranquillity, but less decision and energy, in the bodily movements also. With respect to the qualities of temperament there is a remarkable difference from the hyper-autonomic type. It is true that, as in the case of the hyper-autonomic type, the average values point to an increase in the activity (69—58), but there is a striking difference in the nature of the increase. In the execution of their professional or official duties the persons of the hypo-autonomic type display much more activity (82—78—80). The first figure refers to the hypo-, the second to the hyper-autonomous type, the third to the general average percentage. This also applies to the energetic tackling and finishing of a work once begun (58—50—51), but in their spare time they are more inclined to take it easy and are less occupied (65—78—70). This difference in the direction of their activity is connected with differences in the tendencies which will presently be mentioned. The secondary function is considerably increased (47—42), and this increase is at least partly dependent on greater activity, since it is especially noticeable in those qualities which are benefited thereby, viz. constancy in affections (81—74), attachment to old memories (60—57), the formation of habits (42—36), the fixing of the thoughts on the future (49—40), the agreement between thought and action (75—69). The average primary function, as in the case of the hyper-autonomic type, displays no deviation (26—26). If we compare the individual replies, we find that here, too, the activity has exerted an influence: reconciliation after anger occurs more quickly than with the hyper-autonomic (38—33—38), and the same holds good of susceptibility to new points of view (71—62—66). The emotionality is reduced (59—65). In agreement with this is the greater coolness (46—32), the better temper (68—58), the calm behaviour (71—63), the slighter fear of (18—22) and the greater patience in sickness (43—39), the less readiness to call in medical assistance (26—29). Intellectually the intelligence is smaller (66—69), the common-sense greater (59—54), they possess a broader mind (83—79), greater independence (73—69), a slighter aptitude for wit (35—40). The tendencies are on a higher level. Greater than the average are: the indifference to good living (35—29), the sexual continence (74—66), the dissatisfaction with their own performances (52—45), the indifference to praise (24—16), the desinterestedness in money matters (54—48). Smaller on the other hand are the vanity

(14—17), and the love of power (12—17). Above the average are also the strict veracity (68—64), the absolute reliability in money matters (92—88), the friendship for children (74—71), and animals (57—52), the tendency to discuss business (48—33), the desire to read books (68—56) of which the contents are accurately remembered (54—49), the desire for intellectual games (38—30), the exact performance of agreements (70—69), the slight tendency to laughter (51—37).

Physically the persons of this type are more corpulent (51—47), more coarse and robust (28—24) and more thick-set (15—10). The face is short (26—24), broad (35—30); the neck is short (41—37), rounded (66—61), broad (41—35); the thorax is broad (65—61), the intercostal spaces are broad (11—8), the thorax is barrel-shaped (7—4), the shoulders are broad (68—59); the pelvis is broad (50—42), coarse (35—24); the arms are long (47—41), coarse (41—28), the muscles are strong (37—33); the legs are long (47—39), coarse (41—28), the muscles are strong (46—39); the hands are large (56—44), broad (52—39), the fingers are long (54—47), thick (34—24), blunt (49—40); the feet are large (32—26), thick (22—17); the toes are long (36—26), thick (19—12).

The susceptibility to catarrh of the nose, throat, and bronchia (18—16) is somewhat above the average but much smaller than with the hyper-autonomic type. The predisposition to exaltation (2—5), to depression (15—16), palpitations (10—12), and the susceptibility to cutaneous stimuli (11—13) are somewhat reduced.

Summing up, it may therefore be said that the hypo-autonomic type belongs psychologically to the active, non-emotional, secondary functioning temperament-type, and that accordingly the intelligence is slighter, the common-sense greater. The lower tendencies are on a lower level, the higher ones on a higher. Physiologically speaking, there is, in addition to the hypo-autonomic effect, a reduced rapidity and decision of the automatic operations, which, however, are performed more quietly and regularly. Anatomically speaking this type is especially characterized by euryblastia, although longitudinal growth, especially in the extremities, is sometimes in evidence, just as the external shape of the body is in some cases thick-set, in others coarse and robust. This robustness is also shown by the powerful development of the muscular system.

Amongst the autonomic functions there is also the metabolic process, which, as is well-known, is closely connected with the physique, and the physiological and psychological functions. It is therefore of interest to trace the influence of the increased and decrased metabolism on these functions. With a high metabolism the consumption is greater than with a low one. It is therefore obvious that with a high metabolism the chance of an accumulation of fat is slighter than with a low one. For these reasons it may be taken that amongst lean people there will be found more persons with a higher metabolism and amongst fatter people more with a lower metabolism. The lean and slender persons and the fat and corpulent ones were therefore picked out from the material of the inquiry and compared with one another with respect to physique and physiological and psychological qualities.

The lean and slender persons (172) are marked by general leanness (33—14), slenderness (78—33), absence of corpulence (0—47), by slight formation of fat over the whole body: face (58—42), neck (38—21), breast and back (76—45), abdomen (64—35), pelvis (48—42), arms (64—53), legs (60—48).

With respect to the physiological operations the carriage of the body and of the back is somewhat limper (24—19). The remaining automatic movements, speaking and walking, are somewhat quicker (54—50), but otherwise they show little deviation in decision and sureness (57—56) and none whatever in quietness. The autonomic operations, on the other hand, are considerably increased: the defecation is more regular [less inclination to constipation] (77—75), the temperature of the body is higher (11—7), the pulse is faster (27—25), the respiration is quicker (9—8) and more superficial (29—23).

Psychologically the lean persons, so far as the temperamental qualities are concerned, are somewhat less active (64—67) and somewhat more inactive (27—25); more emotional (71—65), more irritable (34—31), less cheerful (26—31), gloomier (34—31), more timid in danger (38—35), but on the other hand, in spite of the increased emotionality, less vehement (41—44), more courageous in sickness (50—32), more patient (48—39), and not more inclined to call in medical aid (30—26). The secondary function is hardly any greater (43—42), the primary function somewhat smaller (23—24). The lean persons therefore do not differ to any great extent from the average in activity and psychical after-effect, but they are more emotional. In intellectual matters they are more intelligent (72—69), more sensible (58—55), have broader views (81—79), are somewhat better observers (62—61), more skilful (68—64), but they are less independent (67—69). With regard to the tendencies they do not show any striking differences, They are on the one hand less fond of good living (33—42), which of course is beneficiel to leanness, sexually more continent (71—66), more disinterested in money matters (51—48), less domineering (14—17), kind to subordinates (86—85), fond of animals (56—52), averse to sexual jokes (48—45), but on the other hand more satisfied with their own performances (25—22), vain (22—17), ambitious (26—24), with less interest in the lot of others (51—60), less natural, more constrained (19—17), uncommunicative (44—40), less accurate (66—69), not prone to laughter (44—37).

Physical phenomena: the lean are delicate and slight (55—23), not coarse and robust (15—23); the skin is thin (72—63) and soft (79—75); the face is long (45—43), narrow (37—24) and oval (66—54); the nose is long (51—43), pointed (41—30), prominent (43—37), thin (41—32);

the lips are thin (54—43) ; the cranium is long (41—36) ; the neck is long (67—41), narrow (43—25), not muscular (38—31) ; the thorax is flat (34—21), long (51—32), and narrow (29—16) ; the ribs (11—6) and intercostal spaces (8—6) are narrow ; the angulus epigastricus is acute (35—21), the shape of the thorax is paralytic (9—6); the dorsal muscles are weak (18—13) ; the abdominal muscles are weak (25—22) ; the shoulders are narrow (33—21), sloping (24—18) and bent forward (20—14) ; the arms are longer (30—20), more slender (53—47), the muscles are not so strong (22—34); the legs are long (52—39); slender (48—44), the muscles are not so strong (28—39); the hands are long (48—37), not so broad (22—39); the fingers are long (70—47), thin (65—49), tapering (42—32) ; the feet are thin (58—45) ; the toes are long (40—26) and thin (52—39).

Summing up, there is seen to be, physiologically speaking, in the case of the lean and slender, an increase of the autonomic functions and an acceleration of the automatic operations. Psychologically speaking, with respect to the temperamental qualities the emotionality is somewhat increased (the activity and the psychical aftereffect show but little difference) ; with respect to the intellect it is the intelligence and the common sense which are more especially seen to be somewhat greater. The tendencies are partly on a higher level and partly on a lower one. So far as the bodily build is concerned, the lean belong to the leptosomics. The body and all its parts are long, narrow, and thin. The muscles are weak.

The fat and corpulent persons (205), who are characterized by a greater accumulation of fat (9—5) and corpulence (94—47), with an absence of leanness and slenderness (0—33), show larger deposits of fat on various parts of the body: face, a good deal (60—45), neck (9—5), breast and back (46—26), arms (36—21), legs (37—24).

Of the physiological operations the carriage of the back and body is somewhat more energetic (57—55), the decision and sureness of the automatic movements are rather greater (58—56). The quietness shows no deviation from the average, and resembles that of the lean. The autonomic operations are much less vigorous than those of the lean and also than those of the average: temperature less high (4—8), pulse in greater number slow (36—33), respiration less rapid (5—8).

Psychologically the activity is found to be higher (70—67), the emotionality lower (62—65). In agreement with this is the slighter degree of vehemence (41—44), the reduced irritability (28—31), the greater cheerfulness (36—31), the slighter inclination to gloominess (28—31), the increased lightheartedness (25—20), whilst on the other hand the courage in sickness is smaller (24—32), the impatience greater (27—25), the fear increased (27—22), as a result of which medical aid is more quickly called in (33—29). The secundary function is somewhat smaller (41—42), the primary function somewhat greater (25—24). The fat and corpulent are distinguished intellectually by a lesser degree of intelligence (66—69), and a somewhat greater superficiality (9—7). They are more decided (49—44) and less inclined to express themselves conditionally (23—28), less good-observers (58—61), and less skilful (60—64). With regard to the tendencies, the vital ones, such as fondness for good living (52—42), by which of course the formation of fat is enhanced, are increased, but they are less vain (14—17), less ambitious (20—24), less disinterested in money matters (46—48), and less egotistical (6—7). They are more demonstrative (42—38) and less reserved (34—40), more accurate (75—69), less ironical (4—11), they are more given to laughter (46—41).

Physically they are coarse and robust (30—24) and thick-set (19—10), round (47—29); the skin is thick (17—13); the face is short (29—24), broad (43—31), round (41—29); the nose is short (30—26), blunt (41—33), thick (30—24); the eyes are small (34—27); the skull is short (29—27); the neck is short (52—37), broad (48—35), muscular (55—47); the thorax is deep (60—48), short (30—20), broad (78—61); angulus epigastricus is obtuse (30—19); the arms are not so long (15—41), coarse (39—28), the muscles strong (42—35); the legs are short (43—28), coarse (38—28); the muscles strong (45—39); the hands are short (48—35), broad (52—39), the fingers are short (46—33), thick (36—24) and blunt (46—40); the feet are small (55—49) and thick (25—17), the toes are short (40—34) and thick (18—12).

Summing up, the fat and corpulent are characterized physiologically by reduced autonomic and retarded automatic functions. Of the qualities of temperament the emotionality is lower, the activity stronger, whilst the psychical after-effects show scarcely any deviation. The intellect is on a somewhat lower level. The vital tendencies are increased, the most egotistical ones are reduced.

If we compare the physiological types, which were classified according to their automatic and autonomic operations, with one another, then a great similarity is found to exist somatically and psychologically between the quickly reacting persons, those with a frequent cardiac action, and the lean. These three types are somatically marked by an increased activity of the automatic and autonomic functions and by leptoblastia; psychologically by increased emotionality. A similar resemblance exists between the slowly reacting persons, those with a retarded cardiac action, and the fat. These are characterized somatically by lowering of the automatic and autonomic functions and by euryblastia; psychologically by reduced emotionality.

The constant concurrence of the increase of the physiological functions with leptoblastia and with increased emotionality, and conversely of the reduction of the physiological functions with euryblastia and with reduced emotionality justify us in supposing that these phenomena are under the influence of a common factor. It is well-known that the emotional are more mobile, that they are more impulsive and react more violently, that their pulse frequence and respiration are quicker, that the secretion of perspiration is increased, and conversely, that the non-emotional are quieter, calmer, and react more slowly, that their pulse frequence and respiration are less frequent, and that the secretion of perspiration is reduced. And if we bear in mind that the leptoblastics are much more emotional than the average, and the euryblastics much less so, then it is obvious that there is a close correlation between the emotionality and the physiological operations and between the emotionality and the bodily build. But the concurrence of the somatic operations mentioned and the thyroid activity is at least equally great. It is wellknown that the autonomic operations, such as the cardiac action, metabolic process, secretion of perspiration, respiration, etc., are increased by thyroid, and that the actions are in consequence executed more rapidly. Thyroid also exerts an important influence on growth. HOLMGREEN's investigation, confirmed by SCHLESINGER, has demonstrated that longitudinal growth is stronger in the case of young persons with a swelling of the thyroid gland, which is accompanied by tachycardia. Conversely we are taught by pathology that the reduced thyroid secretion in cases of cretinism is accompanied by stunted growth.

The thyroid action and the emotionality exert, therefore, a simular influence on the automatic and on the autonomic functions, of which growth is also one.

The unity of the personality is shown not only by the constant concurrence of certain forms with certain functions of a psychological and physiological nature, such as e.g. slender bodily build with quickness, litheness and adroitness of the movements, but also by the reciprocal relation that exists between the predisposition to the development of form and function. The predisposition to the development of a particular form implies the predisposition to the development of the appropriate physiological and psychological operations and vice versa. Which of the two predispositions, the predisposition to the development of the form or that to the development of the function, is primary, it is difficult to say. The force which gives rise to the forms and that which produces the functions are inseparably bound together, for both are dependent on a primitive straining after conditions in which the existence of the individual is as far as possible ensured. This straining dominates the rise both of form and of function. It is impossible to speak of the precedence of either of these functions. They both serve the urge, the primeval impulse, to the evolution and unimpeded subsistence of the individual. The priority of this force may be demonstrated by numerous examples. Wherever, in the organic sphere, impeding influences threaten the existence of the individual, the form and function of the organs adapt themselves to the increased impulse towards an unhindered life. With valvular defects of the heart hypertrophy and increased function are seen to occur, with constriction of the urethra the wall of the bladder becomes thicker and the muscular contraction more powerful, with infectious diseases antidotes are formed which neutralize the noxious effect of the infection.

This endeavour to repair a disturbed equilibrium is so inherent a phenomena that it plays a powerful role in every department of life. In the psychological sphere artificially applied impeding stimuli such as a nose-clamp, the ticking of a metronome or an elastic band, increase the attention so as to compensate for these obstacles 1) ; the scientific investigator, the artist, the business-man, are stimulated to greater efforts by difficulties which crop up ; the masses are incited by religious, economic, or political oppression to resistance and greater activity. Centrifugal impulses, that is, exist, the object of which is to ensure the most favourable possible course to the vital processes, and for this purpose it is essential that the form and the function of the body and its organs shall be in harmony therewith, and that they shall be governed by these centrifugal impulses. Regarded in this way, therefore, neither the form nor the function is primary, both being dependent on a more central straining after a balanced co-operation of the vital processes. Build and function are two vital phenomena which run parallel, and which in their appearances give us a view of the force and of the direction of the straining after equilibrium, after correctness and usefulness of the vital processes of the individual. This straining may be strengthened when obstacles are placed in the way of the efficient action of the vital operations. This strengthening reveals itself in the hypertrophic build and in the increased activity of the organs affected. If, however, the obstacles are so great that they cannot be compensated for by a greater straining, the energy relaxes, and this relaxation is recognizable by the inferiority in build and function of the organs affected. Furthermore, the straining after equilibrium and correct and efficient functioning may be inherently feeble, in which case this inferiority will be evident in the form and functioning of the organs. The pathological predisposition to physiological and psychological disturbances will therefore show itself not only in a particular functioning, but also in a particular bodily build.

With regard to physical deviations this was pointed out in very early times. HIPPOCRATES speaks of a habitus apoplecticus, BENEKE of the carcinomatous and of the scrofulous-phthisical constitution, STILLER of the typus asthenicus. So far as mental disturbances are concerned, KRETSCHMER has pointed out the connection between physique and character and between physique and psychical disturbances. As stated above, the investigation with the somato-psychological inquiry 2) enabled me to distinguish the thick-set, who are eurysomics from the slender and narrow, who are leptosomics. It was at the same time found that these two types of physique are characterized by very special psychological and physiological phenomena. The thick-set belong to the active, the non-emotional, and the secondary functioners ; the fine and slender are marked by a greater emotionality. In agreement with this the thick-set are calmer, quieter, more level-headed ; the leptosomics more mobile, more agitated, more irritable. It was

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1) E. D. WIERSMA, Lectures on Psychiatry, 1932, p. 193.

2) E. D. WIERSMA, Karakter en Psychose. Psychiatrische en Neurol. Bladen 31, 1927.

further possible by means of another investigation on character and psychosis [1]) to confirm the opinion of O. GROSS [2]) that psychopathology makes us acquainted with the psychical phenomena in a highly magnified form. The pathological disturbances are to be regarded as phenomena which differ from healthy ones only in their deviating from the average. Normal psychical phenomena and psychopathological ones obey the same laws. They form one whole; their separation is artificial. The psychologist who studies only the normal psychical phenomena, can enormously widen his outlook by including in his study the abnormal psychical phenomena, since these show him the normal phenomena in a magnified form. The limited deviations of the psychical phenomena from the average which occur within the limits of sanity, assume excessive proportions as soon as the morbid deviations are added. It was shown by the investigation on character and psychosis that the pre-morbid mental state of melancholics is characterized by non-activity, by enhanced emotionality, and by a strong secondary function, so that the melancholics display the charecteristics of the sentimental temperament-type before the occurrence of the disease. The same qualities of temperament are found in a greatly enhanced degree in melancholics, for in their case there is not infrequently an absence of any initiative to action, so that owing to the lack of activity the patients usually sit limp and motionless, and are unable to get on with their thoughts; they are constantly occupied, owing to their enhanced emotionality, by fear, depression, and by delusions of disease and sinfulness, and have, as a result of the strong after-effect of thoughts, impressions, emotions, etc., a very restricted consciousness. Among this type, from which the melancholics are recruited, the thick-set or eurysomics, who on the contrary, as seen above, are active and only slightly emotional, cannot be reckoned. And is it really as certain as is maintained by some that the praecox patients are to a greater extent than the melancholics characterized by a leptosomic physical growth? The narrow-built and slender, or leptosomics, are according to the investigation above mentioned, „Karakter en psychose", more than averagely emotional, irritable, agitated, and mobile, and at the same time they display greater interest in new impressions, languages, drawing, and imitating others. This is also seen in the behaviour of animals, e.g. of slender horses, dogs, and hens, which take notice of all strange objects and are easily frightened by very unusual impressions. The psychological aspect of the praecox patient, with his split thinking, feeling, and acting, with his irritability and his frequently great indifference to his surroundings, is so different from the mental state of the leptosomics that this can hardly be regarded as the pre-morbid psychical condition of the praecox patients. It is therefore of importance to try to determine whether melancholics are really characterized in the majority of cases by the eurysomic physique and the praecox patients more especially by the leptosomic

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[1]) Psychiatrische en Neurol. Bladen, 31 1927.

[2]) O. GROSS, Die Cerebrale Secundärfunction, 1902.

bodily build. If this supposition is confirmed, the pre-morbid conditions will of course also display the same physiques; if this conjecture is found to be baseless, the above-mentioned physical characteristics will also be absent in the case of pre-morbid praecox patients. In order to solve this problem the following investigation of the bodily build was instituted.

Physical Proportions.

The following measurements, according to MARTIN's 1) anthropological prescription, were performed on 111 male and 88 female patients who were treated in the Groningen psychiatrical neurological clinic before 1930 for melancholia or dementia praecox. A few of the melancholics had previously also, although seldom, had a maniacal attack.

Length of body
Breadth of shoulders
Girth of head
Length of head
Breadth of head
Height of face
Length of nose
Girth of chest
Girth of abdomen
Length of legs
Length of arms
Girth of pelvis
Girth of left forearm
Girth of hand
Girth of neck
Weight of body

Length of body. Owing to their psychical disturbances it was not possible to obtain reliable measurements of the length of body of all these patients. The number was restricted to 166. The average height of the men is 170 cM., that of the women 160.9 cM. Of the 166 patients 91 are taller, 75 smaller than the average. Of the 91 taller, 46 = 50.5 % are praecox patients and 45 = 49.5 % melancholics. Of the 75 shorter persons 37 = 49.3 % are praecox patients and 38 = 50.6 % melancholics. There are therefore approximately the same number of melancholics as of praecox patients above and below the average height.

Breadth of shoulders. Reliable measurements were obtained of 179 patients. The average shoulder-breadth of the men was 39.4 cM., of the women 35.6 cM. Of the 179 patients 89 are broader, 90 narrower than the average. Of the 89 broader, 41 = 46.1 % are melancholics, 48 = 53.9 % praecox patients. Of the 90 narrower persons 49 = 54.4 % are melancholics and 41 = 45.6 ... praecox patients. According to these absolute measurements, therefore, the melancholics are narrower than the praecox patients.

Breadth index. Although it would generally speaking be premature to draw conclusions from these absolute breadth measurements as to a greater or lesser degree of lateral growth, since with a greater length the breadth

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1) R. MARTIN, Anthropometrie 1925.

will also increase, even if not invariably in a proportionate degree, the above measurements do certainly indicate that the melancholics are narrower than the praecox patients, since both the number of persons who exceed the average height and of those below this comprise almost the same number of melancholics and of praecox patients. We are, however, not entitled to express this opinion until we have expressed the breadth-measurements of all the persons in percentages of the height. For this reason the breadth index of all the persons whose height and breadth were known, was calculated. This average index in the case of the men is 23.1, in that of the women 22.1. Of the 166 patients the index of 86 is above the average, of 73 it is below, and of 7 it is the same as the average. Of the 86 broader 47 = 54.6 % are praecox patients and 39 = 45.4 % are melancholics. Of the 73 narrower persons 30 = 41.1 % are praecox patients and 43 = 58.9 % are melancholics. Of the broader persons, therefore, more are praecox patients, of the narrower ones more are melancholics. This investigation, therefore, confirms the opinion that the melancholics in their pre-morbid state do not belong as a general rule to the thick-set nor the praecox patients as a rule to the narrow and slender.

The indices enable us to divide the broad from the narrow. We can then endeavour to determine in the first place whether the greater lateral growth of the body is accompanied by eurysomia of its parts, and whether leptosomia of the body is accompanied by greater longitudinal growth of its parts; and in the second place whether agreement in growth can be found between the melancholics and the eurysomics on the one hand and the praecox patients and the leptosomics on the other. It is of importance to make this comparison between the absolute measurements, but also between the relative measurements, the height of all the persons being reduced to 100. Below is given first a comparison of the breadth-measurements, and then one of the length measurements.

Absolute breadth measurements. In the following table are shown the average measurements of all the persons, men and women, the average measurements of the eurysomics, of the leptosomics, of the melancholics, and of the praecox patients.

The table shows that as a rule the eurysomics are broader built, the leptosomics narrower, and that the difference in the breadth measurements of the melancholics and of the praecox patients is only slight. It is true that the breadth measurements of the melancholics more frequently exceed the average, and those of the praecox patients are more often below it, but some of the measurements of the melancholics are smaller and some of those of the praecox patients are larger than the average. In the case of the men even the shoulder-breadths of the melancholics are below the average, those of the praecox patients above it.

	Men					Women				
	Av.	E.	L.	M.	P.	Av.	E.	L.	M.	P.
Girth of head	57.5	57.5	57.4	57.7	57.4	55.8	56.0	55.5	56.0	55.6
Breadth of head	15.8	15.8	15.8	15.9	15.7	15.2	15.2	15.2	15.3	15.2
Girth of chest	94.8	95.8	93.8	95.7	93.9	87.1	88.1	86.1	89.7	86.5
Girth of abdomen	84.1	84.4	83.3	85.9	82.0	78.5	81.7	75.4	80.9	77.4
Breadth of shoulders	39.4	40.3	38.4	39.1	39.7	35.6	36.1	35.0	35.8	35.4
Breadth of pelvis	32.9	33.1	32.7	33.3	32.5	32.6	33.4	32.4	33.9	31.3
Girth of pelvis	90.9	—	—	9.0	90.7	95.5	—	—	97.2	93.7
Girth of left forearm	25.8	—	—	25.9	25.6	24.0	—	—	24.2	23.8
Girth of left hand	33.0	—	—	32.9	33.1	32.3	—	—	33.0	31.0
Girth of neck	37.3	—	—	37.4	37.1	33.8	—	—	33.9	33.6
Weight	66.6	68.5	64.4	68.5	64.4	59.4	60.7	58.0	61.8	57.0

Breadth measurements in percentages of the height.

	Men					Women				
	Av.	E	L.	M.	P.	Av.	E.	L.	M	P.
Girth of head	33.8	34.2	33.4	33.8	33.6	34.6	35.3	34.0	34.8	34.4
Breadth of head	9.3	9.4	9.2	9.3	9.3	9.5	9.6	9.3	9.5	9.4
Girth of chest	55.8	56.9	54.5	56.3	55.2	54.1	55.6	52.1	54.6	53.5
Girth of abdomen	49.5	50.2	48.7	50.5	48.2	48.8	51.5	46.5	50.4	47.9
Breadth of shoulders	23.1	24.0	22.3	23.0	23.3	22.1	22.8	21.4	22.3	21.9
Breadth of pelvis	19.2	19.7	19.0	19.4	19.1	20.2	21.1	19.7	21.1	19.4
Girth of pelvis	53.5	—	—	53.5	53.4	59.4	—	—	60.6	58.1
Girth of left forearm	15.2	—	—	15.2	15.2	14.9	—	—	15.1	14.7
Girth of left hand	19.4	—	—	18.8	19.5	20.0	—	—	20.0	19.8
Girth of neck	21.9	—	—	22.0	21.3	21.0	—	—	21.1	20.9
Weight	39.0	40.7	37.4	40.3	37.9	36.9	38.2	35.5	38.5	35.3

If the breadth measurements are reduced to those of a person 100 cM. in height, there is entire agreement between the breadth of the body and its parts, for in the case of the eurysomics all the measurements exceed the average and in that of the leptosomics they are below it. The melancholics and the praecox patients show so slight a difference in breadth that no value can be attached to it.

Absolute length measurements. In the following table are shown some length measurements, first of all the persons, then of the eurysomics, of the leptosomics, of the melancholics, and of the praecox patients.

	Men					Women				
	Av.	E.	L.	M.	P.	Av.	E.	L.	M.	P.
Length of body	170.0	168.1	172.0	170.0	170.0	160.9	158.6	163.2	160.5	161.4
Length of head	19.2	19.1	19.2	19.2	19.1	18.3	18.3	18.2	18.5	18.2
Height of face	8.5	8.4	8.6	8.6	8.4	8.0	8.0	8.0	8.0	8.0
Length of nose	6.0	6.0	6.0	6.1	5.9	5.6	5.6	5.6	5.7	5.6
Length of legs	88.2	87.3	89.3	87.9	88.5	81.5	80.9	82.5	81.5	81.5
Length of arms	78.2	77.6	78.5	78.6	77.8	72.4	72.0	73.5	72.8	71.9

As a rule the absolute length measurements of the parts of the body are in agreement with the total length of the body. In the case of the eurysomics they are smaller, in that of the leptosomics larger than the average. This does not, however, apply to the measurements of the melancholics and of the praecox patients, for in some cases the measurements of the melancholics and in others those of the praecox patients are above the average.

Length measurements in percentages of the height.

	Men					Women				
	Av.	E.	L.	M.	P.	Av.	E.	L.	M.	P.
Length of head	11.3	11.4	11.2	11.3	11.3	11.4	11.5	11.2	11.5	11.3
Height of face	5.0	5.0	5.0	5.1	4.9	5.0	5.1	4.9	5.1	4.9
Length of nose	3.5	3.5	3.5	3.6	3.5	3.4	3.5	3.4	3.5	3.4
Length of legs	51.9	51.9	51.9	51.7	52.1	50.6	51.0	50.7	50.7	50.4
Length of arms	46.0	46.0	46.0	46.2	45.8	44.9	44.0	45.0	45.3	44.5

The length measurements of the eurysomics and of the leptosomics reduced of those of persons of 100 cM. are practically alike, and this is also the case with the melancholics and the praecox patients.

The result of this inquiry is, therefore, that in the material given eurysomia cannot be called characteristic of melancholia and leptosomia of praecox. We are compelled to assume that the body and its parts may be either narrow or broad in the case of the melancholic and either broad or narrow in that of the praecox patient. For although most of the absolute and relative breadth measurements are greater than the average in the case of melancholics and smaller than the average with praecox patients, it must be borne in mind that there is a great difference in age between these two groups of patients. The average age of the male melancholics is 44.7 years, that of the male praecox patients 29.5, that of the female melancholics 43, and that of the female praecox patients 32. Owing to the greater age of the melancholics the chance of an adipose deposit is greater, with the result that the girth of the chest, abdomen, extremities and neck, and the weight of the body will be considerably greater.

The above shows that there is such a close connection between physical and psychical phenomena, that bodily build, physiological operations and psychological functions are always found to be in fixed proportions, so that they must be regarded as one whole. For the sake of an accurate investigation it is necessary that these functions should be studied separately. It is then found that the fixed relation which exists between the physical and the psychical functions is also to be seen in the parts of the body. There is a harmony between the various bodily forms, between the individual physiological operations and between the different psychological functions of the same individual.

With regard to the bodily build it is found, as has been said above, that with the thick-set the lateral growth of the entire body and of all its parts (shoulders, face, chest, nose, etc.), and with the narrow and slender leptoblastia of the body and all its parts is prominent. The question naturally arises whether these growth-forms are confined to the external bodily build and whether they do not also extend to the internal organs and tissues. So far as the internal organs are concerned, the answer has already been given. For this I need only refer the reader to the investigation of BENEKE, who found that with his carcinomatous constitution, corresponding to the eurysomic type, the osseous and muscular system, the heart, the vascular system, and the liver were powerfully developed, whilst the lungs, in agreement with the short chest, were small, and the intestines, in harmony with the large abdominal cavity, were long. With his scrofulous-phthisic constitution, which corresponds to the leptosomic type, the osseous and muscular system, the heart, the vascular system, and the liver were less powerfully developed, whereas in this case the lungs, in harmony with the long thorax, were large, and the intestines, in agreement with the small abdominal capacity, were short. With regard to the structure of the tissues in connection with the bodily build I found no data in the literature. I therefore append the results of the investigation into the thickness of the muscular fibres in the case of two thick-set and two narrow-built persons. As I am convinced that this small number does not permit of general conclusions being drawn, I wish these results to be regarded as merely provisional. In the laboratory of my colleague, Prof. DEELMAN, and in concert with him, the m. sartorii were removed several hours after death, measured, and then hardened in formol. This muscle was chosen for the investigation owing to its being of nearly equal thickness over its entire length. After sufficient hardening cross-sections were made of the middle part of the muscle vertically to the longitudinal axis of the fibres. In each muscle-section the average surface of a fibre was determined from the measurements of 100 fibres. The average surface of the fibres of the thick-set type is considerably larger than that of the small, slender type. The difference in dimensions of the fibres is plainly seen in the photographs. Fig. 6 and 7.

Euryblastia and leptoblastia, which are found in every race of mankind as physical characteristics of the types of constitution, are also found with animals as distinguishing characteristics. The races, and also the types of constitution found within each race, are distinguished by these forms of growth. The differences in bodily build in horses and dogs, for instance, are very striking. The Brabantine draught horse, e.g., is massive and heavily-built. The body and all its parts, such as the head, the neck, the breast, the belly, are broad, the legs are thick. The saddle-horse, on the other hand, is slender and elegant. The body and all its parts are narrow. In the same way the massive bull-dog is distinguished by breadth of the body and its parts from the lithe, slenderly-built greyhound, the body and every part of which are characterized by narrowness. These differences are also found amongst birds, e.g. hens. The Barnevelds are heavy and thick-set, the head, the beak, the comb, the wattles, the neck, the wings, and the tail are broad, the legs are thick. Leghorns, on the other hand, are more slenderly-built. The head is narrower, the beak, the comb, and the wattles are longer and thicker, the neck, the wings, and the tail are narrower, the legs are thinner. Euryblastia and leptoblastia are both constant inherent growth-impulses, which, as we have seen, determine, in human beings, not only the external bodily build, but also affect the shape of the internal organs and probably even the form of the component elements of these organs, the cells. May it not therefore be the case with animals also that this difference in growth is not confined to the external build of the body and the parts of the body properly so called, but also extends to parts which are no longer, or only very loosely, connected with the body, for instance, the eggs and feathers of birds?

The breadth-index of 80 eggs from 10 Leghorns and of 159 eggs from

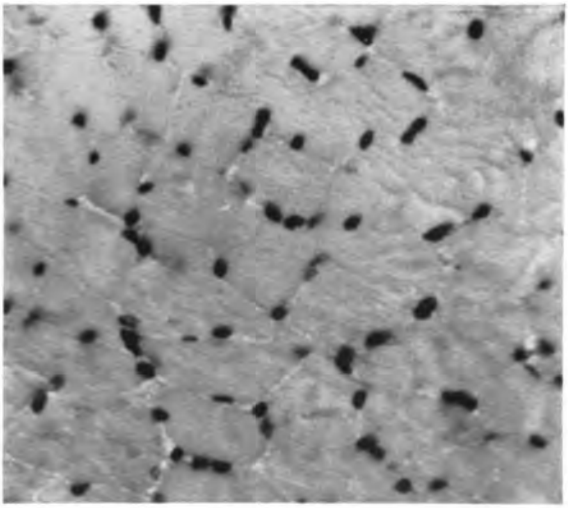


Fig. 6. Muscle-fibres of a leptosomic.

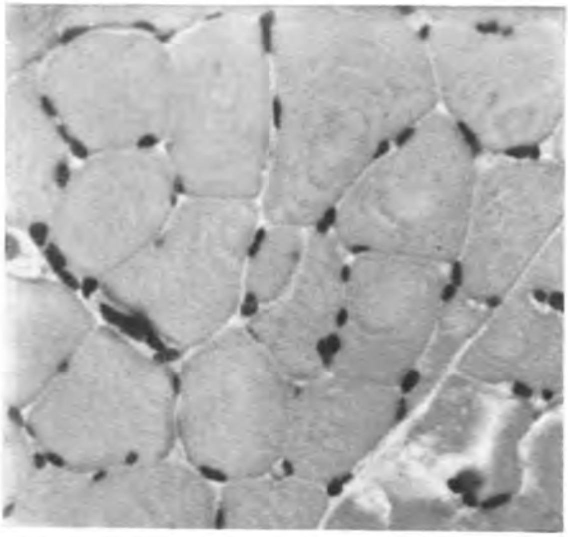
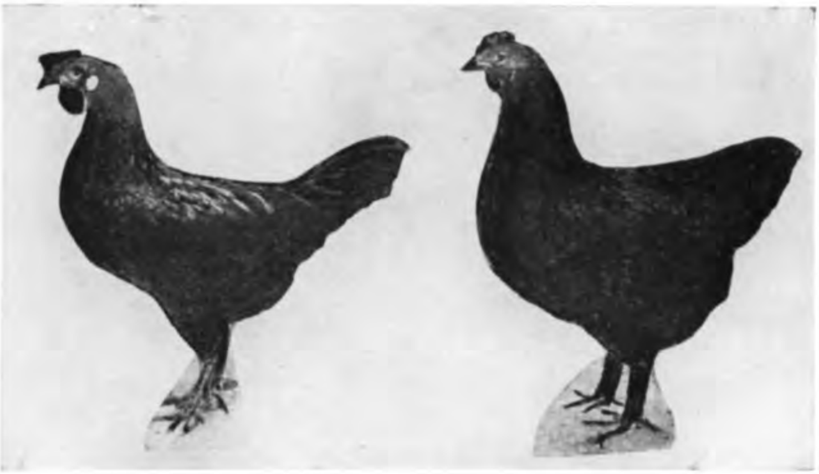


Fig. 7. Muscle-fibres of a eurysomic.



Leghorn Fig. 8. Barneveld

Fig. 9.

15 Barnevelds was determined. The average breadth-index of the Leghorn eggs was 70, that of the Barnevelds was 74.8. The eurysomic hens, that is, lay broader eggs than the leptosomic. This is shown in fig. 9, in which the white eggs are from the Leghorns, the coloured ones from the Barnevelds. There are six eggs, the two in each couple being of approximately equal weight. I was unable to compare the eggs of the broad-built Barnevelds with those of more narrowly-built Barnevelds, nor was I able to find a distinction between the eggs of the broader and more narrowly-built Leghorns. It may therefore be said that the difference in the form of the eggs is to be put down to a difference of race. But even then it is remarkable that there should be such a resemblance between the general bodily build and the shape of the eggs.

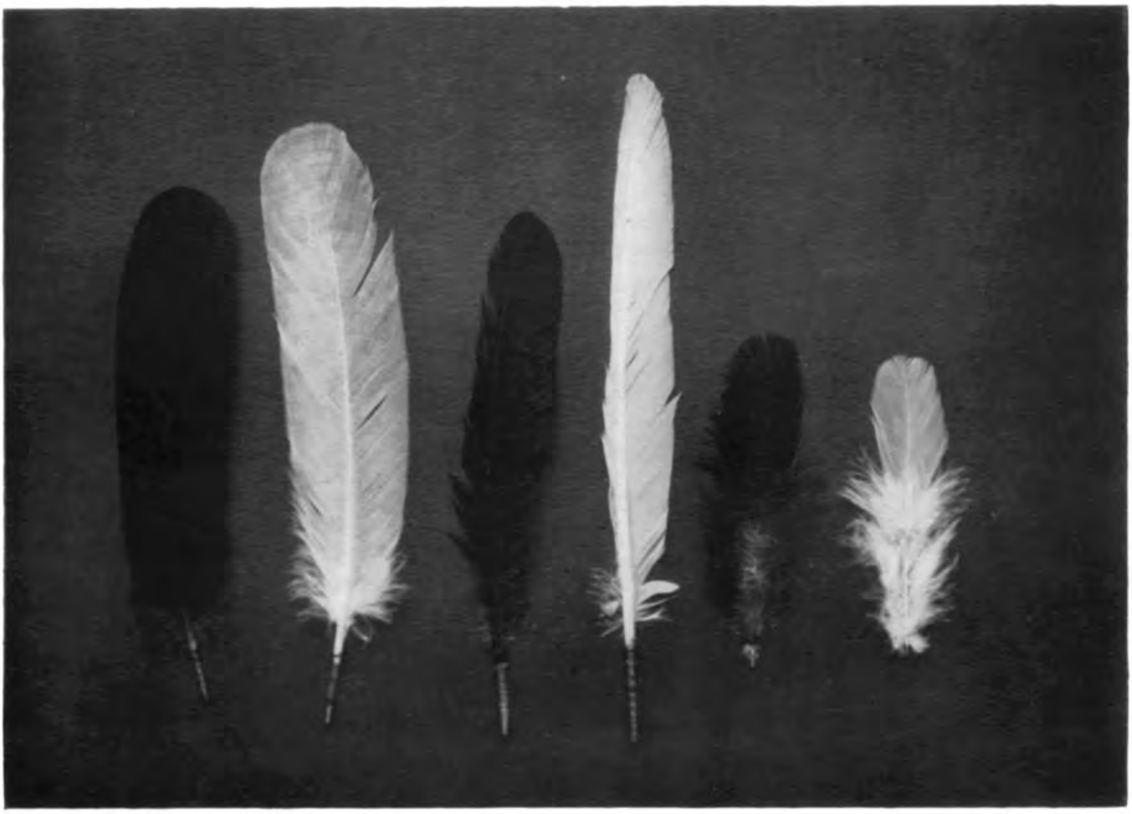
The same holds good with respects to the feathers. The breadth-index was determined in the case of 5 Leghorns and 5 Barnevelds, 6 wing-feathers, 6 tail-feathers, and 30 dorsal-feathers being taken from each hen, altogether that is, 60 wing-feathers, 60 tail-feathers, and 300 dorsal-feathers. In the following table the average indices of the feathers of each hen separately are given. Both the table and the figure show that the Leghorns, in harmony with their slighter build, have narrower wing, tail, and dorsal-feathers than the Barnevelds. This is true of the average breadth of the feathers of each hen, but also of nearly every separate feather.

	60 Wing-feathers		60 Tail-feathers		300 Dorsal-feathers	
	Leghorns	Barnevelds	Leghorns	Barnevelds	Leghorns	Barnevelds
Hen I	11.6	15.2	17.3	26.8	26.1	30.4
Hen II	12.2	15.4	15.5	27.4	22.5	34.8
Hen III	12.9	14.4	19.8	25.9	23.7	33.3
Hen IV	11.2	13.2	18.1	22.4	19.6	30.5
Hen V	12.4	15.5	19.1	23.5	24.2	30.3
Total	60.3	73.8	89.8	126.0	116.1	159.3
Average	12.1	14.8	17.9	25.2	23.2	31.9

The types of build in animals as in men are characterized not only by the form but also by physiological and psychological qualities. The draught-horse is calm and quiet, not easily startled, it does not react violently to stimuli from its environment, and will stand still for a long time; it belongs to the quiet, sure tempo-type. The saddle-horse, on the other hand, gives the impression of liveliness, it is more easily startled, reacts more violently, and is more uneasy and skittish. It belongs to the quick, restless, uncertain tempo-type. There is a similar difference between the massive, inelegant, quiet bulldog and the slender, lithe, mobile, restless greyhound, which is characterized by the superfluous movements in its gait. No less distinct is the difference between the Barnevelds and the Leghorns. The Barnevelds are more calm, more quiet, less mobile, and react more feebly to stimuli from the outside; the Leghorns, on the other hand, react more violently to impressions, they are more mobile, more restless, more timid, and more inquisitive. If one approaches a number of tame hens in the company of animals they are not familiar with, for instance a cat or a dog, the Leghorns flutter noisily off, whereas the Barnevelds retreat much more quietly and less rapidly. Unusual objects such as coloured cloths arouse the curiosity of the Leghorns in a marked degree; the Barnevelds look at them, too, but are much less engrossed by the strange objects.

Summing up, we may say that euryblastia and leptoblastia determine not only the form of the body, but are at the same time accompanied by the development of particular physiological and psychological functions

E. D. WIERSMA : BODILY BUILD, PHYSIOLOGICAL AND PSYCHOLOGICAL FUNCTIONS.



Tail Wing Dorsal-feather

Fig. 10.

UEBER TORF UND MOOR IN NIEDERLÄNDISCH INDIEN

VON

Frl. ELISABETH POLAK

VERHANDELINGEN DER KONINKLIJKE AKADEMIE
VAN WETENSCHAPPEN TE AMSTERDAM
AFDEELING NATUURKUNDE
(TWEEDE SECTIE)
DEEL XXX, No. 3

UITGAVE VAN DE N.V. NOORD-HOLLANDSCHE
UITGEVERS-MAATSCHAPPIJ, AMSTERDAM 1933

EINLEITUNG.

Das Studium der Moore in den Tropen ist noch immer in den ersten Anfangsstadien. Die Literatur beschränkt sich hauptsächlich auf beschreibende Arbeiten; eingehende Analysen fehlen. Leider vermag auch die hier gegebene Arbeit nichts weiter als nur Übersicht und Vergleichung der von mir beobachteten Moorbildungen in Niederländisch Indien zu geben.

Im Studium der Tropenmoore lassen sich zwei Perioden unterscheiden, und zwar die Zeit vor und nach 1909.

Im Jahre 1909 veröffentlichte POTONIÉ seine Arbeit: „Die Sumpflachmoor-Natur des produktiven Karbons", veranlasst durch die Beschreibung welche KOORDERS im Jahre 1895 gab in der groszen Abhandlung der IJZERMAN-Expedition. Die theoretischen Erörterungen POTONIÉ's, worin besonders betont wird, dasz, im Gegensatz zur damals allgemein geltenden Ansicht, Moorbildung im tropischen Klima stattfinden kann und tatsächlich in der Gegenwart noch stattfindet, erwarben sich allgemeine Bekanntheit. Seitdem tauchen von Zeit zu Zeit immer neue Mitteilungen auf über das Vorkommen von Torf und Moor in den Tropen.

Jedoch vorher war schon Manches veröffentlicht worden über Moorbildung auf Java, in der Absicht, das vom niederländischen Geologen STARING verkündigte und damals allgemein vertretene Dogma zu vernichten, „dasz in den Tropen Torfbildung unmöglich sei, weil die Pflanzen sich zu schnell zersetzen". Leider haben diese Publikationen ihr Ziel verfehlt, vor 1909 sind sie auszerhalb Indien nicht beachtet worden.

Schon im Jahre 1864 wurde in Batavia in der Versammlung der „Koninklijke Natuurkundige Vereeniging" Torf aus der Nähe des Dorfes Siak auf Sumatra den Anwesenden gezeigt. Sehr bald nachher erschienen einige Mitteilungen über Torfbildungen auf Java in der Zeitschrift dieses Vereins.

1865 beschreibt J. C. BERNELOT MOENS eine Torfart, gefunden in der Nähe des Dorfes Djoengelangan [1]), Residenz Besoeki, Java. Damals schon betonte BERNELOT MOENS, dasz das Vorkommen von Torf in den Tropen, und die Bildung der Steinkohle ähnliche Probleme sind und einen Gegensatz bilden zu STARING's Aussage: „dat 't veen als het ware geen tijd heeft om zich te vormen" (der Torf hat nicht die Zeit sich abzusetzen).

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[1]) oe wird u ausgesprochen.

Im selben Jahre teilt Dr. C. L. VAN VLAANDEREN einiges mit über eine Torfart südlich von Djenoe, Residenz Rembang. Die Schicht hatte jedoch nur eine Mächtigkeit von ½ bis 1½ Fusz, der Torf enthielt nur 22,5 % brennbare Substanz.

1870 beschreibt A. J. C. EDELING ein Moor von Bidara Tjina; er betrachtet besonders die Pflanzengesellschaften. Er erwähnt das Vorkommen schwimmender Inseln und Urbänke, doch eigentliche Torfbildung wurde nicht von ihm beobachtet.

Im Jahre 1885 teilt A. STOOP einiges mit über die Rawah Pening bei Ambarawah (Java). Ein Teil des Seebodens hat sich als eine torfige schwimmende Insel erhoben, ein Phänomen ebenfalls von JUNGHUHN in seinem Werke „Java" II (1854) erwähnt.

Im Jahre 1895 erscheint die Abhandlung der IJZERMAN-Expedition, mit einem Beitrag KOORDERS, die Waldmoorbildungen bei Siak betreffend.

Nachdem POTONIÉ sich mit KOORDERS in Verbindung gesetzt hatte und in dieser Weise nähere Auskünfte erhielt über die Moorwälder, welche die Expedition auf Sumatra durchquert hatte, veröffentlichte er 1909 die vorher schon genannte Abhandlung. Nachdrücklich wird das Vorkommen und Stattfinden van Vermoorungen in den Tropen betont; dieselben gelten ihm als Muster der Steinkohlenformationen, welche sich nach POTONIÉ in einem tropischen Klima unter ähnlichen Bedingungen wie die Moore Sumatras gebildet haben.

Seitdem erregt dieses Problem gröszeres Interesse, jedoch 1908 hatte SCHIMPER noch verkündet dasz es in den Tropen: „zur Torfbildung auszer im Gebirge über 1200 m. nirgends kommt".

Im selben Jahre 1909 reagiert WICHMANN mit einem Sammelreferat der damaligen Angaben über Tropentorf, und jetzt werden zum ersten Male die Mitteilungen BERNELOT MOENS c.s. in „Natuurkundig Tijdschrift voor Nederlandsch Indië" in weiteren Kreisen bekannt.

Nach 1909 folgen dann und wann mehrere Abhandlungen, besonders über tropische Moore auszerhalb Niederländisch Indien.

LANG (1914) beschreibt Humusanhäufungen und Schwarzwasser Flüsse von Sumatra und Malakka.

Die Arbeit KEILHACKS (1915) ist ebenfalls von POTONIÉ inspiriert worden. Er stellt fest, dasz man auf Ceylon Gräsermoore im Gebirge, Waldmoore in der Ebene antrifft.

GATES (1915) erwähnt ein kleines Moor im Gebirge der Philippinen.

Eine ausführliche Arbeit widmet E. KRENKEL (1920) den Mooren des tropischen Afrikas. Torfschichten werden dort im Gebirge und in der Ebene angetroffen, im Gebirge Cyperaceen-Gramineen Moore, in der Ebene Waldmoore. Er gibt eine Einteilung der afrikanischen Moortypen, man bekommt den Eindruck, dasz dieselben sehr viel Ähnlichkeit mit denjenigen Indiens haben. Auch untenstehende Schluszfolgerung gilt sehr allgemein: „Die Feuchtigkeit ist für die Bildung eines Moores in allen Klimaten ausschlaggebend. Die Temperatur steht ihr als weniger wichtig nach, wenn sie auch nicht unter ein Mindest hinabreichen darf". — Auch für das tropische Amerika ist die Aussprache KRENKELS geltend. ULE (1900) und BOUILLENNE beschreiben das Rio Negro und Amazone Gebiet. In einem äquatorialen Klima trifft man Moorwälder aus Bäumen mit Atemwurzeln, die aus schwarzen Gewässern hervorragen wie auf Sumatra. Völlig stimmt mit Niederländisch Indien auch die Beschreibung BOUILLENNES der „Igapo" (Moorwald) Amerikas überein, wo er erwähnt wie der Rio Negro sich allmählich im Urwald verliert. Ähnliche Formationen gibt es ebenfalls in Suriname, wie Dr. F. W. WENT mir mündlich mitteilte.

Auch die Abhandlungen betreffend indische Torfbildungen vermehren sich. F. C. VAN HEURN (1922) und MOHR (1922) beschreiben Waldmoore von der Ostküste Sumatras, TOBLER (1922) von Djambi, SCHÜRMANN (1922) erwähnt Schwingrasen und Moorwälder bei Palembang (Süd-Sumatra) im Anschlusz an Mitteilungen des Oberförsters F. H. ENDERT (1920).

Grosze Moorgegenden gibt es ebenfalls auf der malaiischen Halbinsel (SAMPSON, 1923; COOKE, 1930), die besonders den sumatranischen Moorwäldern ähnlich sind.

Mündliche Mitteilungen der Herren DOCTERS VAN LEEUWEN und LAM bestätigen dies ebenfalls für Neu-Guinea.

Weiteres Studium wird uns belehren, welche die Unterschiede und Ähnlichkeiten der äquatorialen Moore sind; vorläufig haben wir nur das Vorkommen und die oberflächliche Übereinstimmung des Typus betonen wollen und beschränken unsere weiteren Betrachtungen nur auf die indischen Torfbildungen.

Auf Grund eigener Anschauung und im Anschlusz an die Literatur teilen wir dieselben ein in:

1. Regional verbreitete ombrogene Küstenmoore [1]):
   In der Ebene Sumatras, Borneos und wahrscheinlich Neu-Guineas.
2. Topogene Moore:
   a. In der Ebene Javas, Sumatras.
   b. Im Gebirge Javas, Celebes und Boeroes.

Zu den Torfbildungen rechnen wir nur diejenigen Moore, die eine Torfschicht von mehr als 30 cm. Mächtigkeit aufweisen, gebildet aus reinem Pflanzenmaterial. Vielfach werden jetzt in der Praxis Böden als Torfböden bezeichnet, die eigentlich nur humöse Erden sind, gemischt mit nur wenig deutlich erkennbaren Pflanzenresten.

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[1]) "Ombrogene" Moore sind in erster Linie durch das Klima bedingt;
"topogene" Moore durch die Topographie.

I. DIE REGIONAL VERBREITETEN KÜSTENMOORE SUMATRAS UND BORNEOS.

ALLGEMEINES.

Wie schon erwähnt wurden diese Formationen zum ersten Male von der IJZERMAN-Expedition beim Dorfe Siak auf Sumatra entdeckt und von KOORDERS beschrieben. KOORDERS berichtet wie man dort mühsam einen Wald zu durchqueren hatte, dessen Boden aus weichem Torfschlamm von mehr als sieben Meter Mächtigkeit bestand. Zahlreiche Atemwurzeln von verschiedener Art ragten hervor und bildeten die einzigen festen Stellen im weichen und sehr feuchten Bodenbrei. KOORDERS stellte fest, dasz die Formen der Atemwurzeln dieselben seien wie diejenigen der eigentlichen Mangroven, doch die Baumarten zu denen sie gehören sind ganz verschieden.

Diese „Süszwasser-Mangroven", wie SCHIMPER (1908) dieselben nannte, haben eine weite Verbreitung in den Tropen, und sind an die Meeresnähe gebunden, obwohl sie auszerhalb jeder Einwirkung des Salzwassers stehen.

Aus eigener Anschauung, mündlichen Mitteilungen und Beschreibungen von ENDERT (1920 und 1932), SCHÜRMANN (1922), MOHR (1922), TOBLER (1922), VAN HEURN (1922), RUTTEN (1927), THORENAAR (1927), JELLES (1929) und COOKE (1930), stellt sich heraus, dasz an der Ostküste von Sumatra von Assahan bis Palembang, an der West- und Ostküste von Borneo, und wahrscheinlich auch auf Neu-Guinea (mündliche Mitteilungen der Herren Prof. Dr. W. DOCTERS VAN LEEUWEN, Prof. Dr. H. J. LAM und Dr. W. G. N. VAN DER SLEEN) grosze Strecken Moorwälder vorkommen hinter den Salzwasser-Mangroven, die eigentlichen Flutwälder.

Überall weist die Mangrove einen zonalen Bau auf: die mehr salzliebenden Arten stehen dem Meere zugewendet, mehr landeinwärts wird die Vegetation weniger halophil. Eine gewisse Grenze erzeugt die Niboeng *Oncosperma filamentosum BL.*, eine hohe, schlanke, gesellig wachsende Palme, der Kokospalme etwas ähnlich. Sie bildet einen Gürtel, dort wo die typische Brackwasser Palme, die Nipa, *(Nipa fruticans* WURMB), schon im Verschwinden ist, und stellt in dieser Weise den Übergang her zwischen Mangrove und Moorwald. An den Ufern der Brackwasser führenden Flüsse dringt die Mangrove, und besonders die Nipa tief ins Land hinein; nach der Nipa kommt dann wieder die Niboeng. Am Rande des Moorwaldes finden wir anfangs die Niboeng eingestreut, allmählich nur noch ganz vereinzelt, bis sie schwindet.

Die Süszwassermangrove hat einen eigentümlichen Charakter. Während der Regenzeit steht dieselbe fast gänzlich unter Wasser, aber auch in der trockenen Zeit verliert der Boden nie seine Feuchtigkeit; nasse Stellen findet man überall. Dort wo die Oberfläche unbenetzt ist, steht doch das Grundwasser schon auf ± 20 c.m. Tiefe. Diese augenscheinlich trockenen Stellen sind ganz weich, so dasz man leicht darin versinkt. Die Bäume wachsen also in einem mit Wasser gesättigten Brei, völlig aus Pflanzenresten zusammengestellt, und selbstverständlich wenig durchlüftet.

Soweit ich es beobachten konnte, breiten die Wurzeln sich flach aus und sind rings um den Stamm mit Atmungsorganen verschiedener Gestalt versehen, von THORENAAR (1927) als sprosz-, knie- oder schleifenförmig beschrieben. Stelzen und Brettwurzeln sind ebenfalls häufig.

Der Torfschlamm ist so feucht, dasz man das Wasser mit den Händen auspressen kann. Dazu hat derselbe die Fähigkeit das Wasser lang festzuhalten, wie die einfache Beobachtung im Laboratorium zeigt. Proben aus Ton trockneten ein wenn dieselben aufbewahrt wurden in Gläsern, welche nur mittels Korke verschlossen sind, die Torfproben aber waren nach einem Jahr im Tropenklima noch ebenso feucht wie bei der Einsammlung.

Ein weiteres Kennzeichen dieses Bodens ist die tiefbraune, fast schwarze Farbe der Gewässer und der hohe Säuregrad. Im Gebiet der Moorwälder fließzen die schwarzen Ströme (ajer itam). Diese sind nicht, wie WICHMANN (1909) erwähnte, auf die Torfbildungen beschränkt. In Westborneo z.B. im Sandsteingebiet bei Mandor, gibt es künstlich für die Goldgewinnung gegrabene Teiche, deren Wasser ebenfalls humös braun gefärbt ist. Doch gibt es hier keine Spur von Moorbildung, nur Trockenhumus wird in einer Schicht von weniger Mächtigkeit abgesetzt. Wie es jedoch sein mag, die Flüsse und Bäche, Teiche und Kanäle in den Moorgegenden führen schwarzbraun gefärbtes Wasser, wie ich es wunderschön beobachtete am Siak und dessen Nebenflusz, der Mandau. Und nicht allein für Sumatra trifft dieses zu, es gilt auch für Borneo und für die tropischen Moore auszerhalb des Archipels, wie die Beschreibungen des Rio Negro, der Amazone und der Torfmoore Afrikas uns lehren. In einem Trinkglas ist diese Farbe nur gelb, so wie dünner Tee, in gröszeren Mengen aber erscheint das Wasser tiefschwarz, und erzeugt wegen seiner Klarheit sehr treffende Spiegelbilder. Unvergesslich ist der Anblick dieser ruhigen, glänzend schwarzen Ströme, worin das phantastische Bild der Ufervegetation aus Pandanen *(Pandanus heliocopus* KURZ) sich noch einmal scharf wiederholt.

Wo das Wasser des Flusses nicht mehr unter Einflusz des Meeres steht, hat es einen Säuregrad ± 3 (Siak und Mandau) [1]. Am Rande des Urwaldes auf Tjabang Doea Estate bei Laboean Bilik (Sumatra, Ostküste) war die p_H des Bodenwassers = 4, ebenfalls tiefer im selben Walde. Zu Soengei Pallas in derselben Gegend wies das Bodenwasser

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[1] Der Säuregrad wurde an der Stelle gemessen mit B. D. H. Universal Indikator, nach einer von Ir. TAN, damals Chemiker der "Allgemeinen Versuchsstation für die Landwirtschaft" zu Buitenzorg, für mich geeichten Farbskala. Wie RUTTNER (1931) erwähnt gestattet diese Methode eine Genauigkeit bis auf 0.2 p_H.

eine $p_H = 5$ auf. Das Bodenwasser auf der Insel Bengkalis (Ostsumatra) in einem von Chinesen bewirtschafteten Holzschlag [1]) hatte eine $p_H = 3$, ebenso in derselben Gegend auf Poelau Padang, Selat Akar, Panglong 24. Das stehende Wasser auf den Werdern der Mandau, auch an Stellen wo es augenscheinlich keine Torfbildung gibt, hatte eine $p_H = 3$. Auf Borneo war die p_H des braunen Moorwassers zu Soengei Raja und Soengei Bangkong (unweit von Pontianak) = 3. COOKE (1930) gibt für die malaiische Halbinsel nicht an welche Methode er benützt. Seine Zahlen jedoch variieren von 3.5—4.3 für tiefes Moor, und sind bei geringerer Mächtigkeit der Torfschichten = 5.1.

In der Nähe der Küste wird der Säuregrad geringer. Das Wasser in den „Kreeken" der Mangrove zu Poelau Padang an der Mündung des Siak Flusses ist klar und hellbraun $p_H = 6.3$). Es hat einen deutlich salzigen Geschmack und umspült eine Rhizophorenvegetation. Der Kapoeasflusz bei Pontianak führt ebenfalls braunes klares Wasser. Die Ufervegetation bildet einen Übergang zwischen Salzwassermangrove und Süszwassermoor. Im Dezember 1930 war die $p_H = 5$. Die beiden letzten Zahlen wechseln stark mit Ebbe und Flut und mit dem Ost- und Westmonsun. Für das Abnehmen des Säuregrades ist das Einströmen des salzigen Wassers in das saure Moorwasser der Flüsse verantwortlich: die Einwohner Pontianaks erzählen, dasz das Fluszwasser in ihrer Stadt in der trockenen Zeit salzig ist, in der Regenzeit aber süsz, das heiszt sauer.

Die Mächtigkeit der Torfschichten variiert von 30 cm. bis mehr als 6.5 m., auf Sumatra sowie auf Borneo. KOORDERS erwähnt sogar Schichten von 8 m. Die Mächtigkeit nimmt von dem Rand zur Mitte zu, erreicht dort im Zentrum ihr Maximum und nimmt dann wieder ab. Die Messungen des Oberförsters LUYTJES zu Laboean Bilik, sowie die des „B.O.W." [2]) zu Pontianak zeigen, dasz die Torfschicht die Form einer bikonvexen Linse hat. Hier sei nachdrücklich betont, dasz die Küstenmoore, solange sie noch mit Urwald bedeckt und noch nicht von künstlichen Abwässerungskanälen durchzogen sind, eine sehr deutliche Erhebung zeigen. Auf der Ölpalmen Plantage Negri Lama (Ost-Sumatra, Paneh) sah man kürzlich entwaldeten Torfboden bedeutend höher als der weisze Ton (tanah poetih) an den er grenzt. Auch der Querschitt des Moores zu Soengei Raja (West-Borneo) zeigt, wie es sich am Rande rasch erhebt, jedoch in der Mitte horizontal ist (Fig. 1).

Die Karte der Halbinsel Paneh verdanke ich Herrn Oberförster LUYTJES. Paneh wird an der einen Seite von der Strasze Malaka begrenzt, zur andrer Seite von der Mündung des Paneh Stromes. Die Halbinsel wird also beiderseits von Salzwasser umspült (Fig. 2). Die Vegetation dieser Landzunge hat einen Saum aus Salzwassermangrove auf Meeresschlamm.

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[1]) Von den Chinesen "Panglong" genannt.

[2]) B. O. W., Abkürzung für Staats und Gemeindewerke.

Dieser Fluszwald liegt tiefer als das Binnenland, das von Moorwäldern auf Torfboden eingenommen wird. Die gröszte Erhebung und die gröszte Mächtigkeit der Torfschichten findet man in der Mitte. Wie eine grosze, doch seichte Kuppel wölbt sich der Wald über dem Land. Die Profile angebracht in der Karte von Paneh, zeigen den Verlauf der Tiefe, und die Tatsache, dasz *allerseits* Flüsse ins Meer abströmen, deutet auf die hohe Lage des Inneren.

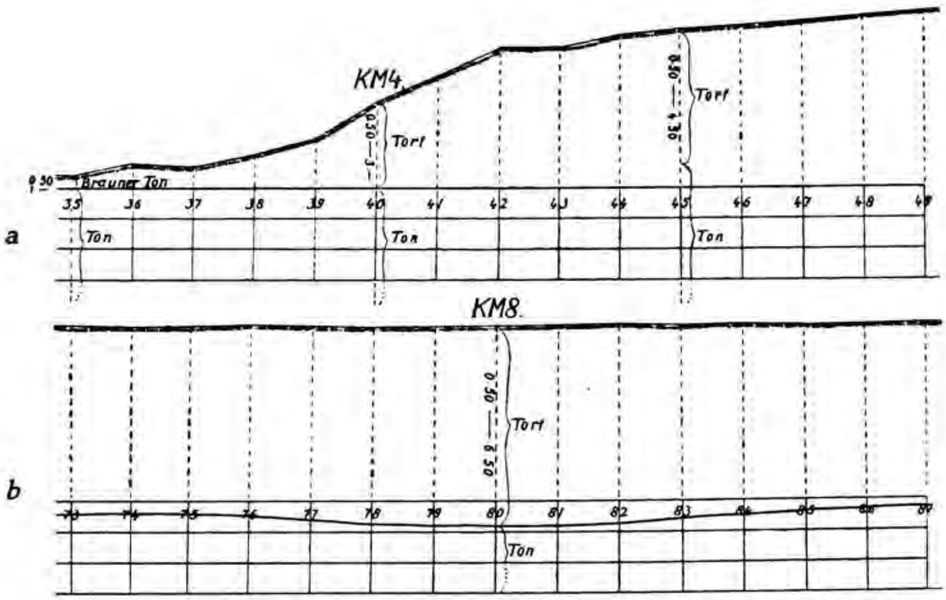

Fig. 1.

Torfprofil zu Soengei Raja Res. West-Borneo, Ableitung Pontianak.
a. Anfang der Torferhebung.
b. Mitte des Torfprofiles (B. O. W. Pontianak).

Es gibt kleinere und selbst gröszere Flüsze, die ausschlieszlich aus Sickerwasser der Moore entstehen, wie aus der Beschreibung des Mandau-Flusses von MOSZKOWSKY (1917) hervorgeht. Das Wasser jedoch das dem Torfe entströmt, stellt nur einen Bruchteil dar der groszen Massen die darin aufgespeichert sind, und die nur dann abflieszen können, wenn die wie ein durchtränkter Schwamm geschwollenen Torfschichten von Drainierungskanälen angeschnitten werden. Diese Entwässerung geht sehr rasch vor sich und der Boden fängt an zu schrumpfen; die Einschrumpfung beträgt anfangs sogar 1 m. jährlich. Dieses hat das öfters erwähnte Umfallen der Kulturgewächse zur Folge (VAN HEURN, 1922; COOKE, 1930). Die blosze Entwaldung schon verursacht Schrumpfung, da die Oberfläche eintrocknet und verpulvert.

Die Moorwälder kommen nur in den regenreichen Gebieten des Archipels, wo es keinen deutlich Ost-Monsun gibt, vor, wie eine Vergleichung von BRAAKs Tabelle für den Regenfall mit der Verbreitung der Küstenmoore zeigt. Die Waldbedeckung schützt vor Verdampfung, der Torfboden speichert das Wasser auf und so bilden sich mächtige Wasser-

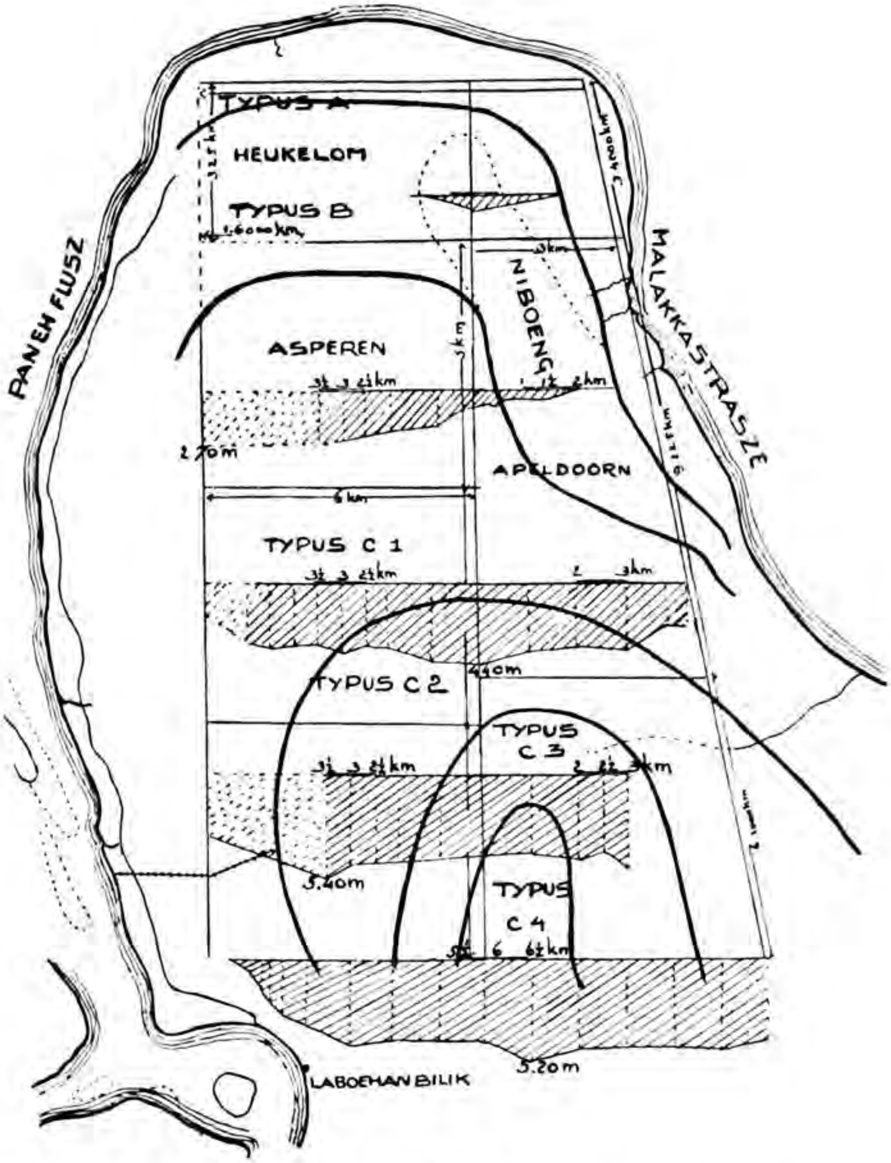

Fig. 2.

Karte der Halbinsel Paneh mit eingezeichneten Torfprofilen und Waldzonen (nach LUYTJES).

reservoire; nur der Teil, der vom Riesen-Schwamm aus feuchtem Torf nicht behalten werden kann, flieszt in die schwarzen Moorflüsse.

Nebenstehende Zahlen beziehen sich auf die untersuchten Gebiete und sind Braaks Arbeit entnommen; sie zeigen den jährlichen Regenfall:

Sumatra:
Medan 2.069 m.
Tandjong Penang 3.034 m.,
Laboean Bilik 2.139 m.,
Bagan Si Api Api 2.563 m.,
Tanah Poetih 2.128 m.,
Bengkalis 2.498 m.,
Selat Pandjang 2.408 m.,
Siak 2.392 m.

West-Borneo:
Pontianak 3.204 m.,
Singkawang 3.252 m.,
Mempawah 2.747 m.

Die Zahlen dieser Tabellen stimmen völlig mit Langs (1914) Behauptung überein, dasz man dort Humusansammlung antrifft, wo die Niederschlagsmenge über 2000 mm. jährlich beträgt. Wo genügend Regenfall ist, schützt die Feuchtigkeit den Humus vor Zersetzung und umgekehrt kann dieser wieder das Wasser aufspeichern. Die Gebiete mit groszen Niederschlagsmengen ohne starken Monsunwechsel finden sich regional an den Küsten und bedingen in dieser Weise das regionale Auftreten der Moorwälder. Jedoch das Klima ist nicht allein ausschlaggebend, sonst könnte man überall dort wo der Regenfall über 2000 mm. beträgt Moorbildung erwarten und dies ist tatsächlich nicht der Fall. Auch unbekannte edaphische und geologische Faktoren sind zweifelsohne mit im Spiel. Vielleicht hat Mohr (1922) recht mit der Behauptung, dasz der Untergrund und das einflieszende Wasser sauer sein müssen, und dasz auf alkalischen oder jung vulkanischen Gesteinen keine Vertorfung in oben beschriebener Weise stattfindet. Allerdings trifft dies nicht zu für die Verlandungsmoore Pagandarans (siehe Kap. II). Lang andererseits hält die Zusammensetzung des unterliegenden Gesteins von keiner Wichtigkeit. Auch eine Einsenkung im Boden musz als Vorbedingung anwesend sein, so dasz das Wasser sich ansammlen kann.

Nach meinen Erfahrungen musz der Anfang der bis jetzt betrachteten Moore meistens ein Wald gewesen sein. In vielen Fällen nämlich fand ich unter Torfschichten von bis 4 m. Mächtigkeit Tone, in die Holz und Wurzeln hineingewachsen waren. Diese Tatsachen zeigen, dasz es einen Wald gegeben haben musz, etwa 4 m. unter der heutigen Torfoberfläche. Fig. 3 und 4 zeigen solche, unter Torf liegende Tone, in die Baumwurzeln hineingewachsen sind. Ob jedoch auch der Boden unter den sehr mächtigen Torfschichten (mehr als 6,5 m. auf Poelau Padang) mit Wald bewachsen war, ist indessen noch nicht bewiesen. Endert (1920) und Schürmann (1922) jedoch, halten Schwingrasen für den ersten Anlasz der Moorwälder. Wenn dies der Fall ist, dann gilt es nur für jene tiefen Stellen, denn nur von diesen gibt es noch die Ungewiszheit der Zusammensetzung des Untergrundes.

Fig. 3.
Baum des Torfwaldes, wurzelnd im Ton. (Nach einer Photographie von Soengei-Raja-Borneo).

Fig. 4.
Profil welches Torf auf Ton zeigt. In den Ton sind Holz und Wurzeln gedrungen. (Nach einer Photographie von einem Graben auf Bila Estate-Sumatra).

Ein rezenter Moorwald auf Ton, den man wie ein Moor „in statu nascendi" betrachten könnte, kommt vor in Süd-Sumatra, am Lalan-Flusz (Residenz Palembang, Doesoen Karang Agoeng). Der Ton, fast ohne Humus an der Oberfläche liegend, hat graue Farbe, der Waldtypus und die Baumarten sind denjenigen der Moorwälder sehr ähnlich (besonders die typischen Arten *Durio carinatus* MAST und eine *Palaquium* Species sind häufig.). Das Grundwasser und das stehende Wasser zeigten eine $p_H = 3$. Der Boden dieses Waldes steht in der Regenzeit grösztenteils unter Wasser: Überschwemmung des Lalans.

Baumarten, welche die ganze Zeit hindurch mit den Wurzeln und der untersten Stammhälfte im Wasser stehen gibt es ebenfalls. Folgende Arten fand ich in dieser Weise wachsend bei Ambawarah in der Rawah Pening (Mitten-Java): *Salix tetrasperma* ROXB., *Hibiscus tiliaceus* L. und *Sarcocephalus orientalis* MERR. Im Wasser wachsende Bäume, ein kleiner Wald sogar, befindet sich an dem Danau-See (Bantam, West-Java). Die Arten wurden von KOORDERS (1918) beschrieben (*Elaeocarpus littoralis* T. et. B., *Glochidion palustris* KOORD.); dieselben bilden einen Teil der Ufervegetation. Die einzelnen Bäume, deren Atemwurzeln aus dem Wasser emporragen, stehen so weit auseinander, dasz man mit einem Kanu herum fahren kann. An der Innenseite des Vegetationsgürtels, wo das Wasser allmählich tiefer wird, schieben grosze Felder aus schwimmenden Wasserpflanzen die äuszerste Grenze der Vegetation nach vorne. Die tiefsten Stellen des Sees, in der Mitte, sind unbewachsen.

Eine ähnliche Waldvegetation darf man mit Tiefmoor vergleichen, die Moorwälder Borneos und Sumatras mit Hochmoor. Die Möglichkeit liegt vor, dasz bei den letzteren das Hochmoor auf dem Tiefmoor gelagert ist. Die erste Vegetation an einer tiefen Einsenkung des Bodens kann also zusammengesetzt sein von Moorwald, Sumpfmoorwald, Schwingrasen und sogar in den Anfangsstadien submersen Wasserpflanzen. Wird die Oxydation, die völlige Zersetzung der Pflanzenreste gehemmt, dann häuft der Humus oder Torf sich an; es kann eu- oder mesotropher Sumpfwald, später vielleicht ein oligotropher Moorwald entstehen; desto üppiger die Vegetation, desto schneller die Humusaufspeicherung. Die Bäume, die in der Unterlage wurzelten, ersticken im Torf, eine neue Generation wächst an, die anfangs mit den Wurzeln noch in der Unterlage steht, doch die bei weiterer Erhöhung dieselben nicht mehr erreichen kann und deren Wurzeln sich alsdann horizontal ausbreiten müssen (Fig. 5). Horizontale Bewurzelung ist jetzt in den Moorwäldern vielfach zu beobachten. Die Fähigkeit des Torfes das Wasser aufzuspeichern, die feuchte Atmosphäre, die dichte Waldbedeckung, welche die Sonne ausschlieszt, verhindern die völlige Zersetzung der Holz- und Blattreste, immer mehr Material häuft sich an, stets mehr erhebt sich der Boden.

Folgende Tatsachen stellen sich also heraus:

1. Mineralarmes Niederschlagswasser wird aufgespeichert;
2. Die Materialanhäufung erzeugt Erhöhung des Bodens;
3. Die Waldgenerationen folgen einander, die älteren werden in ihren eigenen Produkten vergraben.

Dasz letzteres tatsächlich der Fall ist, zeigen mehrere Funde von alten morschen Kniewurzeln, 1 m. unter der jetzigen Oberfläche. Die Krümmung des Knies musz doch ursprünglich in die Luft hineingeragt haben. Immerhin ist es noch schwer sich vorzustellen, wie es doch möglich war, dasz ein Wald 4 m. unter dem jetzigen gewachsen war. Es ist möglich, dasz für diese Erscheinung eine allgemeine Senkung des Bodens verantwortlich war, oder dasz die Umgebung des Moores durch Sedimentation allmählich erhöht worden ist.

Der Charakter des Torfes erklärt sich aus der Entstehungsweise. Der Torf stellt eine rotbraune Masse dar, die sich an der Luft schwarz verfärbt und mit äuszerst saurem Wasser gesättigt ist. Er besteht aus einem halbflüssigen Brei, mit Wurzeln durchflochten. Von den gröszeren Wurzeln ist nur die Rinde und die Zentralachse da: hohle Zylinder mit einem Strang in der Mitte. In dieser Grundmasse eingebettet finden wir sehr grosze Mengen Holzreste, wie Stämme, Rinden, Äste, alles auf und durcheinander: mehrere Waldgenerationen überlagern sich. Die groszen Mengen Holz erschweren auszerordentlich die Untersuchung des Torfschlammes, der sehr wertvolles Material zur mikroskopischen Untersuchung darstellt.

Betrachtet man die schon gegebenen Tatsachen, dann kann man sich fragen, mit welchen schon bekannten Moortypen man die Waldmoore Sumatras und Borneos vergleichen darf. Alle Untersucher, die diese Formationen beschrieben haben, folgen der Ansicht POTONIÉs und behaupten die „Flachmoornatur" des Gebietes. Solche mächtige Holzschichten, solche üppige Waldentwicklung, von äuszeren Einflüssen nicht gehemmt, gibt es aber nicht in den gemäszigten Zonen. Vielmehr als mit Tiefmoor, das immer aus der Verlandung von offenen mineralreichen Gewässern hervorgeht, und dessen Torf also hauptsächlich aus Kräutern zusammengesetzt ist, dessen Oberfläche tiefer oder gleich mit der Umgebung liegt, trifft die Vergleichung mit Hochmoor. Zuerst die Linsenform: das *Hoch*moor verdankt seinen Namen der Tatsache, dasz seine Oberfläche wie eine niedrige Kuppel sich über dem Gelände wölbt. Das trifft zu für die indischen Waldmoore, sowie für die europäischen Hochmoore. Zweitens ist der hohe Säuregrad bezeichnend für Hochmoore. Drittens ist der oligotrophe Charakter des Moorwassers für Hochmoor in den gemäszigten Zonen und das Waldmoor der Tropen kennzeichnend. Derartige Formationen werden von VON POST (1926) als „ombrogene" Moorbildungen bezeichnet, für die Vegetation bilden dieselben also einen oligotrophen Nährboden. In West-Europa ist die Klimaxvegetation für solche ombrogene Bildungen ein Sphagnetum, und man bekommt den Eindruck, alsob den Autoren, die tropische Torflager beschrieben haben, immer das *Sphagnum*moor von Augen stand. Viel verbreitet daher ist der Gedanken, dasz Hochmoor in den Tropen nur im Gebirge über 1200 m. vorkommt, weil es dort *Sphagnum* gibt, und in der Ebene nur Flach- oder Sumpfmoor (SCHIMPER, 1908; POTONIÉ, 1909; VON FABER, 1927; VON BÜLOW, 1929). Jedoch sogar in der gemäszigten Zone braucht das Endstadium eines oligotrophen Moores nicht immer ein Sphagnetum zu sein. Dies trifft nur zu für die Gebiete mit ausgesprochenem ozeanischen Klima, wie es die Küste Nord-West-Europas ist; in mehr kontinental bedingten Gegenden sind die Hochmoore von Ericaceen oder Nadelhölzern bewachsen. Eigentlich ist es ja selbstverständlich, dasz die oligotrophe Moorvegetation der Tropen grundverschieden sein musz von derjenigen Europas und es darf uns gar nicht wundern, dasz man in diesen Gebieten der üppigsten Pflanzenfülle das Hochmoor mit dichtem Urwald bedeckt findet, und den Torf zusammengestellt aus den Resten desselben. Ein Kennzeichen dieses Waldtorfes ist die Armut an anorganischen Bestandteilen. Für den Torf von Bila-Estate ergab sich ein Glührest von 1.35 %. Im „Jaarboek voor Nijverheid en Handel" (1922) wird erwähnt, dasz chemisch der Torf der groszen Waldmoore dem oligotrophen Torf Europas ähnlich ist und dasz die kleinen lokalen Moorbildungen mehr dem eutrophen Torfe ähneln.

Wenn in Europa der Wald versumpft, tritt *Sphagnum* ein, und die *Sphagnum*decke, die entsteht nachdem der Wald erstickt (ertrunken) ist, hat die Fähigkeit das Wasser festzuhalten und allmählich eine Steigerung der Bodenfeuchtigkeit zu bewirken (RAMANN, 1911). Diese Fähigkeit, den Boden für das Wasser zu verschlieszen und es selber zu behalten, kommt ebenfalls dem Torfbrei der Moorwälder zu.

VON BÜLOW (1929) achtet Hochmoorbildung in den Tropen und den

Subtropen für ausgeschlossen. „In dem Bereich mediterranen, semiariden oder subtropischen Klimas ist bislang noch keine oligotrophe Moorbildung beobachtet worden. Selbstverständlich in den Tropen noch weniger." Jedoch hierbei ist nicht beachtet worden, dasz die äquatorialen Gebiete mit ozeanischem Klima, eine grosze Niederschlagsmenge aufweisen, die über das ganze Jahr gleichmäszig verteilt ist. Im Walde herrscht eine grosze Luftfeuchtigkeit; Austrocknung des Bodens und somit Oxydation der organischen Bestandteile findet nicht statt. Die verhältnismäszig rasche Verwesung wird kompensiert von einer sehr intensieven Produktion an Pflanzenresten. Das an gelösten Humussäuren reiche Bodenwasser mit hohem Säuregrad hat konservierende Eigenschaften.

VON BÜLOW behauptet für die gemäszigte Zone: „Eigentliche Hochmoore sind an Meeresnähe und das dadurch hervorgerufene ausgeglichene Klima gebunden", doch denselben Ausgleich findet man in den ozeanisch bedingten Gebieten der Tropen. Hier ist ebenfalls der Überschusz von Produktion über Zerstörung der Pflanzenreste so grosz, dasz in ähnlicher Weise wie in Europa ausgedehnte regionale Vermoorungen entstehen, vom Klima an die Meeresnähe gebunden.

Wie schon LANG (1914) richtig erkannt hat, sind „Trockenheit und Wärme, jeder Faktor für sich, der Humusbildung feindlich, Feuchtigkeit und Kälte befördern dieselbe". „Durch die hohen Niederschlagsmengen in Indien wird einerseits der Pflanzenwuchs auszerordentlich gesteigert, anderseits die völlige Zerstörung der Humusbestandteile verhindert und eine Anreicherung derselben bewirkt". LANG spricht immer von Humusablagerungen, andere, z.B. POTONIé und VAN HEURN bezeichnen den Boden der Moorwälder als Torf. Diese Ablagerungen kann man als humösen Waldtorf betrachten, die Grundmasse besteht aus braunem organischem Schlamm, dessen botanische Zusammensetzung nur mikroskopisch zu erkennen ist. Diese Masse ist als richtiger Humus zu bezeichnen. Sie wird durchsetzt von Holz, Zweigen, Rinde, Wurzeln, also von Torfbestandteilen.

Bildet der Moorwald die Klimaxvegetation, oder wird er auf die Dauer enden als Krüppelholz oder als Sumpf mit Gäsern und Cyperaceen? Eine Betrachtung der europäischen Hochmoore ruft verschiedene Möglichkeiten hervor. Die Form des europäischen Hochmoores und ebenso die des tropischen Waldmoores ist die einer groszen bikonvexen Linse, deren eine Seite in den Boden gesunken ist, deren andre Seite sich über das Land wölbt wie eine Kuppel. Die Erhebung geht rasch, in der Mitte aber ist das Moor flach. Oft gibt es bei den europäischen Hochmooren im Zentrum ein offenes Wasser, eine oder mehrere Blänken, sekundär entstanden als ein Überrest des Niederschlages, der nicht vom Torf und von der Vegetation absorbiert worden ist, oder als ein Relikt des ehemaligen Sees, die der Anfang des Torfmoores gewesen ist. Ähnliches könnte es auch in den tropischen Waldmooren geben. Ohne dasz begründete Wahrnehmungen vorliegen, behauptet man in der Gegend von Bengkalis, dasz das Zentrum des Waldes eingenommen wird von Krüppelholz abwechselnd mit kleineren oder gröszeren Tümpeln.[1]) Wenn dies tatsächlich der Fall ist, kann man sich fragen ob diese Gewässer sekundären oder primären Ursprunges sind, ob hier vielleicht der Relikt des eventuellen Sees zu suchen sei, dessen Verlandung zur Bildung des Moores Anlasz gab, oder ob hier die Hubhöhe des Torfes die Saugkraft überschritten hat. In letzterem Falle musz die Vegetation spärlicher werden, die Sonne kann den Boden austrocknen, so dasz dieser hart und undurchlässig wird und Wasser sich ansammelt. Wie es auch sei, jedenfalls ist es eine Tatsache, dasz nach den Ergebnissen vom „Boschwezen" [2]) und auch nach eigener Anschauung die Vegetation zonal zusammengesetzt ist.

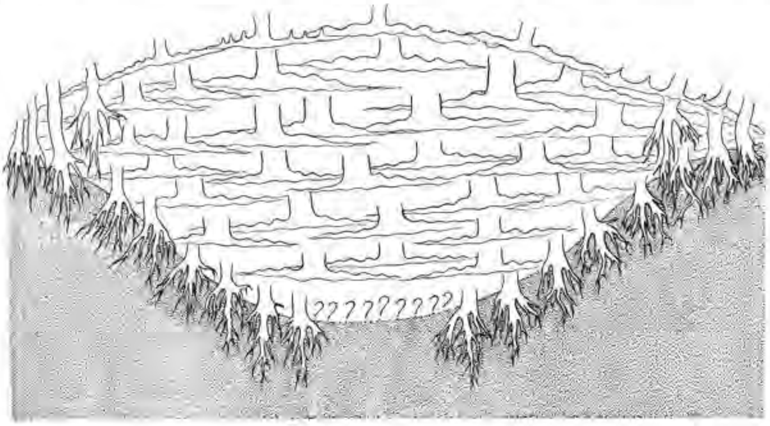

Fig. 5
Schema der Waldtorfbildung an den Küsten.
Nur an den tiefsten Stellen in der Mitte ist der Charakter des Torfes unbekannt. Vielleicht dasz hier keine Bäume im Ton wurzeln, doch dasz dieser von Sumptorf aus Gräsern bedeckt wird.

Wo die Torfschicht noch dünn ist, oder mit Ton vermischt, gibt es wesentlich andre Baumarten als an den tieferen Stellen. Am Auszenrande wachsen viele Palmen wie *Zalacca conferta* GRIFF, *Licuala, Oncosperma filamentosum* BL. (Niboeng), *Pholidocarpus sumatrana* BECC. und eine Palme mit roten Blattstielen, Pinang Mentjong oder Linoh genannt (die noch nicht bestimmt worden ist, nach F. H. ENDERT vielleicht *Cyrtostachys renda* BL). Diese rote Palme ist an den tieferen Stellen die einzige ihrer Art die eingestreut im Walde übrig bleibt.

Auf Poelau Padang (Bengkalis) an Stellen, wo auf 6,5 m. Tiefe noch immer die Unterlage nicht erreicht war, wurde der Baumwuchs spärlicher und die Vegetation am Boden fing an aufzutreten. In der trocknen Zeit waren noch Löcher mit Wasser stehen geblieben, die Atemwurzeln bil-

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[1]) Prof. Dr. R. KOLKWITZ teilte mir mündlich mit, dasz er vom Flugzeug aus grosze offene Sümpfe in den Wäldern sah.

[2]) Forstwirtschaft.

deten kleine Hügel, reichlich mit grünen Moosen überzogen, worin *Nepenthes*-Rozetten eingestreut waren. Ringsum die Wasserlöcher wuchs eine Cyperaceenart (*Hypolytrum* sp.). Das Ganze rief das Bild europäischer Bruchwälder hervor, die tropischen Bäume aber sind weit höher.

Oberförster LUYTJES unterscheidet vier Zonen der Vegetation auf Paneh (siehe Karte der Halbinsel Paneh, Fig. 2):

a. Flutwald.
b. Wald auf wenig mächtiger Torfschicht (weniger als ½ m.).
c. Wald auf mächtiger Torfschicht.
  1. Wald mit dichtem *Licuala-Zalacca*unterwuchs.
  2. Dichter Wald.
  3. Hochwald aus dünnen Stämmen, untermischt mit niedrigem Gehölz.
  4. Kleinwald, worin *Tristania* dominiert.

Leider ist die Zusammensetzung des Moorwaldes noch sehr unvollständig bekannt. Die Moore sind noch immer sehr wenig zugänglich, sehr dünn bevölkert und nur in den letzten Jahren versucht man dort europäische Kulturen. Man braucht sich also nicht zu wundern, dasz die floristischen Kenntnisse dieser Vegetation noch so mangelhaft sind, wozu noch kommt, dasz die Bestimmung von Waldbäumen immer sehr beschwerlich ist. Groszen Dank verschulde ich darum dem „Boschwezen", insbesondere den Herren Oberförstern SCHUITEMAKER und ENDERT, die mir mit untenstehenden Listen geholfen haben. Aus praktischen Gründen beschränken diese Angaben sich nur auf Bäume mit einem Stammdurchmesser von 40 cm. oder mehr.

SUMATRA.

BÄUME IM MOORWALD DER INSEL PANEH (NACH LUYTJES).

KONZESSION „DE GROOT" — LABOEAN BILIK.

Anacardiaceae, *Campnosperma auriculata* HOOK. *f.*; **Anonaceae,** *Polyalthia, Xylopia*; **Apocynaceae,** *Alstonia pneumatophora* BACKER; **Aquifoliaceae,** *Ilex*; **Bombacaceae,** *Durio carinatus* MAST; **Dipterocarpaceae,** *Shorea*; **Ebenaceae,** *Diospyros*; **Guttiferae,** *Calophyllum*; **Icacinaceae,** *Urandra secundiflora* KUNTZE; **Leguminosae,** *Dialium, Koompassia malaccensis* MAING; **Meliaceae,** *Amoora*; **Myrtaceae,** *Eugenia, Tristania*; **Rosaceae,** *Parastemon urophyllum* A. DC.; **Sapindaceae,** *Pometia*; **Sapotaceae,** *Palaquium*; **Theaceae,** *Tetramerista glabra* MIQ.

SUMATRA.

BÄUME IN PROBE-WALD ± 6 KM. NORDÖSTLICH VON BENGKALIS.

Anacardiaceae, *Campnosperma, Mangifera*; **Anonaceae,** *Xylopia*; **Aquifoliaceae,** *Ilex*; **Burseraceae,** *Santiria*; **Dilleniaceae,** *Dillenia*; **Dip-**

terocarpaceae, *Shorea, Vatica;* **Ebenaceae,** *Diospyros;* **Elaeocarpaceae,** *Elaeocarpus;* **Euphorbiaceae,** *Antidesma, Aporosa, Blumeodendron, Macaranga;* **Gonystylaceae,** *Gonystylus;* **Guttiferae,** *Calophyllum, Cratoxylon arborescens* BL., *Garcinia;* **Icacinaceae,** *Stemonurus;* **Lauraceae,** *Actinodaphne, Cryptocarya, Litsea;* **Lecythidaceae,** *Barringtonia;* **Leguminosae,** *Koompassia malaccensis* MAING; **Meliaceae,** *Aglaia;* **Moraceae,** *Artocarpus Kemando* MIQ., *Ficus;* **Myristicaceae,** *Myristica;* **Myrtaceae,** *Eugenia, Tristania;* **Ochnaceae,** *Brackenridgea;* **Palmae,** *Metroxylon;* **Rosaceae,** *Parastemon urophyllum* A. DC., *Parinarium, Pygeum;* **Rubiaceae,** *Jackia ornata* WALL.; **Sapindaceae,** *Pometia;* **Sapotaceae,** *Besonders Palaquium oder Madhuca;* **Sterculiaceae,** *Pterocymbium oder Sterculia;* **Styracaceae,** *Stryrax Benzoïn* DRYAND; **Theaceae,** *Tetramerista glabra* MIQ.

SUMATRA.

BÄUME AUF DER INSEL BENGKALIS.

Anacardiaceae, *Campnosperma;* **Anonaceae,** *Xylopia;* **Apocynaceae,** *Alstonia pneumatophora* BACKER; **Bombacaceae,** *Durio carinatus* MAST.; **Burseraceae,** *Santiria;* **Celastraceae,** *Lophopetalum;* **Dipterocarpaceae,** *Shorea;* **Euphorbiaceae,** *Blumeodendron, Macaranga;* **Fagaceae,** *Quercus;* **Gonystylaceae,** *Gonystylus;* **Guttiferae,** *Calophyllum, Cratoxylon;* **Icacinaceae,** *Stemonurus;* **Leguminosae,** *Koompassia malaccensis* MAING.; **Meliaceae,** *Aglaia oder Amoora;* **Moraceae,** *Ficus, Parartocarpus triandra* J. J. S.; **Myrtaceae,** *Eugenia;* **Oleaceae,** *Strombosia;* **Rosaceae,** *Parastemon urophyllum* A. DC.; **Rubiaceae,** *Jackia ornata* WALL.; **Sapotaceae,** *Ganua Motleyana* PIERRE, *Palaquium oder Madhuca;* **Theaceae,** *Tetramerista glabra* MIQ.

SUMATRA.

BÄUME IM MOORWALD ZU BAJOENGLINTJIR (PALEMBANG), DEM MEDAK ENTLANG, NEBENFLUSZ DES LALANS (NACH ENDERT).

Bodenvegetation: *Susum malayanum* HOOK *var. sylvatica, Freycinetia spec., Pandanus? johorensis* MASTELLI, *Scirpodendron oder Mapania, Hypolythrum, Zalacca conferta* GRIFF., *Cyrtostachys? renda* BL., *Pholidocarpus sumatrana* BECC., *Stenochlaena palustris* BEDD., *Nepenthes ampullaria* JACK., *Santiria Planchonii* A. W. BENN., *Eugenia bankensis* BACKER.

BÄUME.

Anacardiaceae, *Campnosperma, Mangifera, Melanorrhoea Wallichii* HOOK.; **Anonaceae,** *Mezzettia, Xylopia;* **Apocynaceae,** *Alstonia pneumatophora* BACKER, *Dyera;* **Bombacaceae,** *Durio carinatus* MAST., *Neesia* *malayana* BAKH.; **Burseraceae,** *Santiria Griffithii* ENGL. *Santiria? Planchonii* A. W. BENN.; **Celastraceae,** *Lophopetalum*; **Dilleniaceae,** *Dillenia*; **Dipterocarpaceae,** *Anisoptera, Shorea*; **Ebenaceae,** *Diospyros*; **Euphorbiaceae,** *Blumeodendron, Endospermum, Macaranga*; **Fagaceae,** *Quercus*; **Gonystylaceae,** *Gonystylus*; **Guttiferae,** *Calophyllum, Cratoxylon arborescens* BL., *Garcinia*; **Icacinaceae,** *Stemonurus secundiflora* BL., *Urandra corniculata* FOXW.; **Lauraceae,** *Notaphoebe*; **Leguminosae,** *Dialium, Koompassia malaccensis* MAING.; **Meliaceae,** *Amoora, Sandoricum emarginatum* HIERN.; **Moraceae,** *Artocarpus Kemando* MIQ., *Ficus, Parartocarpus*; **Myristicaceae,** *Gymnacranthera, Myristica*; **Myrtaceae,** *Eugenia*; **Oleaceae,** *Strombosia* **Rhizophoraceae,** *Combretocarpus Motleyi* HOOK. *f.*; **Rosaceae,** *Parastemon urophyllum* A. DC.; **Rubiaceae,** *Jackia ornata* WALL., *Mussaendopsis Beccarii* BAILL.; **Sapotaceae,** *Ganua Motleyana* PIERRE,*Madhuca sericea* H. J. L., *Palaquium rostratum* BURCK., *Palaquium Ridleyi* K. et G.; **Symplocaceae,** *Symplocos*; **Theaceae,** *Tetramerista glabra* MIQ.

BORNEO.

RESIDENZ WESTERABTEILUNG BORNEO.

ABTEILUNG SINGKAWANG, UNTERABT. MEMPAWAH, DISTRIKT SG. PINJOE (ANDJONGAN).

Anacardiaceae, *Mangifera*; **Apocynaceae,** *Dyera*; **Bombacaceae,** *Durio*; **Casuarinaceae,** *Casuarina*; **Dipterocarpaceae,** *Dipterocarpus, Shorea, Vatica*; **Gonystylaceae,** *Gonystylus*; **Guttiferae,** *Garcinia*; **Leguminosae,** *Koompassia malaccensis* MAING.; **Myrtaceae,** *Eugenia, Tristania*; **Pinaceae,** *Agathis borneensis* WARB.; **Sapotaceae,** *Ganua, Palaquium*; **Tiliaceae,** *Pentace.*

RESIDENZ WEST-BORNEO.

Anacardiaceae, *Bouea, Campnosperma auriculata* HOOK. *f., Gluta, Mangifera, Melanorrhoea Wallichii* HOOK., *Swintonia*; **Anonaceae,** *Mezzettia, Xylopia*; **Apocynaceae,** *Alstonia spathulata* BL., *Dyera Lowii* HOOK. *f.*; **Bombacaceae,** *Durio carinatus* MAST.; **Burseraceae,** *Santiria*; **Celastraceae,** *Lophopetalum*; **Compositae,** *Vernonia arborea* HAM.; **Datiscaceae,** *Octomeles*; **Dilleniaceae,** *Dillenia, Wormia, Anisoptera Curtisii* DYER; **Dipterocarpaceae,** *Dipterocarpus Hasseltii* BL., *Dipterocarpus Lowii* DYER, *Dryobalanops, Hopea, Isoptera borneensis* SCHEFF., *Shorea Belangeran* BURCK, *Shorea leprosula* MIQ., *Vatica*; **Ebenaceae,** *Diospyros*; **Euphorbiaceae,** *Baccaurea, Blumeodendron, Macaranga, Podadenia*; **Fagaceae,** *Quercus*; **Gonystylaceae,** *Gonystylus*; **Guttiferae,** *Calophyllum, Cratoxylon formosum* DYER, *Garcinia, Kayea*; **Icacinaceae,** *Stemonurus oder Urandra*; **Lauraceae,** *Cryptocarya, Litsea*;

Leguminosae, *Crudia, Dalbergia parvifolium* BENTH., *Koompassia parvifolia* PRAIN, *Pithecolobium* ; **Linaceae,** *Ctenolophon* ; **Lecythidaceae,** *Barringtonia* ; **Loganiaceae,** *Fagraea fragrans* ROXB. ; **Melastomataceae,** *Dactylocladus stenostachys* OLIV., *Kibessia oder Pternandra* ; **Meliaceae,** *Aglaia, Amoora, Sandoricum emarginatum* HIERN., *Xylocarpus granatum* KOENIG ; **Moraceae,** *Artocarpus, Parartocarpus* ; **Myristicaceae,** *Horsfieldia, Myristica* ; **Myrtaceae,** *Eugenia spicata* LANK., *Tristania* ; **Polygalaceae,** *Xanthophyllum* ; **Rhizophoraceae,** *Anisophyllaea, Carallia* ; **Rosaceae,** *Parastemon urophyllum* A. DC., *Parinarium* ; **Rubiaceae,** *Jackia ornata* WALL., *Mitragyne* ; **Sapotaceae,** *Ganua, Lucuma, Madhuca lancifolia* H. J. L., *Palaquium* ; **Sterculiaceae,** *Heritiera littoralis* DRYAND, *Sterculia* ; **Taxaceae,** *Podocarpus Beccarii* PARL. ; **Theaceae,** *Archytaea alternifolia* HOCHR., *Tetramerista glabra* MIQ. ; **Ulmaceae,** *Gironniera nervosa* PLANCH.

RESIDENZ WESTERABTEILUNG BORNEO.

ABTEILUNG PONTIANAK, DISTRIKT SG. RAJA.

Anacardiaceae, *Campnosperma macrophylla* HOOK. *f.* ; **Anonaceae,** *Mezzettia* ; **Apocynaceae,** *Dyera* ; **Bombacaceae,** *Durio* ; **Dipterocarpaceae,** *Shorea* ; **Ebenaceae,** *Diospyros* ; **Gonystylaceae,** *Gonystylus* ; **Guttiferae,** *Calophyllum* ; **Lauraceae,** *Notaphoebe* ; **Leguminosae,** *Sindora* ; **Sapotaceae,** *Palaquium.*

Man beachte die Übereinstimmung von Sumatra und West-Borneo. Nach LUYTJES findet man auf Paneh auf Torfschichten bis 0.5 m. die Palmen: *Licuala, Zalacca* und *Oncosperma* gemischt mit *Campnosperma auriculata* HOOK.f., *Pometia* sp., *Polyalthia* sp., *Alstonia pneumatophora* BACKER., *Urandra secundiflora* KTZ. und *Ilex* sp. Typische Arten wachsend auf mächtigen Torfschichten sind: *Durio carinatus* MAST., *Shorea* (meranti), *Palaquium, Tetramerista glabra* MIQ., *Eugenia* (djamboe), *Calophyllum* und *Tristania.* Bis zu einer Mächtigkeit von 2.5 m. noch viel *Licuala;* 3.5 m. dichten Wald, ± 5 m. hohe geschlossene Baumvegetation mit vielen *Shoreas* (meranti) und eingestreut *Zalacca* und Pinang mentjoeng. Die Randvegetation also ist locker mit Unterwuchs von niedrigen Palmen: *Zalacca* und *Licuala,* während die *Oncosperma* und *Pholidocarpus* hoch emporragen. Im dichten Wald gibt es fast keinen Unterwuchs. Im Herzen der Halbinsel Paneh traf LUYTJES einen dünnstämmigen Wald, für 60 % aus *Tristania,* weiter *Eugenia, Parastemon, Calophyllum* und *Shorea* (meranti). Hier könnte man Blänken erwarten, die LUYTJES jedoch für Paneh nicht erwähnt.

Einen ähnlichen dünnstämmigen Wald traf ich auf Bengkalis, mit reichlicher Bodenvegetation aus Cyperaceen, Pandanaceen, Lebermoosen und besonders Nepenthaceen.

Studiert man die Stratigraphie der Torfschichten, so musz eine detaillierte Kenntnis der rezenten Flora vorausgesetzt werden. Wie könnte man sonst eine vertikale Gliederung konstatieren?

Die Untersuchung der Torflager hat grosze Schwierigkeiten. Die Aufeinanderschichtung von hartem Holz macht das Bohren fast unmöglich. Mit äuszerster Vorsicht gelingt es dann und wann zwischen den Stämmen den Torfbrei in der Sonde aus der Tiefe aufzuheben.

Das Gewinnen von Torfproben in gegrabenen Löchern ist ebenfalls beschwerlich. Das Holz hindert an der Grabearbeit und wenn man schlieszlich ein Loch fertig hat, dann füllt es sich augenblicklich mit braunem Sickerwasser!

In West-Borneo wurde ein Kanal gegraben (Soengei Raja). Dieser Einschnitt im Torf gewährte einen schönen Einblick in die Struktur.

Nicht nur floristisch, sondern auch biologisch warten wichtige Probleme der Lösung. Wie rasch wächst die Torfschicht? Wie ist das Gleichgewicht zwischen Anwuchs und Zersetzung? Die Antwort dieser Fragen kann erst Aufschlusz über das Alter dieser Bildungen geben! Die Bewurzelungsweise der Bäume ist auch noch immer sehr unklar. Meiner Ansicht nach werden nur dort wo die Torfschichten wenig mächtig sind die Hauptwurzeln den Untergrund erreichen. Jedenfalls haben die meisten Bäume ein flaches horizontales Wurzelgestell; auf den neuen Entwaldungen, wo die Baumstümpfe auf ausgetrocknetem Boden stehen, war das deutlich zu beobachten, besonders an umgefallenen Stämmen. VAN HEURN (1922) und Oberförster J. SCHUITEMAKER (briefliche Mitteilung) jedoch behaupten, dasz von gewissen Arten die Wurzeln 4 m. und mehr eindringen können, um die Unterlage zu erreichen.

Eine weitere Frage ist, ob die Bäume der Erhebung des Bodens angepaszt sind. Wachsen die Wurzeln mit, oder ersticken dieselben? Wenn es tiefwurzelnde Arten gibt, sind dann diese Wurzeln von oben her eingedrungen bis an den Untergrund, oder sind sie von diesem heraus mitgewachsen mit der Erhöhung der Oberfläche?

Etagewurzeln waren zu beobachten an den Stämmen im Profil zu Soengei Raja. Daraus dürfte man schlieszen, dasz jedenfalls die Fähigkeit besteht mit der Erhöhung des Bodens mitzuwachsen!

SPEZIELLER TEIL.

Als Hauptergebnis der Beobachtungen im Felde kam heraus, dasz die Küstenmoore Borneos und Sumatras ombrogene Gebilde sind, welchen im Einklang mit ähnlichen europäischen Moorformationen Hochmoorcharakter zugeschrieben werden musz.

In der Absicht Wesen und Zusammensetzung des Torfes zu erkennen, sind an verschiedenen Stellen Proben gesammelt worden zwecks Untersuchung im Laboratorium. Dies geschah in *Sumatra* zu Tjabang Doea: *Hevea*plantage der Firma HARRISON und CROSSFIELD, Laboean

Bilik Bila Estate: *Hevea*plantage der „Société financière des caoutchoucs"', bei Negri Lama, Ölpalmenplantage und Poelau Padang, Urwald bei Bengkalis. In *West-Borneo* zu Andjongan, Landschaft: Mempawah, Soengei Bangkong bei Pontianak und Soengei Raja, auch bei Pontianak.

Wie schon erwähnt, ist die Gewinnung der Proben sehr beschwerlich, da die Torfschicht eine Anhäufung von Baumstämmen und Wurzeln darstellt, eingebettet in einem Torfschlamm, von den Kulis „boeboer" (Brei) genannt. Nur dieser Schlamm wurde mikroskopisch untersucht. An einzelnen Stellen nur wurde ein vollständiges Profil gesammelt und zwar zu Tjabang Doea, Soengei Raja, Soengei Bangkong und Andjongan. Die mir zur Verfügung stehende DACHNOWSKY-Sonde erwies sich als sehr ungeeignet für diesen Zweck. Die übrigen Proben sind mittels Grabearbeiten gesammelt worden.

Die feuchten Proben wurden vorläufig aufbewahrt in mit Nummern versehenen Papiertüten. Die Tüte wurde in Blattaluminium eingewickelt, und das Ganze wieder gehüllt in eine gröszere Papiertüte mit derselben Nummer wie die erste. Sämtlich in Biskuitbüchsen gepackt, erhielten die Proben sich gut auf der Reise. Im Laboratorium wurden dieselben in mit Kork verschlossenen Glasröhren definitif aufbewahrt. Ohne Konservierungsmittel haben dieselben sich schon ein halbes Jahr feucht und pilzfrei erhalten!

Folgende Fragen kann man sich stellen:

1°. Gibt es aufeinander Torfschichten von verschiedener botanischer Zusammensetzung?

2°. Was für eine Vegetation bildete den Anfang des Moorwaldes? War die Vegetation der Unterlage grundverschieden von den folgenden Formationen?

3°. Wurde der Moorwald vielleicht eingeleitet von einer Verlandung mittels Gräser und Cyperaceen?

Nur eine genaue Analyse der Torfproben vermag diese Probleme endgültig zu lösen. Die Pollenanalyse, die sich in Europa so glänzend bewährt hat, unterliegt hier groszen Schwierigkeiten. Die Ursache hierfür ist immer wieder die unvollständige Kenntnis des heutigen Waldes: man kennt weder genau die Arten, noch deren Verhältniszahlen. Jedoch, der Pollen wird sehr gut erhalten im Torf, und so kann man wenigstens das Studium anfangen mit dem Versuch die Körner der schon bekannten rezenten Arten zu identifizieren mit den fossilen.

Der günstigen Lage des Treub-Laboratoriums im Botanischen Garten und der freundlichen Hilfe der Mitarbeiter des Herbariums zu Buitenzorg verdanke ich es, dasz ich von verschiedenen der von den Förstern notierten Arten frisches Pollen zur Vergleichung erhalten habe. Öfters war nur eine verwandte Art der Gewünschten zu haben.

Antheren derselben, Blüten oder Infloreszensen wurden nach der Methode DE GRAAFF (1927) behandelt. Nachdem die Objekte während einigen

Minuten in 10 %-iger Salpetersäure gekocht waren, wurden dieselben ausgewaschen und eine Minute in 2½ %-iger Natronlauge gekocht. In fast allen Fällen ist der Inhalt völlig gelöst und geht die Struktur der Wand ganz klar hervor! Der Pollen ist ebenso leer wie derjenige des Torfes und ist deshalb gut vergleichbar. Nur hat man zu kontrollieren ob die Körner nach dem Kochen nicht geschwollen sind. Tafel I zeigt einige Zeichnungen solcher Präparate; Tafel II und III Abbildungen von Pollen im Torf, gezeichnet mit dem Zeisprisma, Oc. 3 Obj. D.

Vielmehr als zu einer genauen Bestimmung der Arten kommt man zu einem Erkennen verschiedener Typen. Vorläufig kommt nur in Betracht das Moor stratigraphisch zu studieren, wobei der Pollen nur einen Komponenten des gesamten Materials bildet. Leider kann man in dieser Weise nur vorläufige und unvollständige Resultate erzielen. Am besten wäre es die Holzstämme im Felde zu bestimmen, und eine grosze Sammlung Holzreste von der Oberfläche und von der Tiefe anzufertigen. Leider fehlten mir die Kenntnisse zum Bestimmen und die technischen Hilfsmittel zum Sammeln. Ich habe mich also nur auf das Studium des Torfbreis beschränkt. Derselbe wurde im Laboratorium mittels aufhellen in 10 %-iger Kalilauge untersucht. Die schönsten Präparate wurden erhalten nach Aufschlämmen der intensif braun gefärbten Flüssigkeit in einer Serie Sieben verschiedener Feinheit. Die Flüssigkeit die durch die letzte Siebe flieszt, gibt, wenn dieselbe zentrifugiert wird, Präparate, die sehr reich sind an Körnern.

Das Gesamtbild der verschiedenen Proben, sei es von Borneo oder Sumatra, zeigt nur wenige Unterschiede. Die gröberen Reste sind hauptsächlich Holzfragmente, Rinde, feinere Würzelchen. Das Zentrifüge-Präparat zeigt besonders Pollenarten, weiter Blattepidermen von Dikotylen mit Stomata. Solche Sachen sind unbestimmbar. Das Ganze ist durchflochten mit Pilzfäden, welche die Gewebefragmente umspinnen. Meistens sind die Hyphen schwärzlich gefärbt. Die Sporen liegen zerstreut und abgelöst von der Hyphe im Präparat. Der Mykologe des Herbars zu Buitenzorg, Dr. K. B. BOEDIJN, konnte nur in einzelnen Fällen eine saprophytische Art bestimmen: *Rosellinia bunodes* SACC., die sehr häufig ist, und eine *Endogone* sp. Höchstwahrscheinlich gibt es Mykorrhizen. Die Würzelchen sind von Hyphen umsponnen, ähnlich den Ericaceenwurzeln der europäischen Hochmoore. Nach VON FABER (1927) ist ein horizontales Wurzelgestell zusammen mit Mykorrhiza eine häufige Form des Wachstums an sauren Kraterböden. Im Moorwald hat man denselben Säuregrad wie am Kraterboden, jedoch eine weit üppigere Vegetation. Also haben dort die horizontalen Wurzeln mit Pilzen umsponnen eine viel mächtigere Entwicklung und Ausdehnung als hier, die Erscheinung aber ist dieselbe.[1])

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[1]) Nachdem dieses Manuskript abgeschlossen wurde, erhielt ich die Arbeit SNOEPS. Darin werden Kaffeekulturen auf Torf erwähnt, SNOEP beobachtete, dasz sogar die angepflanzten Kaffeesträucher eine horizontale Bewurzelung aufweisen.

Bild 111, Tafel III zeigt die letzte Verästelung der Baumwurzeln, (Vergröszerung 250). Ähnliche Formen bilden oft den Hauptbestandteil des Präparates. Tafel I zeigt einige Pollenbilder nach frischem Material, gezeichnet nach Formen, welche während meines Aufenthaltes zu Buitenzorg zu erhalten waren. Sofort fällt die verhältnismäszige Grösze des Koniferenpollens auf (*Agathis, Pinus, Podocarpus*), weiter die einheitliche Gestalt der Dipterocarpaceenpollen, abgerundete Dreiecke (*Shorea, Vatica).* Auch die Form des *Calophyllum, Diospyros* und *Garcinia*pollens stimmt weitgehendst überein, ebenso die der *Tristania* und *Eugenia.*

Zu wenig frisches Material steht bis jetzt zur Verfügung, daher ist es unmöglich die Bestimmung der Arten anzufangen. Ich habe also die Pollenkörner der Präparate in einige Typen eingeteilt, ersichtlich an den Tafeln II und III. Folgende Typen stellen sich heraus: *Calophyllum* Typus (42—46) Tafel II, 79—80) Tafel III; Dipterocarpaceen-Typus (47—59) Tafel II, (81—94) Tafel III; *Garcinia*-ähnliche Dreiecke (60—63) Tafel II, (95—98) Tafel III; *Tristania-Eugenia*-ähnliche Dreiecke (64—68) Tafel II, (103) Tafel III.

Die Formen (72—74) Tafel II, sind sehr häufig in allen Präparaten. Auch Tetraden wie 69 Tafel II, werden öfters gefunden. Nur auf Borneo zeigt sich *Podocarpus*pollen in den Präparaten. Reste von Farnen sind sehr häufig im Torfe. Man findet Treppentracheiden, Schuppen, Sporen und Sporangien. Die meisten Sporen (Tafel II, 32—41) haben Bohnenform mit gelapptem, gekörntem oder gefurchtem Episporium, öfters sind sie glatt, vielleicht hat sich in diesem Falle das Episporium abgelöst (Tafel II, 39). Weniger häufig sind die dreieckigen Formen (Tafel II, 41).

Gebilde ähnlich wie (75—78) Tafel II, (106—110) Tafel III, finden sich sehr häufig in fast allen Präparaten des Waldtorfes und sind bis jetzt unbestimmbar. Es handelt sich um kleine Samen und gröszere Sporen, oder vielleicht um Tiereier. In der Beschreibung der Präparate werden dieselben als „gestachelte Sporen" bezeichnet.

Die Farbe dieser Objekte im Präparat ist dieselbe wie der in Europa. Farnsporen sind gelb oder braun, die Annuli rotbraun, das Sporangium ist farblos. Rotbraun sind ebenfalls die Treppentracheide. Pollenkörner sind hellgelb, so wie die Moosblättchen, die vereinzelt gefunden werden.

Chitinreste werden vielfach in den Präparaten gefunden; auszer Pilzresten findet man Schmetterlingsschuppen und sonstige Arthropodenreste. Oben in dem Siebe liegen öfters kleine Harzblöckchen. Gröszere Harzklumpen sind reichlich im Torfe eingebettet.

Die hier gegebenen Untersuchungen gestatten bis jetzt kein Urteil über den stratigrafischen Bau des Torfes. Augenscheinlich bleibt das Bild konstant bis auf die Unterlage, nur gibt es geringe Anzeichen, dasz die Häufigkeit der Pilzfäden etwas abnimmt.

BESCHREIBUNG DER PROBEN.

SUMATRA-OSTKÜSTE.

TJABANG DOEA ESTATE BEI LABOEAN BILIK (AM RANDE DES MOORWALDES).

No. 37. Tiefe 20 cm.
Pilzfäden und Sporen, Holzreste, Rinde, Dunkelbraune Gefäszbündel (von Palmen?) Wurzeln, Farnsporen und Sporangien, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110, Gestacheltes Pollen, Tafel II 72—74, Dreieckige Spore.

No. 38. Tiefe 40 cm.
Pilzfäden und Sporen, Holzreste, Rinde, Dunkelbraune Gefäszbündel (von Palmen?), Wurzeln, Farnsporen und Sporangien, Bohnenformige Farnsporen, Gestachelte Sporen (?), Tafel III, 106—110, *Calophyllum* ähnliches Pollen, Dreieckige Spore.

No. 39. Tiefe 60 cm.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Dunkelbraune Gefäszbündel (von Palmen?), Farnsporen und Sporangien, *Dipterocarpaceen*-Pollen, Gestacheltes Pollen, Gestachelte Sporen (?), Tafel III, 106—110, Dreieckige Spore.

No. 40. Tiefe 80 cm.
Blauer Ton.

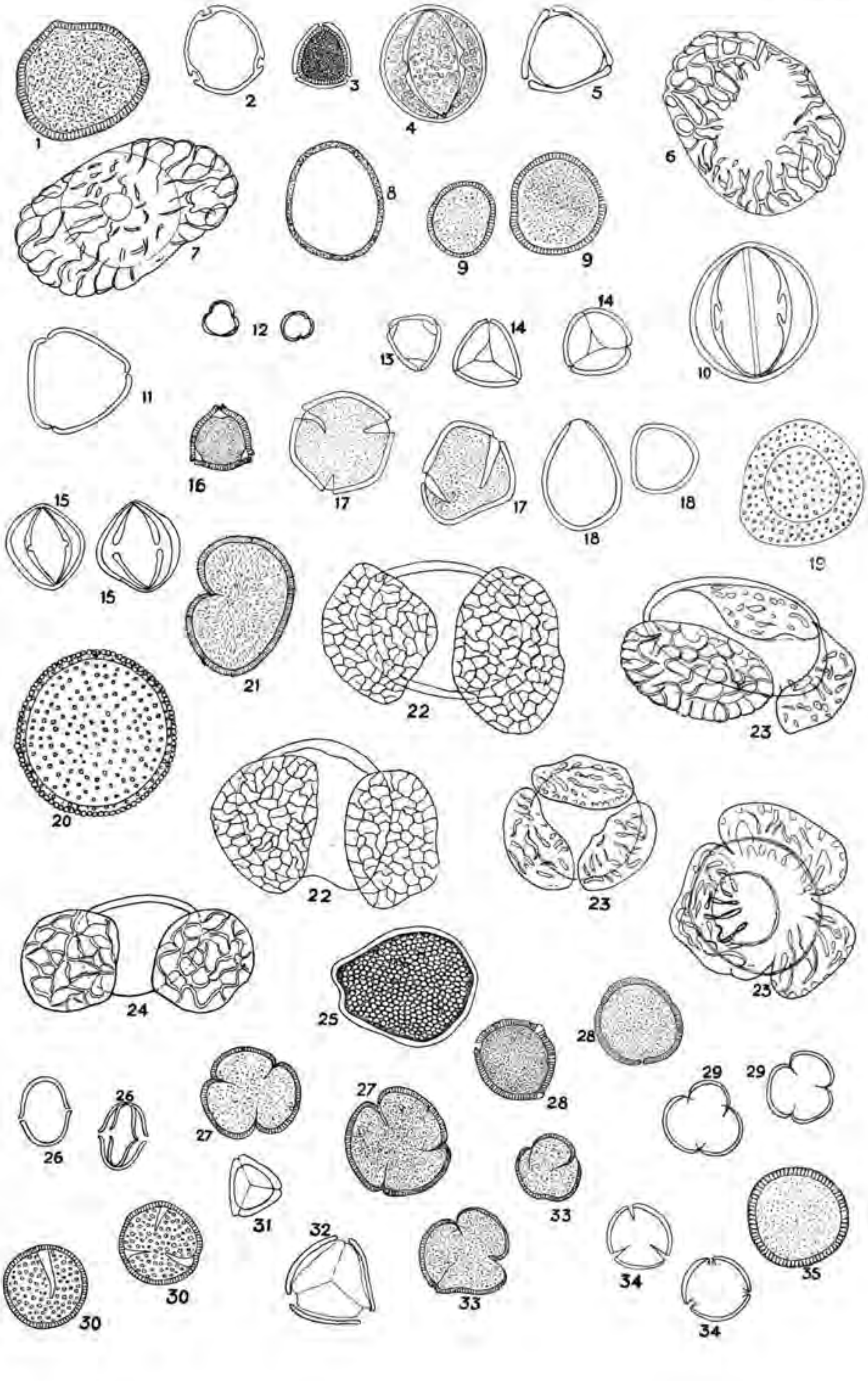
BILA ESTATE, SÜDLICH LABOEAN BILIK.

Oberfläche.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Mykorrhiza, Farnsporen und Sporangien, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

Tiefe 1 m.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, viel mehr zersetzt als in der vorigen Probe, Farnsporen und Sporangien, Schuppen, Treppentracheiden, *Dipterocarpaceen*-Pollen, *Tristania*-ähnliches Pollen, Dreieckige Spore, Gestachelte Sporen (?), Tafel III, 106—110.

Tiefe 1.25 m.
Pilzfäden und Sporen, Holzreste, Wurzeln, Rinde, Farnsporen, Sporangien, Schuppen. Sehr viele *Calophyllum*-ähnliche Pollenkörner, Tetraden-Pollen. Sehr viele gestachelte Sporen (?), Tafel III, 106—110.

TAFEL I.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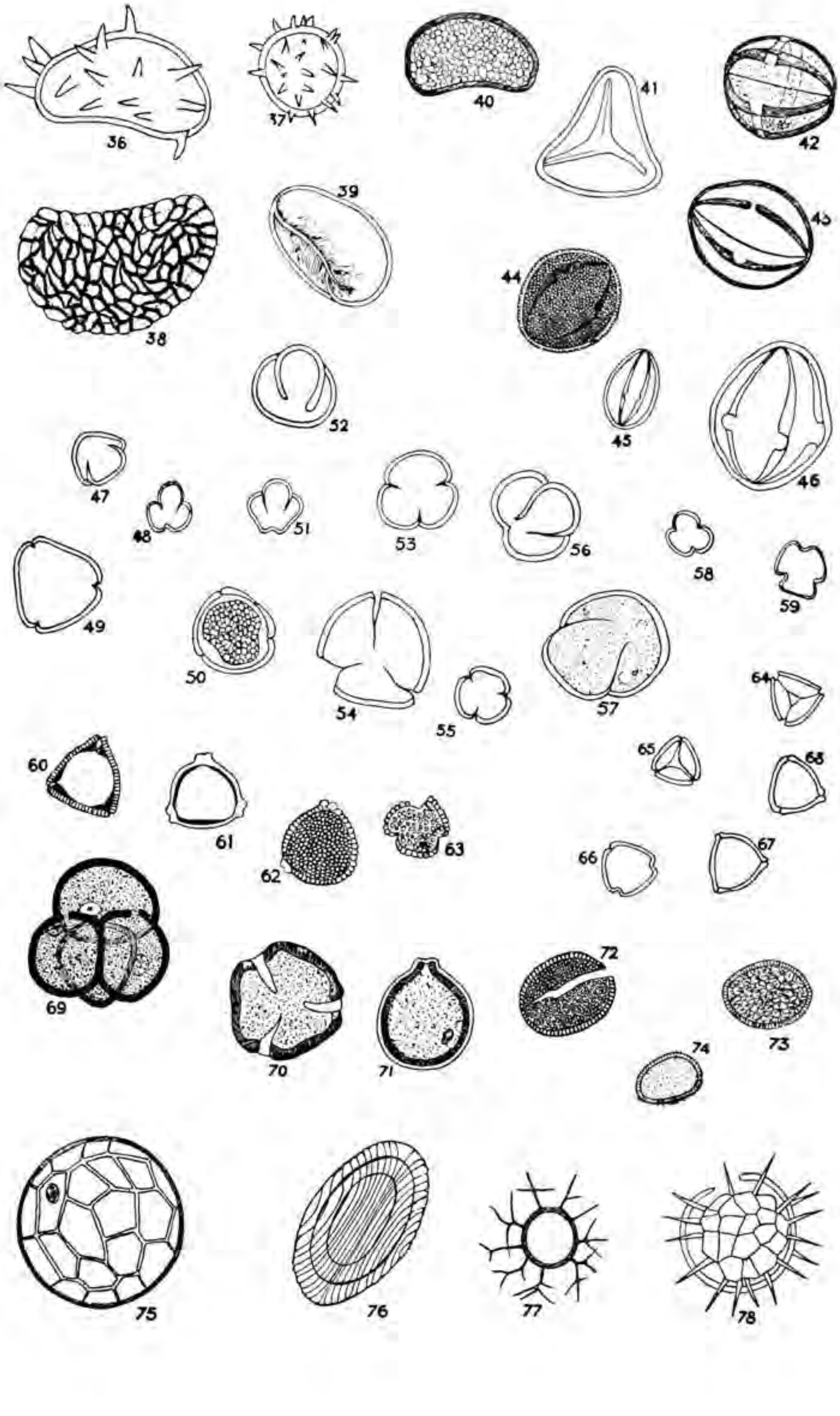
TAFEL I.

POLLEN NACH FRISCHEM MATERIAL GEZEICHNET 500 ×.

1. *Agathis*, spec.
2. *Alstonia Hoodtii*, T. et B.
3. *Blumeodendron elateriospermium*, J. J. SM.
4. *Calophyllum venulosum*, ZOLL.
5. *Casuarina sumatrana*, JUNGH.
6. *Dacrydium elatum*, WALL.
7. *Dacrydium falciforme*, PILG.
8. *Dillenia philippense*, ROLFE.
9. *Dillenia*, spec.
10. *Diospyros discolor*, WILLD.
11. *Dyera costulata*, HOOK, f.
12. *Elaeocarpus edulis*, T. et B.
13. *Eugenia densiflora*, DUTHIE.
14. *Eugenia suringariana*, K. et V.
15. *Garcinia livingstonii*, ANDERS.
16. *Garcinia balica*, MIQU ; var. *Binnendijkii*, BOERL.
17. *Lagerstroemia loudonii*, T. et B.
18. *Licuala spinosa*, THUNB.
19. *Litsea crassifolia*, BOERL.
20. *Litsea chinensis*, LAMK.
21. *Oncosperma*, spec.
22. *Pinus Merkusii*, JUNGH et DE VR.
23. *Podocarpus imbricata*, BL.
24. *Podocarpus polystachius*, R. BR.
25. *Polyalthia laterifolia*, KING ; var. *macrophylla*.
26. *Quercus*, spec.
27. *Shorea Lepidota*, BL.
28. *Shorea lepsosula (Shorea meranti)*, MIQU.
29. *Shorea selanica*, BL.
30. *Sterculia laevis*, WALL ; var. *bracteata*, PIERRE.
31. *Tristania conferta*, R. BR.
32. *Vatica bancana*, SCHEFF.
33. *Vatica papuana*, DYER.
34. *Vatica Wallichii*, DYER.
35. *Zalacca edulis*, BL.

TAFEL II.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TAFEL II

POLLEN UND SPOREN IM WALDTORF SUMATRAS 500 ×

Sporen.

36. 37. 38. 39. } Bila.
40. 41. } Poelau Padang.

Calophyllum ähnliche Pollentypen.

42. 43. } Bila.
44. 45. 46. } Poelau Padang.

Dipterocarpaceen Typus.

47. 48. } Poelau Padang.
49. Tjabang Doea.
50. Bila-Estate.
51. 56. 52. 57. 53. 58. 54. 59. 55. } Poelau Padang.

Garcinia ähnlicher dreieckiger Typus.

60. Tjabang Doea.
61. 62. } Bila-Estate.
63. Poelau Padang.

Tristania — Eugenia Typus.

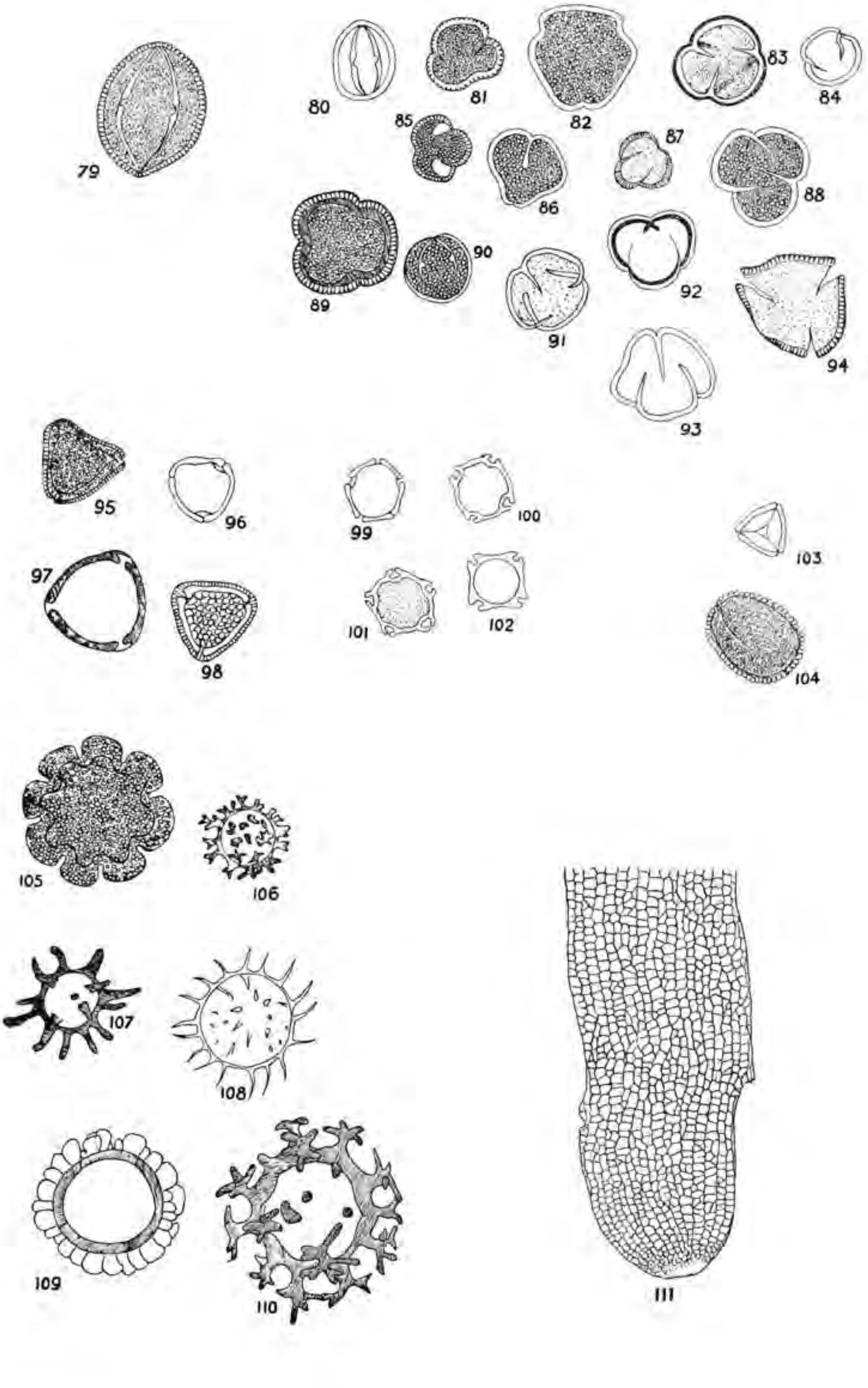
64. 67. 65. 68. 66. } Poelau Padang.

69. *Tetraden-Pollen.* Bila-Estate.
70. 71. } *Lagerstroemia Typus.* Bila-Estate.

Gestachelter Typus.

72. Bila-Estate.
73. 74. } Poelau Padang.
75. 77. 76. 78. } *Fragliche Gebilde.* 250 ×

TAFEL III.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TAFEL III

Pollen im Waldtorf Borneos. 500 ×

Calophyllum Typus.

79. 80. Andjongan.

Dipterocarpaceen Typus.

81. 82. Andjongan.
83. 84. 85. 86. 87. Soengei Raja.
88. Andjongan.
89. 90. Soengei Raja.
91. 92. Soengei Bangkong.
93. Soengei Raja.
94. Soengei Bangkong.

Dreieckiger Typus.

95. 96. Soengei Raja.
97. 98. Soengei Bangkong.

Vier und fünfeckige Körner.

99. 100. 101. 102. Soengei Raja.

Tristania-Eugenia Typus.

103. Soengei Raja.
104. *Ovales Pollen.*

Fragliche Gebilde.

105. 106. 107. 108. 109. 110. Vergr. 250 ×
111. Feinste Verästelung der Baumwürzelchen im Waldtorf. 250 ×

SUMATRA-RES. RIOUW.

BENGKALIS. POELAU PADANG.

Tiefe ± ½ m.
Pilzfäden und Sporen, Holzreste, Wurzeln, Mykorrhiza, Rinde, Farnsporen und Sporangien, *Calophyllum*-ähnliches Pollen, *Dipterocarpaceen*-Pollen, *Tristania*- oder *Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

SÜD-SUMATRA-RES. PALEMBANG.

BAJOENGLINTJIR.

GETROCKNETE PROBE DER OBERFLACHE, GESAMMELT VON DR F. H. ENDERT.

Pilzfäden und Sporen, gestachelte Hyphen, Holzreste, Rinde, Wurzeln, Farnsporen, Sporangien und Schuppen, Gestachelte Sporen (?), Tafel IV, 106—110.

WEST-BORNEO.

ANDJONGAN, LANDSCHAFT MEMPAWAH, EINHEIMISCHE KOKOSPLANTATION.

No. 45. Tiefe 55 cm.
Pilzfäden und Sporen *(Endogone)*, Holzreste, Rinde, Wurzeln, Farnsporen, Sporangien, Schuppen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 46. Tiefe 70 cm.
Pilzfäden, gestachelte Hyphen, Sporen *(Endogone sp.)*, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, *Podocarpus Beccarii*-Pollen (2). Gestachelte Sporen (?), Tafel III, 106—110.

No. 47. Tiefe 85 cm.
Pilzfäden, Sporen *(Endogone)*, Holzreste, Rinde, Wurzeln, Farnsporen und Sporangien, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen.

No. 48. Tiefe 1 m.
Pilzfäden, Sporen *(Endogone)*, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 49. Tiefe 1.15 m.
Pilzfäden, Holzreste, Rinde, Wurzeln, Farnsporen und Sporangien, Treppentracheiden, Blattreste von Dikotylen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 50. Tiefe 1.30 m.
Pilzfäden und Sporen *(Endogone)*, Holzreste, Rinde, Wurzeln, Farnsporen, Dipterocarpaceen-Pollen *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 51. Tiefe 1.45 m.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Fransporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 52. Tiefe 1.60 m.
Pilzfäden und Sporen, Holzreste, Rinde, Blattreste von Dikotylen, Wurzeln, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 53. Tiefe 1.75 m.
Pilzfäden und Sporen *(Endogone)*, Holzreste, Rinde, Blattreste von Dikotylen, Wurzeln, Farnsporen und Treppentracheiden, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen (sehr häufig), Tetraden-Pollen, *Dacrydium*- und *Podocarpus*-Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 54. Tiefe 1.90 m.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Tetraden-Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 55. Tiefe 2.05 m.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Farnsporen, Sporangien, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 56. Tiefe 2.20 m.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Farnsporen, Sporangien, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Tetraden-Pollen, Moosblättchen, Gestachelte Sporen (?), Tafel III. 106—110.

No. 57. Tiefe 2.35 m.
Pilzfäden und Sporen *(Endogone)*, Holzreste, Rinde, Wurzeln, Farnsporen, Blattreste von Dikotylen, *Dipterocarpaceen*-Pollen, *Calophyllum*-

ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 58. Tiefe 2.50.
Pilzfäden und Sporen *(Endogone)*, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 59. Tiefe 2.65 m.
Pilzfäden und Sporen *(Endogone)*, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, *Podocarpus Beccarii*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

SOENGEI RAJA.

No. 62. Tiefe ± 30 cm.
Pilzfäden und Sporen *(Endogone)*, Holzreste, Rinde, Wurzeln, Farnsporen und Schuppen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Blattepidermis von Dikotylen, Pollen,.ähnlich No. 72, Tafel II; Pollen, ähnlich No. 63, Tafel II.

No. 63. Tiefe ± 60 cm.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Podocarpus*-Pollen, Gestachelte Sporen (?), Tafel III, 106—110, Blattepidermis von Dikotylen.

No. 64. Tiefe ±85 cm.
Pilzfäden und Sporen (sehr häufig), Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Pollen ähnlich No. 72, Tafel II, Gestachelte Sporen (?), Tafel III, 106—110.

No. 65. Tiefe ± 100 cm.
Pilzfäden und Sporen (sehr häufig), Gestachelte Hyphen, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 66. Tiefe ± 1.15 m.
Pilzfäden und Sporen (sehr häufig), Holzreste, Rinde, Wurzeln, Farnsporen und Sporangien, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, *Garcinia*-ähnliches Pollen, Gestachelte Sporen (?) (sehr häufig), Tafel III, 106—110.

No. 67. Tiefe ± 1.30 m.
Pilzfäden und Sporen, Gestachelte Hyphen, Holzreste, Rinde, Wurzeln,

Mykorrhizen, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, *Garcinia*-ähnliches Pollen, Blattreste von Dikotylen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 69. Tiefe ± 1.45 m.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Mykorrhizen, Farnsporen, *Dipterocarpaceen*-Pollen, *Tristania-Eugenia*-ähnliches Pollen.

No. 70. Tiefe ± 1.60 m.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Mykorrhizen, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 71. Tiefe 1.75 m.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Mykorrhizen, Farnsporen, Sporangien, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

Unterlage blauer Ton mit Holzresten und Wurzeln.

SOENGEI BANGKONG.

No. 74. Tiefe ± 70 cm.
Pilzfäden und Sporen (sehr häufig), Holzreste, Rinde, Wurzeln, Mykorrhizen, Farnsporen, auch dreieckige, *Dipterocarpaceen*-Pollen, Tetraden-Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 75. Tiefe ± 85 cm.
Pilzfäden und Sporen *(Endogone)*, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Tetraden-Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 76. Tiefe ± 100 cm.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 77. Tiefe ± 1.15 m.
Pilzfäden und Sporen, Holzreste, Rinde, Wurzeln, Farnsporen, *Dipterocarpaceen*-Pollen, *Calophyllum*-ähnliches Pollen, *Tristania-Eugenia*-ähnliches Pollen, Gestachelte Sporen (?), Tafel III, 106—110.

No. 78. Unterlage blauer Ton.

II. DIE TOPOGEN BEDINGTEN MOORE.

A: IN DER EBENE.

ALLGEMEINES.

Die Bildung des Torfes der im vorigen Kapitel beschriebenen oligotrophen Moore wird an erster Stelle vom Klima bedingt. Daneben kommen aber Moore vor, deren Entstehung nur von topogenen Vorbedingungen abhängt, ungeachtet des Klimas.

Zerstreut in der tropischen Flachebene trifft man Torfstellen in Vertiefungen des Bodens, Verlandungsmoore. Theoretisch darf man dieselben überall dort erwarten, wo es stagnierendes Wasser gibt. Jedoch ist es eine Tatsache, dasz nur ein Teil dieser Gewässer Vertorfung zeigt, zweifelsohne ist die chemische Beschaffenheit des Wassers ein wichtiger Faktor, wie MOHR (1922) bemerkt hat. Welcher Art aber die chemische Zusammensetzung sein musz um Torfbildung zu bewirken, ist noch völlig unbekannt. MOHR's Behauptung, dasz an kalkreichen und jung-vulkanischen Böden Vertorfung ausgeschlossen sei, wird von den hier folgenden Beobachtungen nicht bestätigt. Die Torfstelle zu Pagandaran hat kalkreiches, alkalisches Wasser, die Rawah Pening liegt in jung vulkanischer Gegend.

Die topogenen Moore sind Grundwasser- und Verlandungsmoore, deren Oberfläche tiefer liegt als die Umgebung, also die richtigen Flachmoore der Tropen. Auf Java gibt es nur solche. Alle von mir in der Einleitung zitierten Schilderungen von Torf auf Java (Natuurkundig Tijdschrift voor Ned.-Indië) gehören zu dieser Kategorie.

Die botanische Zusammensetzung des Torfes zeigt grosze Verschiedenheiten, und zwar gibt es zwei deutlich getrennte Typen: Der Gräser-Cyperaceen oder Radizellentorf und der Waldtorf.

Die Unterschiede mit dem im vorigen Kapitel betrachteten Waldtorf sind folgende:

1. Die topogenen, eutrophen Waldtorfe treten nur zerstreut und stellenweise auf;
2. Die Oberflächen sind eingesenkt, liegen tiefer als die Umgebung, sie enthalten schwach saures bis alkalisches Wasser.

Ihr Ursprung ist wahrscheinlich wie die der von KOORDERS (1918) beschriebenen Randvegetation des Danau-Sees in West-Java, von mir erwähnt auf Seite 13. Die beiden von KOORDERS genannten Arten, *Elaeocarpus littoralis* T. et B. und *Glochidion palustris* KOORD. stehen mit den Wurzeln im Wasser. Ich war nicht in der Lage in die Rawah Lakbok, (siehe Seite 46 und 53) Süd-Java, einzudringen, also habe ich die dortige Vegetation nicht genügend studieren können. Die Physiognomie derselben ist aber eine ganz andre als die des Danau-Sees. Die Rawah Lakbok hat wenig offenes Wasser, sie ist bewachsen mit dichtem Gestrüpp, von Rottang ganz überzogen. Ob diese Vegetation aber primär ist, ist nicht bekannt. Wie dem auch sein mag, ähnliche Vegetationen und solche die mit dem Fusz im eutrophen Wasser stehen, darf man vergleichen mit europäischem Bruchwald.

Der Radizellentorf, aus Gräsern und Cyperaceen, einer richtigen Sumpfflora entstanden, ist den europäischen Formationen dieser Art besonders ähnlich. In Europa hat man die Sukzession Radizellentorf, Bruchwald, (Übergangsmoor), Hochmoor, Sphagnum- oder Waldmoor; ob dies sich auch in den Tropen vorfindet, wäre zu untersuchen. Jedenfalls wird es schwer sein, den Unterschied Bruchwaldtorf und Hochmoor-Waldtorf zu zeigen. Der Radizellentorf aber, tritt immer deutlich hervor.

Wie in Europa besteht diese Torfart aus Radizellengeflecht (glatte und Pustelradizellen) und aus Blattepidermen der Gräser und Riedgräser. Ähnlich wie in Europa gibt es Gröszenunterschiede und Verschiedenheiten in der Form der Pusteln, ein wichtiges Merkmal zum bestimmen, wie MATJUSCHENKO (1924) gezeigt hat. Ebenso wichtig sind die Strukturen der Blattepidermen, wie Tafel V zeigt. Die Zeichnungen sind nach lebendigem oder Herbariummaterial angefertigt worden, das nach der Methode DE GRAAFF behandelt war; die Epidermiszellen werden leer, und die Struktur tritt klar hervor. Man sieht deutlich den Unterschied zwischen Gräserepidermis mit eingeschalteten Zwergzellen, und der Epidermis der Cyperaceen, wo dieselben fehlen. Man beachte weiter die gewellte Zellwand.

Es würde sich lohnen eine Tabelle zusammenzustellen für diese Zellformen, ähnlich wie MATJUSCHENKO das für die Pustelradizellen gemacht hat. Ich selber habe die Abbildungen der Tafel V benutzt zur Vergleichung mit den Präparaten des Radizellentorfes, und habe in einzelnen Fällen mit groszer Wahrscheinlichkeit die Art bestimmen können. Tafel V gibt nur eine zufällige Auswahl; ich war nicht in der Lage eine vollständige Tabelle anzufertigen.

SPEZIELLER TEIL.

SUMATRA.

SUMATRA-OSTKÜSTE. TORFSTELLE AUF DER TABAKSPLANTATION *TOENTOENGAN* BEI MEDAN.

Diese Torfstelle liegt in der Ebene, inmitten des Kulturgeländes. Der ehemalige Sumpf selber ist kultiviert; sogar die letzten Spuren einer ursprünglichen Vegetation sind verschwunden. Nach Dr. DRUYFF, Geologe der Deli Versuchsstation, hat diese „Paja" (Name, mit dem an der Ostküste Sumatras und in Atjeh diese stellenweise sich vorfindenden Vermoorungen bezeichnet werden), ihren Ursprung einem Fluszarm zu verdanken, der von einer Eruption des Vulkanes Sibajak abgedammt wurde.

Die Zusammensetzung des Torfes bestätigt diese Anschauung. Die Paja ist ein typisches Verlandungsmoor; der Torf besteht fast gänzlich aus Gräsern und Cyperaceenresten, gemischt mit Farnen und ein wenig Holz und Rinde; letzteres besonders in den ersten und letzten Proben des Profils II. Die mittleren Proben des Profils II sind nahezu holzfrei. Dieselben sind besonders weich, und bestehen gröszenteils aus einem Radizellengeflecht. Nur wenig Pollen wurde gefunden, vereinzelt traf ich Diatomeen und öfters Reste von Arthropoden. Häufig sind Gebilde wie Tafel IV No. 124, die ich nicht näher bestimmen konnte. Pilzreste sind ziemlich häufig. Der Torf ist aus einer Sumpfvegetation von Gräsern und Riedgräsern hervorgegangen. Vielleicht wurde diese Verlandung eingeleitet von Schwingrasenbildung. Bäume gehörten ebenfalls zu den hier beschriebenen Formationen. Der Torf wird bedeckt von vulkanischer Asche; man findet dieselbe dann und wann auch in den tieferen Schichten, besonders in Profil I.

„Pajas" findet man vielfach in Deli und im östlichen Atjeh. Die Autoren, die dieselben beschrieben (VAN HEURN 1922, MOHR 1922, RUTTEN 1927) bringen sie mehr oder wenig in Einklag mit den oligotrophen, regional verbreiteten Moorwäldern. Wie schon betont ist das unrichtig, sie sind derselben Natur wie die „Rawahs" auf Java.

Ich habe keine andere Paja als die auf Toentoengan besuchen können, jedoch ist es sehr wahrscheinlich, dasz es derer mehrere Typen gibt, sowie von den Rawahs auf Java.

BESCHREIBUNG DER PROBEN.

PROFIL I. *TOENTOENGAN*, BEI MEDAN.

Wegen der Asche und der Kulturschicht, welche den Torf bedecken, wurde die erste Probe aus einer Tiefe von ± 2 m. entnommen.

No. 1. Tiefe ± 2 m.

Pilzfäden und Sporen *(Endogone)*, wenig Holz und Rinde. Wurzeln von Monokotylen (Pustelradizellen), Treppentracheiden, Gramineenepidermen (u.m. *Phragmites Karka* TRIN.), sehr viele Formen ähnlich Tafel IV, No. 124, Blattreste von Dikotylen, Arthropodenreste, Schmetterlingschuppen.

No. 2. Tiefe 2.15 m.

Pilzfäden *(Endogone)*, wenig Holz und Rinde, wenig Pollen (u.m. *Eugenia, Tristania)* Farnsporen und Sporangien, Pustelradizellen, sehr viele Formen ähnlich Tafel IV, No. 124.

No. 3. Tiefe 2.30 m.

Gemischt mit mineralischen Bestandteilen, Pilzfäden *(Endogone)*, wenig Holz und Rinde, Farnsporen und Sporangien, wenig Pollen, *Calophyllum*-ähnliches, Pustelradizellen, Formen ähnlich Tafel IV, No. 124.

No. 4. Tiefe 2.45 m.
Gemischt mit mineralischen Bestandteilen, Pilzfäden, Holz und Rinde (nur wenig), Farnsporen und Sporangien, Treppentracheiden, Gebilde ähnlich Tafel IV, No. 124.

No. 5. Tiefe 2.60 m.
Pilzfäden, wenig Holz und Rinde, Farnsporen und Sporangien, Radizellen und Pustelradizellen, Epidermis einer Monokotylen, wenig Pollen, wenig Gebilde ähnlich Tafel IV, No. 124, Diatomee (grosze *Pinnularia)*.

No. 6. Ausgefallen.

No. 7. Tiefe 2.90 m.
Vulkanische Asche, Pilzfäden, wenig Holz und Rinde, Reiser, Farnsporen und Sporangien (sehr häufig), Epidermen von Monokotylen, Radizellen und Pustelradizellen, wenig Gebilde ähnlich Tafel IV, No. 124, wenig Pollen, Blattfragment einer Dikotyle, Stacheln ähnlich Rosenstacheln.

No. 8. Tiefe 3.05 m.
Pilzfäden, wenig Holz, Rinde, Reiser, Farnsporen, Radizellen und Pustelradizellen, wenig Pollen, wenig Gebilde ähnlich Tafel IV, No. 124, Stacheln.

No. 9. Tiefe 2.20 m.
Pilzfäden, Reiser, Rinde, Blattfragment einer Dikotyle, Radizellen und Pustelradizellen, wenig Pollen, wenig Gebilde ähnlich Tafel IV, No. 124, Moosblättchen, Kopf einer Arthropode.

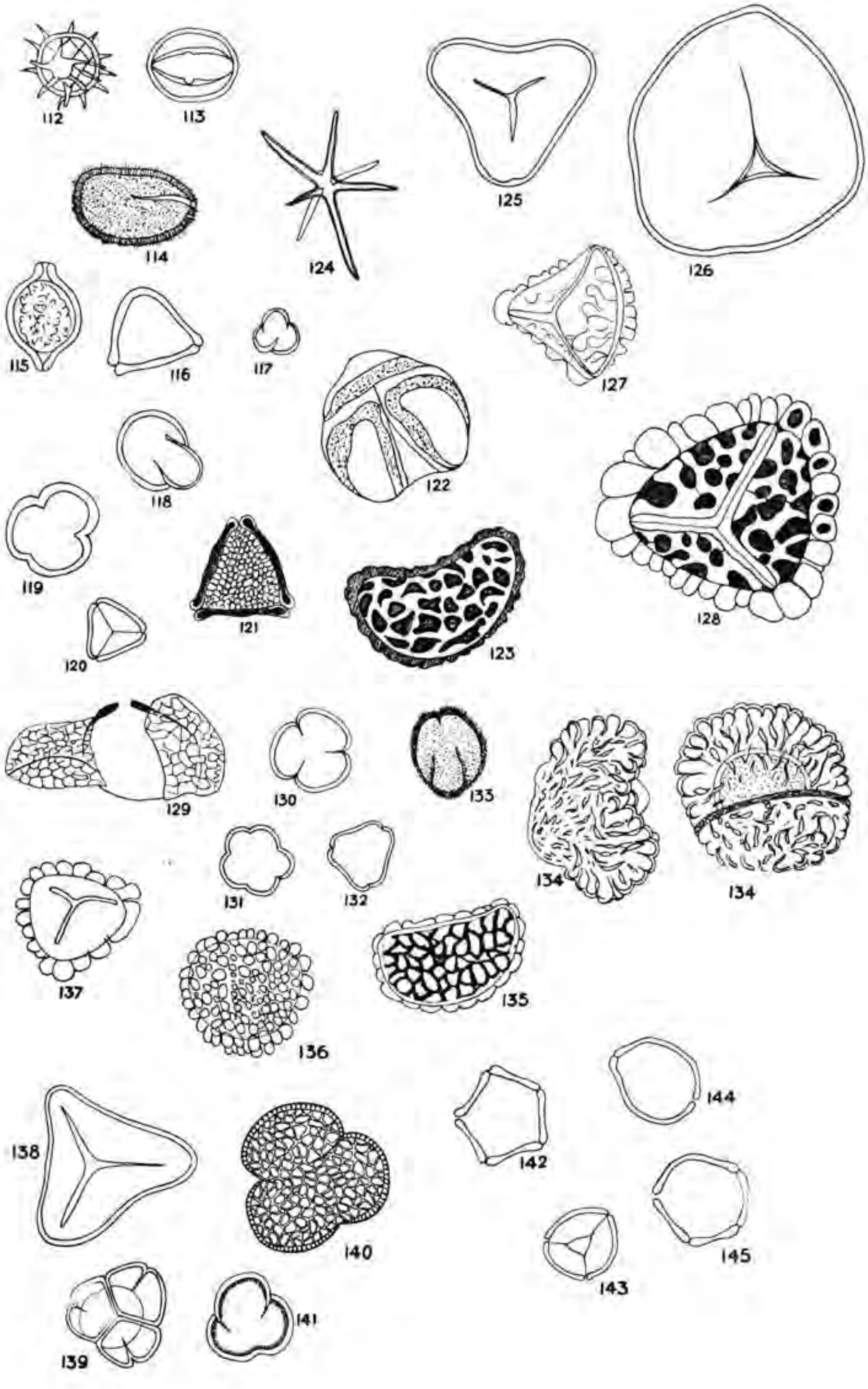
No. 10. Tiefe 2.35 m.
Pilzfäden, Reiser, Rinde, Blattfragment einer Dikotyle, Farnsporen und Sporangien, wenig Pollen, wenig Gebilde ähnlich Tafel IV, No. 124, Stacheln.

No. 11. Tiefe 50 m.
Blauer Ton.

PROFIL II. *EINE STRECKE WEITER.* DIE OBERFLÄCHE IST MIT ASCHE BEDECKT.

No. 12. Tiefe 85 cm.
Pilzfäden *(Endogone)*, Blattfragmente von Dikotylen, wenig Pollen,

TAFEL IV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TAFEL IV.

POLLEN UND SPOREN IN DEN TOPOGENEN MOOREN. 500 ×

112—124.	Toentoengan, Sumatra.
125. 126. 127.	Langen-Estate Java.
128.	Tjikasso.
129—137.	Toba Ebene.
129.	*Pinus Merkusii?*
134.	*Podocarpus imbricata,* Bl.
138—141.	Alahan Pandjang, Sumatra-Westküste.
142—145.	Diëng-Java.

Reiser, Rinde, Radizellen und Pustelradizellen, Gebilde ähnlich Tafel IV, No. 124, Farnsporen und Sporangien, dreieckige Farnspore.

No. 13. Tiefe 1 m.
Pilzfäden *(Endogone)*, wenig Pollen, Reiser, Rinde, Radizellen und Pustelradizellen, Epidermen von Monokotylen, wenig Gebilde ähnlich Tafel IV, No. 124, Gestachelte Sporen (?), Farnsporen, Sporangien.

No. 14. Tiefe 1.15 m.
Pilzfäden *(Endogone)*, wenig Pollen, Reiser, Rinde, Radizellen, Farnsporen, Sporangien, Treppentracheiden.

No. 15. Tiefe 1.30 m.
Pilzfäden *(Endogone)*, wenig Reiser und Rinde, Radizellen, Pustelradizellen, Pollen, viele Gebilde ähnlich Tafel IV, No. 124, Farnsporen, Sporangien.

No. 16. Tiefe 1.45 m.
Pilzfäden *(Endogone)*, wenig Reiser und Rinde, Radizellen, Pustelradizellen, Pollen, Gebilde ähnlich Tafel IV, No. 124, Farnsporen, Sporangien.

No. 17. Tiefe 1.60 m.
Pilzfäden, wenig Reiser und Rinde, Radizellen, Pustelradizellen, Pollen, Gebilde ähnlich Tafel IV, No. 124, Farnsporen, dreieckige Spore.

No. 18. Tiefe 1.75 m.
Pilzfäden und Sporen, wenig Reiser und Rinde, Radizellen, Pustelradizellen, Pollen, Gebilde ähnlich Tafel IV, No. 124, Farnsporen.

No. 19. Tiefe 1.90 m.
Pilzfäden, sehr wenig Reiser, Rinde, Radizellen, Pustelradizellen, Gramineenepidermis *(Leersia hexandra* SWARTZ), wenig Pollen, sehr viele Farnsporen, Sporangien, Treppentracheiden.

No. 20. Tiefe 2.05 m.
Pilzfäden, wenig Reiser, Rinde, Radizellen, Pustelradizellen, Gramineenepidermis *(Leersia hexandra* SWARTZ), wenig Pollen, Gebilde ähnlich Tafel IV, No. 124, Farnsporen, Sporangien.

No. 21. Tiefe 2.20 m.
Pilzfäden, wenig Reiser, Rinde, Radizellen, Pustelradizellen, wenig Pollen, Gebilde ähnlich Tafel IV, No. 124, Farnsporen, Sporangien.

No. 22. Tiefe 2.35 m.
Pilzfäden, wenig Reiser, Rinde, Radizellen, Pustelradizellen, Farnsporen, Sporangien, wenig Pollen.

No. 23. Ausgefallen.

No. 24. Tiefe 2.65 m.
Pilzfäden, keine Reiser oder Rinde, wenig Pollen, Radizellen und Pustelradizellen, Farnsporen, Sporangien.

No. 25. Tiefe 2.80 m.
Pilzfäden, keine Reiser oder Rinde, Radizellen und Pustelradizellen, wenig Pollen, Farnsporen, Sporangien.

No. 26. Tiefe 2.95 m
Pilzfäden, keine Reiser oder Rinde, Radizellen und Pustelradizellen, wenig Pollen, Gebilde ähnlich Tafel IV, No. 124, Farnsporen, Sporangien, Treppentracheiden.

No. 27. Tiefe 3.10 m.
Pilzfäden, keine Reiser, nur wenig Rinde, Radizellen, Pustelradizellen, Farnsporen, wenig Pollen.

No. 28. Tiefe 3.25 m.
Pilzfäden, keine Reiser, wenig Rinde, Radizellen, Pustelradizellen, Farnsporen, Sporangien, wenig Pollen.

No. 29. Tiefe 3.40 m.
Pilzfäden, keine Reiser, wenig Rinde, Radizellen, Pastelradizellen, Farnsporen, Sporangien, Gebilde ähnlich Tafel IV, No. 124, wenig Pollen.

No. 30. Tiefe 3.55 m.
Pilzfäden, keine Reiser, wenig Rinde, Radizellen, Pustelradizellen, Farnsporen, Sporangien, wenig Pollen.

No. 31. Tiefe 3.70 m.
Pilzfäden, keine Reiser oder Rinde, Radizellen, Pustelradizellen, Gramineenepidermis *(Leersia hexandra* SWARTZ), Farnsporen, Sporangien, wenig Pollen.

No. 32. Tiefe 3.85 m.
Pilzfäden, morsches Holz, Radizellen, Pustelradizellen, wenig Pollen, Farnsporen, Sporangien, dreieckige Spore, wenig Pollen.

No. 33. Tiefe 4.00 m.
Pilzfäden, morsches Holz, Radizellen, Pustelradizellen, einzelne Gebilde ähnlich Tafel IV, No. 124, Farnsporen, Sporangien, wenig Pollen.

No. 34. Tiefe 4.15 m.
Nur morsches Holz.

No. 35. Tiefe 4.30 m.
Pilzfäden, morsches Holz, Radizellen, Pustelradizellen, Moosblättchen, Gebilde ähnlich Tafel IV, No. 124, Farnsporen, Sporangien, wenig Pollen.

No. 36. Tiefe 4.45 m.
Pilzfäden, *(Endogone)*, morsches Holz, Radizellen, Pustelradizellen, Farnsporen, Sporangien, wenig Pollen.

DER SCHWINGRASEN ZU BAGOES KOENING.

Bagoes Koening liegt in der Nähe von Palembang (Süd-Sumatra). Der Schwingrasen befindet sich neben der Ölleitung der „Bataafsche Petroleum Maatschappij".

Schwingrasen sind eine häufige Erscheinung in der tropischen Ebene. Auf den groszen Flüssen gibt es sehr viele schwimmende Inseln, ausgedehnte Bestände aus *Susum malayanum* HOOK., aus *Eichhornia crassipes* SOLMS oder aus Gräsern, besonders *Panicum stagninum* RETZ. An Seerändern erblickt man oft schwingende Ufer, meistens aus Schilfen, Gräsern und Riedgräsern. Für Mittel- und Ost-Borneo wurde dies eingehend beschrieben von ENDERT (1925).

SCHÜRMANN (1922) betrachtet die Schwingrasen als das Anfangsstadium der groszen Waldmoore Sumatras, eine Behauptung, die bis jetzt noch nicht genügend begründet ist. Jedoch, vielmehr als in West-Europa wo die Schwingrasen meistens sekundären Ursprunges sind (GAMS 1927, POLAK 1929), liegt in den Tropen die Möglichkeit vor, dasz dieselben tatsächlich die Verlandung bewirken. In den Tropen gibt es nicht die regelmäszigen Stürme zusammen mit starkem Wellenschlag, welche in Europa die anfangs lockeren Bestände zerstören. Im ruhigen Wasser kann die schwimmende Insel dicht verwachsen und schlieszlich in dieser Weise eine andere Vegetation tragen, als diejenige, die sie gebildet hat. Wenn dies stattfinden würde, so hätte man hier eine Form der Verlandung mittels überwachsen.

Ob dazu die Schwingrasen noch torfbildend sind, erscheint mir zweifelhaft. Die gröszte Menge Pflanzenmaterial wird sich an der Oberseite, also an der Luft zersetzen und wird also ganz oxydiert. An der Unterseite darf man nur tote Wurzelfragmente erwarten. Die Ergebnisse der Untersuchung des Schwingrasens zu Bagoes Koening bestätigten die Erwartung, dasz ähnliche Formationen keine Torfbildner sind. Dieser Schwingrasen ist der einzige mir bekannte dieser Art, der kein offenes Wasser mehr aufweist. Die Vegetation hat also die wahrscheinlich anfangs offene Stelle ganz überwachsen. Obwohl das Pflanzendeck sich unter den Füszen schwingt, kann man es doch sehr gut betreten. Die Vegetation besteht aus hohen Kräutern mit eingestreut niedrigen Gehölzern. Bestandbildend ist *Scleria multifoliolata* BOECK., sehr häufig sind die Farnen *Nephrolepis biserrata* SCHOTT und *Stenochlaena palustris* BEDD., *Lycopodium cernuum* L., *Smilax leucophylla* BL. findet man eingestreut, häufig sind die Lianen *Flagellaria indica* L., eine *Uncaria*, *Cassytha filiformis* L. und eine *Nepenthes*. Eingestreut sind die Holzgewächse *Alstonia* sp., *Eugenia spicata* LAMK., *Campnosperma macrophylla* HOOK. f. *Wormia suffruticosa* GRIFF. Unter dieser Vegetation befindet sich kein Torf, sondern ein schwarzer, sehr wasserreicher Schlamm bis zu einer Tiefe von ± 2 m., wo es einen stark blauen Ton gibt. Im Schlamm findet man nur sehr vereinzelt erkennbare Pflanzenreste; Würzelchen, Epidermen, Pollen. Der Säuregrad = 3.

Man behauptet, die Vegetation sei ursprünglich, Ladangs (trockne Reisfelder) soll es dort nie gegeben haben.

Obwohl dieser Bestand keine Torfbildung aufweist, könnte es doch möglich sein, dasz ähnliche Stellen später von Moorwald bewachsen werden, eine Vegetation die infolge ihres Gewichts das Pflanzengeflecht eindrückt und selber hinauswächst; eine Vorstellung also, die nicht in Widerspruch ist mit den Tatsachen aus Kapitel I. In dieser Weise könnten Schwingrasen, welche offene Seen überwachsen haben, den ersten Anfang jener Waldmoore bilden, jedoch bedecken dieselben nicht die ganze Unterlage dieser Formationen, wie die Holzbefunde im unterliegenden Ton zeigen. (Fig. 3 und 4, S. 12).

JAVA.

DER TORFBESTAND ZU PAGANDARAN.

Pagandaran ist eine Kokosplantation im Süd-Westen von Java an der „Dirk de Vriesbaai" und wurde 1924 zuerst von WHITE beschrieben. Ein Teil der Pflanzungen liegt in einer Einsenkung des Bodens, einer ehemaligen Moorstelle, „Rawah", die urbar gemacht und angebaut worden ist. Nach dem Administrateur der Plantage, unter dessen Leitung diese Arbeit erledigt worden ist, war das ursprüngliche Pflanzendeck ein Bruchwald (Rawah-Busch) und hatte das Wasser braune Farbe. Jetzt findet man dort junge Kokospalmen mit *Robusta*-Kaffee als Unterwuchs. Wachstum und Produktion sind besser als in den andren Teilen der Plantage. Nur die älteren Palmen wachsen krumm und halbanliegend am Boden, bleiben aber gesund. Man sieht hier nicht die sterbenden, kranken oder toten Palmen wie in Laboean Bilik und der malaiischen Halbinsel (siehe die Fotografien VAN HEURNS 1922, COOKES 1930).

Der Pflanzer zu Pagandaran erklärte die Rawahböden als die besten für Kokos und Kaffee, im Gegensatz zu den Urteilen, welche man auf Sumatra zu hören bekommt! Es gibt aber zwei Unterschiede: erstens sind die Anpflanzungen zu Pagandaran jünger als diejenigen in Laboean Bilik, und auch dort war der Anfang vielversprechend. Zweitens aber ist die Reaktion des Bodens eine ganz andere. Der Torf zu Laboean Bilik ist sehr sauer, der zu Pagandaran alkalisch.

Man findet zu Pagandaran eine Torfschicht von ± 1 m. Mächtigkeit. Vor der Drainage musz diese Mächtigkeit bestimmt gröszer gewesen sein. An ungefähr 50 cm. Tiefe befindet sich eine Tonschicht; die Unterlage des Torfes besteht aus Sand. Dies ist der einzige Fall den ich kenne, sonst traf ich überall Ton unter dem Torf. Der Sand ist sehr reich an Kalk (wie auch WHITE 1924, erwähnt), mit Säuren braust er, man erkennt Fragmente von Muschelschalen mit freiem Auge. Einmal traf ich ein vollständiges Schalengehäuse, welches Frl. VAN BENTHEM JUTTING bestimmt hat als eine *Melania* Art, die sich in süszem oder brackischem Wasser aufhält. Die Drainagegräben waren ebenfalls sehr reich an Mollusken. Der Torf besteht aus Holzresten zusammen mit Gramineen-Cyperaceen und Farnen; eine Sukzession der Vegetation in den Schichten war nicht zu erkennen. Die Flora war wahrscheinlich ähnlich der jetzigen zu Rawah Lakbok am Tji Tandoej, ebenfalls an der Süd-Westküste. Man darf dieselbe als tropischen Bruchwald (Übergangsmoor) bezeichnen (Rottang, niedrige Bäume, Gebüsch und Schilfe).

BESCHREIBUNG DER PROBEN.

PROFIL I.

No. 1. Tiefe 30 cm.

Nur wenig Pilzfäden, Holz und Rinde, Baumwurzeln, wenig Pustelradizellen, wenig Pollen, Epidermen von Monokotylen (nur wenig), Blattfragment einer Dikotyle, Farnsporen und Sporangien, Skelett einer Arthropode.

No. 3. Tiefe 45 cm.

Tonlinse, Pilzfäden und Sporen, Holz und Rinde, viele Baumwurzeln, Radizellen und Pustelradizellen, Blattfragment einer Dikotyle, Monokotylenepidermen, Farnsporen und Sporangien, dreieckige Spore, wenig Pollen.

No. 5. Tiefe 60 cm.

Ton, Pilzfäden und Sporen, Holz und Rinde, Baumwurzeln (häufig), Radizellen und Pustelradizellen, Blattfragment einer Dikotyle, Farnsporen und Sporangien, wenig Pollen.

No. 7. Tiefe 75 cm.
Abwechselnd Tonschichten, Pilzfäden und Sporen, viel Rinde, Holz, Baumwurzeln (häufig), Radizellen und Pustelradizellen, Blattreste von Dikotylen, Reste von Arthropoden, Farnsporen und Sporangien, Dreieckige Farnspore, wenig Pollen.

No. 9. Tiefe 90 cm.
Pilzfäden und Sporen, viel Rinde, Holz, Baumwurzeln, Radizellen und Pustelradizellen, Cyperaceenepidermis, wenig Pollen, Schuppe eines Schmetterlings, Farnsporen und Sporangien.

No. 11. Tiefe 1.05 m.
Pilzfäden und Sporen, Rinde, Holz, Reiser, Baumwurzeln, Radizellen, Pustelradizellen, Blattreste von Dikotylen, Farnsporen und Sporangien, nur wenig Pollen.

PROFIL II. *AN DERSELBEN STELLE, EINE KLEINE STRECKE WEITER.*

No. 2. Tiefe 30 cm.
Pilzfäden und Sporen, viel Rinde, Holz, Reiser, wenig Wurzeln, viel Farnsporen und Sporangien, wenig Pollen.

No. 4. Tiefe 45 cm.
Pilzfäden und Sporen, Rinde und Holz, Blattreste von Dikotylen, Wurzeln, Farnsporen und Sporangien, wenig Pollen.

No. 6. Tiefe 60 cm.
Pilzfäden und Sporen, Rinde und Reiser, Cyperaceenepidermis, Farnsporen und Sporangien.

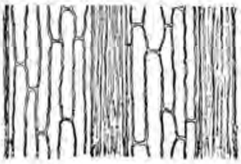
No. 8. Tiefe 75 cm.
Sand, Pilzfäden und Sporen, Reiser, Rinde, Baumwurzeln, Radizellen und Pustelradizellen, Farnsporen und Sporangien,

No. 10. Tiefe 90 cm.
Sand mit Muschelschalen.

PROFIL III. *IN DERSELBEN EINSENKUNG, EINE KLEINE STRECKE* WEITER.

No. 20. Tiefe 35 cm.
Pilzfäden und Sporen (nur wenig), Reiser und Rinde (häufig), weniger

TAFEL V



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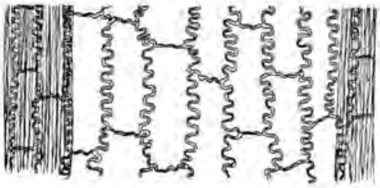

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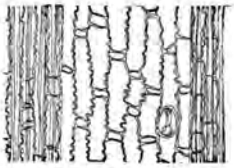

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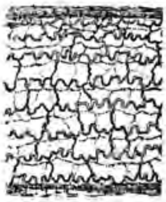

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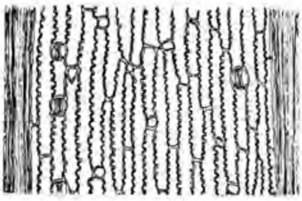

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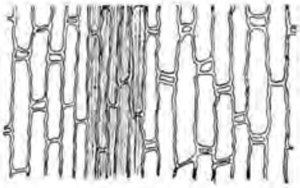

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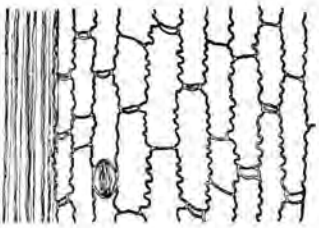

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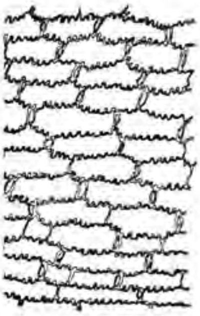

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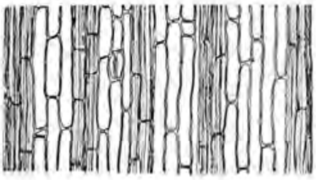

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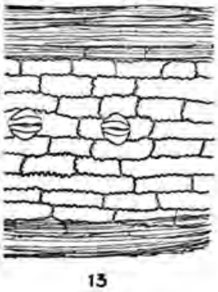

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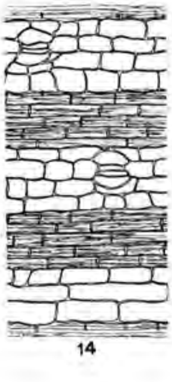

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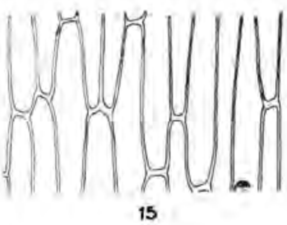

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TAFEL V.

EPIDERMEN VON GRÄSERN UND CYPERACEEN 202,5 ×

1. *Cladium rubiginosum*, K. DOMIN.
2. *Fuirena glomerata*, LAMK.
3. *Hymenachne amplexicaule*, NEES.
4. *Hypolythrum*, spec.
5. *Leersia hexandra*, SWARTZ.
6. *Panicum repens*, L.
7. *Panicum stagninum*, RETZ.
8. *Phragmites Karka*, TRIN.
9. *Rhynchospora aurea*, VAHL.
10. *Rhynchospora fusca*, DRYAND.
11. *Scirpus mucronatus*, POIR.
12. *Scirpus mucronatus*, L.
13. *Scleria elata*, THEID.
14. *Typha domingense*, PERS.
15. *Xyris sumatrana*, MALME.

Wurzeln als in Profil I, Radizellen und Pustelradizellen, Blattreste von Dikotylen (häufig), Farnsporen und Sporangien (häufig), Dreieckige Spore, Moosblättchen, Arthropodenreste, Schmetterlingschuppe, sehr wenig Pollen, Tetraden, Pollen ähnlich Tafel V, No. 114.

No. 21. Tiefe 50 cm.
Ton, Pilzfäden und Sporen, Holz und Rinde, Baumwurzeln, Radizellen Pustelradizellen, Farnsporen und Sporangien, sehr wenig Pollen.

No. 22. Tiefe 65 cm.
Mehr Ton, Pilzfäden und Sporen, Holz und Rinde, Baumwurzeln, Farnsporen und Sporangien, fast kein Pollen.

No. 23. Tiefe 80 cm.
Ton, Pilzfäden und Sporen, Holz und Rinde, Baumwurzeln, Radizellen Pustelradizellen, *Leersia*epidermis (?), Blattrest einer Dikotyle, Farnsporen und Sporangien, sehr wenig Pollen.

No. 24. Tiefe 95 cm.
Fast nur Ton, Pilzfäden und Sporen, Wurzeln, Rinde, Farnsporen und Sporangien, Arthropodenreste, wenig Pollen.

No. 25. Tiefe 110 cm.
Fast nur Ton gemischt mit Rinde, Pilzfäden, Reisern, Würzelchen.

No. 26. Tiefe 125 cm.
Ton mit Sand.

No. 27. Tiefe 140 cm.
Sand.

TJIKASSO ESTATE BEI BANDJAR.

Auf der Hevea Plantation Tjikasso, unweit von Bandjar in der Gegend des Tji Tandoejs trifft man ebenfalls eine Einsenkung im Boden, eine ehemalige „Rawah". Jetzt ist die Stelle mit *Hevea* bepflanzt. Die *Hevea*bäume wuchsen anfangs vorzüglich, später aber traten Erkrankungen auf, und die Bäume fingen an schief und krumm zu werden. Der Pflanzer war hier weit weniger begeistert von der Qualität des Torfbodens als auf Pagandaran.

Die ursprüngliche Vegetation ist ganz vernichtet. Die Torfschicht hat ungefähr 1 m. Mächtigkeit, 25 cm. gelber Ton liegt derselben auf, die Unterlage besteht aus blauem Ton. Die Zusammensetzung des Torfes ist nahezu konstant, eine Gliederung konnte nicht gezeigt werden. Es wurden Reste gefunden von Bäumen, Cyperaceen, Gräsern und Farnen. Besonders Palmenreste sind häufig, vermindern aber etwas nach unten zu. Als Palmenreste bezeichne ich die eigentümlichen braunschwarzen Würzelchen, die in groszen Mengen gefunden wurden. Die Anordnung der Zellen ist sehr regelmäszig, die Farbe ist sehr dunkel. In denselben Proben findet man Bündeln harter, brauner Gefäsze, die den Fibrovasalsträngen der Palmen sehr ähnlich sind. Oft kann man die steifen Bündel in groszen Mengen makroskopisch auffinden. Die Verminderung der Palmenreste geht Hand in Hand mit einer Zunahme der Gräser und Cyperaceen. Wahrscheinlich wird es viel Rottang gegeben haben, wie es jetzt noch der Fall ist in den Tji Tandoej-Sümpfen. Man darf den Torf von Tjikasso als Bruchwaldtorf betrachten. Die Messung des Säuregrades fand erst nach einer Woche statt. Herr TAN fand die merkwürdigen Zahlen $p_H = 8.93$ und 8.41. Vielleicht ist aber die lange Zeit des Aufbewahrens vor der Bestimmung die Ursache dessen, und war die Flüszigkeit schon in Gährung und Zersetzung begriffen.

BESCHREIBUNG DER PROBEN.

PROFIL I.

No. 1. Oberfläche, gelber Ton.

No. 2. Tiefe 25 cm.
Fast nur schwarze Würzelchen (von Palmen?), Pilzfäden und Sporen, Farnsporen, Sporangien und Tracheiden, dreieckige Spore, Tafel IV, No. 128, wenig Rinde, kein Pollen.

No. 3. Tiefe 45 cm.
Nur wenig Pilzreste, dieselben schwarzbraunen Würzelchen als in Probe 2, Radizellen und Pustelradizellen, Rinde, Farnsporen, Sporangien, Treppentracheiden, fast kein Pollen.

No. 4. Tiefe 65 cm.
Pilzfäden und Sporen (*Endogone*), die schwarzbraunen Würzelchen aus Probe 2, Radizellen und Pustelradizellen, Cyperaceenepidermis, Farnsporen, Sporangien, Treppentracheiden, Arthropodenreste, Pollen von Gräsern und Cyperaceen.

No. 5. Tiefe 80 cm.
Pilzfäden und Sporen, schwarzbraune Würzelchen wie in Probe 2, Radizellen und Pustelradizellen, Epidermis einer Monokotyle, Schilfähnliche Stengel, Farnsporen und Sporangien, Diatomee.

No. 6 Tiefe 95 cm.
Pilzfäden und Sporen, weniger schwarzbraune Würzelchen, Rinde, Holz, Reiser, Zunahme Radizellen, Pustelradizellen, Blattreste, Farnsporen und Sporangien, sehr wenig Pollen.

No. 7. Tiefe 1.10 m.
Pilzfäden und Sporen, viel Holz und Rinde (von Palmen?), schwarzbraune Würzelchen, Radizellen, Pustelradizellen, Farnsporen, Sporangien, Treppentracheiden, dreieckige Spore, Arthropodenreste, nur wenig Pollen.

No. 8. Tiefe 1.25 m.
Ton, gemischt mit: Treppentracheiden, Farnsporen, Blattfragmenten, Pilzresten und sehr wenig Pollen.

PROFIL II.

No. 9. Tiefe 50 cm.
Pilzfäden und Sporen, braune Würzelchen ähnlich als in Probe 2, Radizellen und Pustelradizellen, Gefäszbündel von Monokotylen, Holz, Farnsporen, wenig Pollen.

No. 10. Tiefe 65 cm.
Pilzfäden und Sporen (*Endogone*), viel braune Würzelchen, Radizellen und Pustelradizellen, Gefäszbündel von Monokotylen (Fibrovasalstränge), nur wenig Holz, Rinde (von Palmen?), Farnsporen, Sporangien, Treppentracheiden, wenig Pollen.

No. 11. Tiefe 80 cm.
Pilzfäden und Sporen, viel braune Würzelchen, Rinde, Radizellen, Pustelradizellen, wenig Pollen.

No. 12. Tiefe 95 cm.
Pilzfäden und Sporen (wenig), Rinde, Gefäszbündel von Monokotylen (Fibrovasalstränge), braune Würzelchen, Radizellen, Pustelradizellen, Farnsporen und Sporangien, Arthropodenreste, wenig Pollen.

Grosze Mengen Palmrinde (?) und Fibrovasalstränge wurden ausgegraben.

PROFIL III.

No. 14. Tiefe 25 cm.
Gemischt mit gelbem Ton: Pilzfäden und Sporen (wenig), braune Würzelchen, Rinde, Radizellen und Pustelradizellen, Gebilde ähnlich Tafel IV, No. 124, sehr wenig Pollen.

No. 15. Tiefe 50 cm.
Pilzfäden und Sporen, sehr viele braune Würzelchen, Rinde, Radizellen, Pustelradizellen, Farnsporen und Sporangien, sehr wenig Pollen.

No. 16. Tiefe 65 cm.
Pilzfäden und Sporen, sehr viel braune Würzelchen, Radizellen und Pustelradizellen, Rinde, Farnsporen, sehr wenig Pollen.

No. 17. Tiefe 80 cm.
Pilzfäden und Sporen, sehr viel braune Würzelchen, Rinde, Radizellen, Pustelradizellen, Fibrovasalstränge, Farnsporen und Sporangien, wenig Pollen.

No. 18. Tiefe 95 cm.
Pilzfäden und Sporen, braune Würzelchen, Rinde, Fibrovasalstränge, Radizellen, Pustelradizellen, wenig Farnsporen, wenig Pollen.

No. 19. Tiefe 1.10 m.
Pilzfäden und Sporen, braune Würzelchen, Rinde, Fibrovasalstränge, Pustelradizellen, wenig Pollen.

No. 20. Tiefe 1.25 m.
Hauptsächlich Ton, Pilzfäden und Sporen, weniger braune Würzelchen, Radizellen und Pustelradizellengeflecht, Rinde, Fibrovasalstränge (wenig), Farnsporen (wenig), Pollen (wenig).

LANGEN ESTATE BEI BANDJAR.

Diese *Hevea*plantage, unweit Tjikasso, umfaszt einen Teil der groszen Tji Tandoej Sümpfe, Rawah Lakbok genannt, etwa 55 km. landeinwärts der Mündung dieses Fluszes. Der noch unkultivierte ursprüngliche Teil der Rawah ist mit Rottang, Bambus und niedrigem Gebüsch bewachsen, worin eingestreut ausgedehnte Schilffelder vorkommen. Diese Vegetation hat eine Torfschicht abgesetzt auf blauem Ton. Ebenso wie auf Tjikasso wird dieser Torf von einem gelben Ton überlagert. Zwei Profile wurden bemustert, eins in der eigentlichen Pflanzung, eins auszerhalb derselben. Die Mächtigkeit der Torfschicht nimmt ab; in der Nähe der Wohnung des Administrators liegt der gelbe Ton dem blauen auf; der Torf ist verschwunden. Es zeigt sich, dasz die Torfablagerung etwa eine Linsenform hat. Eine Erhöhung der Oberfläche konnte nicht gezeigt werden (Figur 6.)

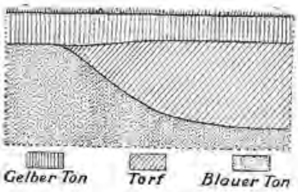

Fig. 6
Schema der Torfschicht zu Langen-Estate.

Die Zusammensetzung des Torfes zeigt grosze Ähnlichkeit mit der bei Tjikasso. Holz kommt aber reichlicher vor als dort. Auch im Torfe Langens gibt es viel scharzbraune Würzelchen, wahrscheinlich von Palmen (*Metroxylon* ?, Rottang?), viele Farnenreste, Pilzfäden, Sporen und nur wenig Pollen. Nach unten (Profil I, No. 28, Profil II, No. 34), vermindern die braunen Würzelchen und treten Gräser und Cyperaceen in den Vordergrund. Dreimal wurde eine Diatomee gefunden. Den Anfang des Torfes bildeten wahrscheinlich die Gräser und Cyperaceen, eine Vegetation ähnlich den Schilffeldern, die wir noch jetzt sehen. Später haben sich diese in Bruchwald umgewandelt. Eine vertikale Gliederung des Torfes läszt sich hier also zeigen, und man kann sich fragen, ob ein weiterer Fortschritt vielleicht zum Moorwald-Typus Sumatras führen würde.

Zur Zeit JUNGHUHNS' war die Rawah Lakbok auch horizontal zoniert. „Dieselbe war mit Bruchwald bedeckt, der Rest ist während der trockensten Monaten des Jahres in ein Grasgelände umgeformt, mit Ausnahme des zentralen Teiles, wo immer Wasser stehen bleibt." In ähnlicher Weise ist also der jetzige Torf aufgebaut und gewisz würde dieser Prozess noch immer weiter fortschreiten, hätte nicht die Kultur eingegriffen und die Beziehungen geändert und zerstört.

BESCHREIBUNG DER PROBEN.

PROFIL I.

No. 22. Tiefe 50 cm.
Viel Holz, nur wenig Pilzreste (*Endogone*), braune Würzelchen, ähnlich Tjikasso, Gefäszbündel von Monokotylen (Palmen?), Fibrovasalstränge, Farnsporen, Sporangien, wenig Pollen.

No. 23. Tiefe 65 cm.
Holz, wenig Pilzreste (*Endogone*), viel braune Würzelchen, ähnlich Tjikasso, wenig Fibrovasalstränge, einzelne Radizellen und Pustelradizellen, Gebilde ähnlich Tafel IV, No. 124, Arthropodenreste, wenig Pollen.

No. 24. Tiefe 80 cm.
Holz, Rinde, wenig Pilzreste, sehr viel braune Würzelchen ähnlich Tjikasso, Farnsporen, wenig Pollen.

No. 25. Tiefe 95 cm.
Sehr viel Holz, Rinde, wenig Pilzreste, braune Würzelchen ähnlich Tjikasso, Gefäsze von Monokotylen (Palmen?), Blattreste Dikotylen, Farnsporen, wenig Pollen.

No. 26. Tiefe 1.10 m.
Sehr viel Holz und Rinde, wenig Pilzreste, braune Würzelchen ähnlich Tjikasso, Gefäsze von Monokotylen (Palmen?) Farnsporen, wenig Pollen.

No. 27. Tiefe 1.25 m.
Holz, Rinde, wenig Pilzreste, braune Würzelchen ähnlich Tjikasso, Gefäsze von Monokotylen (Palmen?), Farnsporen, wenig Pollen.

No. 28. Tiefe 1.40 m.
Die braunen Würzelchen werden nicht mehr gefunden, Holz, Reiser, Rinde (*Endogone*), Baumwürzelchen, viele Farnsporen dreieckiger Form, ähnlich Tafel IV, No. 128, viel Pollen, verschiedene Diatomeen, *Navicula* sp., Ton.

No. 29. Tiefe 1.55 m.
Wenig Pilzreste, fast keine braune Würzelchen, Baumwürzelchen, Farnsporen, Sporangien, wenig Pollen.

No. 30. Tiefe 1.70 m.
Rinde, wenig braune Würzelchen, Radizellen, Pustelradizellen, viele Farnsporen, Blattreste Dikotylen, Zunahme Pollenkörner.

PROFIL II NEBEN PROFIL I.

No. 31. Tiefe 50 cm.
Viel Holz, Rinde, wenig Pilzreste, viel braune Würzelchen, Baumwürzelchen, viele Farnsporen, Sporangien, Blattfragment einer Dikotyle, wenig Pollen.

No. 32. Tiefe 65 cm.
Viel Holz, Rinde, wenig Pilzreste, braune Würzelchen, Baumwürzelchen, viele Farnsporen, Sporangien, Blattfragment einer Dikotyle, wenig Pollen.

No. 33. Tiefe 80 cm.
Viel Holz, Rinde, wenig Pilzreste, wenig braune Würzelchen, Baumwürzelchen, einzelne Radizellen und Pustelradizellen, viele Farnsporen und Sporangien, wenig Pollen.

No. 34. Tiefe 100 cm.
Viel Holz, Rinde, Baumwürzelchen, wenig Pilzreste, viele Farnsporen, Blattfragment einer Dikotyle, Diatomee, Moosästchen, wenig Pollen.

No. 35. Tiefe 1.15 m.
Ton, Holz, Rinde, wenig Pilzreste, Baumwürzelchen, einzelne Radizellen, Pustelradizellen, Farnsporen, Sporangien, dreieckige Spore, wenig Pollen.

No. 36. Tiefe 1.30 m.
Ton, Holz, wenig Pilzreste, Radizellen, Pustelradizellen, Moosblättchen, Farnsporen (u.m. dreieckige), wenig Pollen (u.m. *Calophyllum*-ähnliches).

DIE RAWAH PENING BEI AMBARAWA (± 450 m. ü. M.)

Die Talmulde bei Ambarawa ist ausgefüllt von einem See mit sumpfigen Ufern, die Rawah Pening, ein in Verlandung begriffenes offenes Wasser. Südlich wird die Rawah vom Vulkan Telemojo abgegrenzt, hinter dem der Merbaboe emporragt. Auf dem See fluten Inseln aus üppigen *Eichhornia crassipes*-Beständen, an untiefen Stellen gibt es schwimmende Gräservegetationen aus *Leersia hexandra* SWARTZ, *Hymenachne amplexicaulis* NEES, *Eriochloa ramosa* O.KTZ, *Panicum stagninum* RETZ, und *Phragmites Karka* TRIN., die ebenfalls einen breiten Saum am Ufer bildet. Die *Phragmites* bildet lange Ausläufer, die über der Wasseroberfläche kriechen, die *Hymenachne amplexicaulis* NEES hat geschwollene Blattscheiden, Schwimmorgane für die langen Stengel. An einigen Stellen wuchsen Baumarten im Wasser: *Salix tetrasperma* BOXB., *Hibiscus tiliaceus* L., *Sarcocephalus orientalis* MERR. Schwimmende Wasserpflanzen auszerhalb *Eichhornia* gibt es mehrere, wie; *Jussieua repens* L., *Hydrilla verticillata* PRESL, *Susum malayanum* HOOK.f., *Nymphaea Lotus* L., *Nymphaea stellata* WILLD., *Ipomoea reptans* POIR., *Rhynchospora aurea* VAHL., *Monochoria hastata* SOLMS, *Cyperus elatus* L., An sumpfigen Stellen wurzelnd im Boden: *Scirpus erectus* POIR., *Rhynchospora aurea* VAHL., *Marsilea crenata* PRESL., *Polygonum pulchrum* BL., *Jussieua linifolia* VAHL., *Jussieua peruviana* L.

Diese Vegetationen waren, soweit ersichtlich, nicht in Torfbildung begriffen. An den sumpfigen Ufern hat die Bevölkerung Reisfelder angelegt; man kann dieselben aber nicht betreten, die Bearbeitung geschieht in kleinen Prauen aus hohlen Baumstämmen.

Torfbildung in der Rawah Pening ist von JUNGHUHN schon beschrieben worden. Schwimmende torfige Inseln waren plötzlich entstanden, nach JUNGHUHN hat der hydrostatische Druck dieselben vom Boden losgelöst. STOOP (1886) beschreibt Ähnliches. Vom Boden her sollte eine Torfinsel stammen von 72 bei 50 m.

Ich selber beobachtete einen Torfbestand am Ufer, völlig ohne Vegetation und unbegehbar. Der Torf war ein kompaktes Holzgeflecht ohne deutlich erkennbare Reste. Es wurden Farnsporen, Sporangien, Radizellen, Pustelradizellen und Moosblättchen darin aufgefunden. Sehr wahrscheinlich stammt auch dieser Torf vom Boden her.

Auf der Halbinsel Entassan, unweit des Dessah *Moentjol*, traf ich eine zweite Torfbildung am Ufer, die begehbar war. Die Torfschicht hatte etwa 2 m. Mächtigkeit und lag einem festen Ton auf. Der Boden schwingt unter den Füszen. An der Oberfläche gab es eine dünne Tonschicht, die vielleicht dort angebracht worden ist zwecks Sawahbau. Dieser Torf erwies sich als ein typischer Verlandungstorf. Anfangs besteht er aus Gräsern, Cyperaceen und Farnenresten, auch vielen Diatomeen, welche die Ablagerung im Wasser beweisen. Unter diesem Sumpftorf, in etwa 1 m. Tiefe, gab es eine deutliche Holzschicht, sogar ein Rottanghaken wurde gefunden.

Es ist sehr wahrscheinlich, dasz dort ein Wald ertrunken ist durch die Hebung des Wassers. Vulkanische Wirkung kann solches verursacht haben (man findet reichlich vulkanische Asche im Torf). An der Stelle des Waldes entstand ein Sumpf, dessen Verlandung die obere Schicht des Torfes lieferte.

Der von mir gefundene schwimmende Torf und die schwimmenden Inseln JUNGHUHNS und STOOPS stammen wahrscheinlich vom ehemaligen Walde her, der unter Wasser geraten und vertorft ist. Dieser Waldtorf kann, da er weniger schwer ist als Wasser, durch Gasbildung teilweise losgelöst werden, und an die Oberfläche geraten.

BESCHREIBUNG DER PROBEN.

PROFIL I. *HALBINSEL ENTASSAN.*

No. 70. Tiefe 55 cm.

Ton, wenig Pilzreste, wenig Holz, Rinde, Radizellen und Pustelradizellen, Farnsporen und Tracheiden, Blattreste von Dikotylen, wenig Pollen.

No. 71. Tiefe 70 cm.

Wurzelgeflecht, Radizellen, Pustelradizellen, keine Pilzreste, Holzfragmente, Blattreste von Dikotylen, Farnsporen, Sporangien *(Gleichenia*-ähnlich), Treppentracheide, Gramineen-Cyperaceenpollen, Diatomee *Navicula viridis* (?).

No. 72. Tiefe 85 cm.

Radizellen, Pustelradizellengeflecht, Farnsporen, Sporangien, Treppentracheide, Epidermis von *Leersia hexandra* SWARTZ, Moosblättchen, Gramineen- Cyperaceenpollen.

No. 73. Tiefe 100 cm.

Radizellen, Pustelradizellengeflecht, Farnsporen, Sporangien, Treppentracheide, Epidermis *Panicum stagninum* RETZ, Epidermis *Hymenachne amplexicaulis* NEES, *Endogone*, Gramineen-Cyperaceenpollen.

No. 74. Tiefe 1.15 m.

Radizellen, Pustelradizellen, Farnsporen, Sporangien, Treppentracheide, Wurzeln von Dikotylen, Holzfragmente, mehr Pilzreste.

No. 75. Tiefe 1.30 m.

Holz, Rinde, Reiser, Radizellen, Pustelradizellen, Pilzreste, Baumwürzelchen, Mykorrhiza, Blattreste von Dikotylen, Zunahme Pollen.

No. 76. Tiefe 1.45 m.
Holz, Rinde, Reiser, Radizellen, Pustelradizellen, Baumwürzelchen, Farnsporen, Sporangien, Treppentracheiden (sehr häufig), Pilzfäden, Blattfragmente von Dikotylen, Moosblättchen, verschiedene *Naviculae*.

No. 77. Tiefe 1.60 m.
Holz, Reiser, Rinde, Pilzfäden, Baumwürzelchen, Mykorrhiza, Radizellen, Pustelradizellen, Farnsporen, Sporangien, Treppentracheiden, Moosblättchen.

PROFIL III.

No. 79. Tiefe 85 cm.
Radizellen, Pustelradizellen, einzelne Reiser, wenig Rinde, Mykorrhizawürzelchen, Cyperaceenepidermis, Epidermis *Leersia hexandra* SWARTZ, *Tristania*-ähnliches Pollen, Diatomeen, *Navicula (viridis* EHRENB.?) Farnsporen, Sporangien *(Gleichenia*-ähnlich), Moosblättchen.

No. 80. Tiefe 1.00 m.
Radizellen, Pustelradizellen, einzelne Reiser, wenig Rinde, Cyperaceenepidermis, Pilzfäden *(Endogone)*, Blattreste von Dikotylen, Farnsporen, Sporangien, viele Treppentracheiden, Moose, Diatomeen (reichlich).

No. 81. Tiefe 1.15 m.
Reiser, Rinde, wenig Radizellen, Pustelradizellen, Epidermen von Gramineen, Cyperaceen, *Endogone*, Pilzsporen (wenig), sehr viele Farnsporen, Sporangien, Treppentracheiden, Moosblättchen, wenig Diatomeen.

No. 82. Tiefe 1.30 m.
Reiser, viel Rinde, Baumwürzelchen, viele Farnsporen, Sporangien, Treppentracheiden, *Endogone* Sporen, Moosblättchen.

No. 83. Tiefe 1.45 m.
Ton, Reiser, Rinde, Baumwürzelchen, Farntracheiden, Sporen, Sporangien, Pilzfäden, Radizellen, Pustelradizellen, Diatomeen.

B: GEBIRGSMOORE.

ALLGEMEINES.

Es ist eine weit verbreitete Ansicht, dasz es in der tropischen Ebene nur Tiefmoor gibt und Hochmoor nur im Gebirge. In Bezug auf die Ebene sei verwiesen nach Abschnitt I „Die regionalen Küstenmoore" wo dieses im allgemeinen abgelehnt wird; und ebenso gilt diese Aussage nicht fürs Gebirge. Man kann sich sogar der Auffassung nicht verschlieszen, dasz die hohe Lage dieser Formationen den Untersuchern den Gedanken des Hochmoores gegeben hat.

MOHR (1922) schreibt vom Hjang-Plateau in Besoeki: „Man findet dort merkwürdigerweise Stellen mit einer Art von bleichem Torf bedeckt, welche sich halten kann unter Einwirkung der Kombination von niedriger Temperatur und des Unterwasserstehens". Hier ist ohne Zweifel ein topogener Torf unter Wasser angedeutet worden, jedoch wird es in der Beschreibung Hochmoor genannt.

VAGELER (1930) behauptet, dasz nur die Gebirgsmoore aus Sphagnaceen gebildet, richtige Hochmoore sind, während sogar UMBGROVE in Bezug auf die Seen des Diëng-Plateaus sagt: „Dies (das Plateau) ist ein Kratersee gewesen, welcher schlieszlich von Sedimenten und von „Hochmoorformation" ausgefüllt wurde, sodasz grosze Strecken trockengelegt wurden".

Moorbildung im Gebirge wurde von mir untersucht auf der Toba-Ebene (Sumatra, 1450 m. ü.M.), Gedeh, Telaga Saät (Java, ± 1400 m. ü. M.) und Diëng Plateau (Java, ± 2000 m. ü. M.). Von den Herren JACOBSON und POSTHUMUS erhielt ich Proben aus Sumatra, Alahan Pandjang (Padangsche Bovenlanden 1500 m. ü. M.) und von dem Lindoesee auf Selebes, (1000 m. ü. M.)

Die Gipfel vieler Vulkane zeigen eine Einsenkung in der sich Wasser ansammelt. Wenn in dieser Weise kein Kratersee gebildet wird, so neigen doch die übrigen Gipfel zur Sumpfbildung (VON FABER, 1927). So findet man z.B. auf dem Papandajan und Pagrango sumpfige Stellen: das überflüssige Wasser wird von einem kleinen Bach abgeführt. Die Sumpfvegetation besteht dort aus Gräsern und Cyperaceen, auf dem Pangrango hauptsächlich aus *Isachne pangerangensis* Z.M. und *Carex hypsophila* MIQ.

Der Papandajan zeigt gröszere Verschiedenheit; dem Bach Tjiparoegpoeg entlang auf der Tegal Aloen-Aloen, findet man eine Ufervegetation aus *Sphagnum*polstern mit *Juncus prismatocarpus* R.BR., Gräsern und Cyperaceen.

Besonders auf dem Pangrangogipfel zeigt die Vegetation einen Hochmoorhabitus, die Carices bilden seichte Bulten, das Ganze hat eine braune

Farbe und sieht den toten Gehängemooren der Alpen sehr ähnlich. Jedoch gibt es einen groszen Unterschied. Obwohl auch hier spärliche Bündel Cyperaceen aus dem braunen Boden hervorragen, trifft man unter dieser dürftigen Vegetation eine mehr oder weniger mächtige Torfschicht, während auf der Pangrango die Pflanzen dem steinigen Boden aufsitzen. Ebenso wächst das *Sphagnum* des Papandajans unmittelbar auf Stein, ohne Torf abzulagern. Man darf daher diese Stellen nur als „anmoorig" bezeichnen.

Auf der Toba-Ebene (1450 m. ü. M.) kann man alle Stadien zwischen richtigen Sümpfen und den Anfängen von Torfmooren beobachten. Die Toba-Ebene wird von einer baumfreien Vegetation auf Liparit-Tuff bedeckt, welche hauptsächlich von *Gleichenia*, *Melastoma*, *Rhodomyrtus* und *Leptospermum* gebildet wird. Diese Planzen verleihen der Landschaft ein braunes dürres Aussehen, das hier und dort von der violett-rosa Farbe der *Melastoma* und *Rhodomyrtus* belebt wird. Der Ähnlichkeit wegen hat RUTTNER (1930) dies als „Toba-Heide" bezeichnet. Diese Ähnlichkeit mit einer europäischen Heide trifft weiter zu, wenn man die stellenweis eingestreuten Sümpfen betrachtet. Man findet auf der Toba-Ebene verschiedene Einsenkungen des Bodens, bisweilen mit Wasser gefüllt, doch meistens nur von einer Sumpfvegetation eingenommen, worin *Sphagnum* einen der wichtigsten Komponenten darstellt. Bei der Untersuchung, ob es auch Torfbildung gibt, zeigt sich, dasz der harte Untergrund nur 20 à 30 cm. unter der lebendigen Pflanzendecke liegt.

Das Diëng-Plateau wird von einigen Seen mit moorigen Ufern eingenommen. Sehr oft findet man dort Schwingrasenbildung: auf dem flutenden Pflanzengeflecht, dann und wann auf dem harten Boden und ein einziges Mal sogar im Wasser wächst *Sphagnum*. Diese Formation kommt sehr häufig vor, leitet aber nirgends zu vertikalen Ablagerungen!

Die Rawah Tjibeureum (Gedeh, ± 1400 m.) ist von VON FABER (1927) als ein im Anfangsstadium begriffenes Hochmoor bezeichnet worden. Jedoch findet man dort keine Spur von Torfbildung, die Vegetation besteht hauptsächlich aus hohen Schilfen, eingestreut trifft man *Nepenthes gymnamphora* NEES. Das Wasser dieser Rawah strömt, was auf die Humusablagerung keineswegs fördernd wirkt.

Typischer Waldhumus oder sehr humöser Waldtorf wurde auf Sumatra, Toba-Ebene, unweit Negri Djandi, gefunden und in der Nähe Alahan Pandjangs (Padangsche Bovenlanden). Die Ablagerungen haben beträchtliche Mächtigkeit erreicht, und bestehen grösztenteils aus einem fetten, braunen, seifenartigen Humus; eingelagert sind nur spärliche Reiser, Wurzeln und Rinde und viele gröszere Stämme und Stubben. Es ist ein ehemaliger Waldboden; an Stelle des Waldes aber trifft man jetzt Kulturgelände und eine wilde Vegetation aus kleinen Kräutern. Die Entstehung einer derartigen Formation war zu beobachten bei Si Borong-Borong, Toba Ebene. Dort wuchs ein ausgedehnter Urwald mit viel *Dacrydium Junghuhni* MIQ. Das stehende Wasser am sehr feuchten Boden hatte braune Farbe. JUNGHUHN (1847) beschreibt Ähnliches aus den „Battaländern": „Im Fluszbette selbst, von der Waldung beschützt, sieht ihr Wasser sehr dunkel aus, gesättigt kaffeebraun, geschöpft aber erscheint es in einem durchsichtigen Gefäsze goldgelb." Bei Si Borong-Borong konnte das Wasser wahrscheinlich nicht rasch in den Boden eindringen. Die Bevölkerung hatte eine Art Bohlweg aus Stämmen hergestellt. Torfbildung oder mächtige Humusschichten konnte ich dort nicht beobachten, doch wurde *Sphagnum* angetroffen. Merkwürdigerweise wuchs es im braunen Wasser auf kahlem Sandboden. Wenn jedoch das Wasser längere Zeit stehen bleibt, dann kann man sich vorstellen, dasz Humusschichten gebildet werden, und dasz Ablagerungen ähnlich Alahan Pandjang oder des noch zu beschreibenden Negri Djandi entstehen. Die Entstehungsweise solcher Formationen ist ombrogenen Ursprunges, offene Gewässer sind nicht zugewachsen. Der Torf hat aber wesentlich verschiedene Konsistenz als derjenige der regionalen Moorwälder der Ebene Sumatras. Es werden weniger Pilzreste gefunden, und ebenso sind andere deutlich geformte Elemente spärlich, nur Sporen und Pollen sind besonders häufig. Wenn man ähnliche Ablagerungen zu den Torfmooren rechnen darf, dann trifft man hier also Hochmoor im Gebirge.

Die Hochmoore in den Tropen sind immer Waldmoore, von *Sphagnum* werden dieselben nicht zusammengesetzt. Jedoch ist *Sphagnum* oberhalb 1200 m. (WARNSTORF, 1912) sehr häufig in dem Archipel. Die Pflanze wächst nur an feuchten Stellen, der Habitus ist ähnlich demjenigen Europas; daher kann man leicht verstehen, dasz verschiedene Forscher die Vegetation als Hochmoor bezeichnet haben. Jedoch sogar in Europa wird von Nicht-Botanikern oft das Vorkommen von Torfmoosen als Indikator des Hochmoores angemerkt. So allgemein aufgefaszt ist das unrichtig, denn der Genus *Sphagnum* umfaszt viele Arten; verschiedene bevorzugen Tiefmoorgelände und wachsen zwischen Schilf oder auf Schwingrasen, an Gesteinen oder auf dem Rohhumus der Wälder. Massenhaft als Torfbildner kommen die Sphagnen nur vor in den gemäszigten Gegenden mit ozeanischem Klima und empfangen das Wasser als Niederschlagswasser, wachsen also ombrogen. Bisher habe ich auf Java und auf der Toba Ebene nur *Sphagnum* gefunden dort wo der Boden feucht war und an Schwingrasen. In den meisten Fällen war das Wasser genügend sauer, auf dem Schwingrasen bevorzugte das *Sphagnum* die sauersten Stellen. So beschreibt RUTTNER (1930) einen Tümpel in der Nähe von Huta Gindjang (Toba Ebene, Sumatra). Die p_H des Wassers betrug 5.5, der Schwingrasen aber, mit *Sphagnum* bewachsen, hatte $p_H = 4–4.2$. Öfters habe ich *Sphagnum* unmittelbar auf dem Gestein wachsen sehen, z.B. am Tji Paroegpoeg (Java; Papandajan, 2600 m. ü. M.). Auch auf dem Diëng-Plateau traf ich *Sphagnum* mehrmals auf hartem Untergrund wachsend, öfters auch auf Schwingrasen und dann und wann sogar im Wasser. Es ist aber bezeichnend, dasz, sobald der Schwingrasen ganz festgewachsen ist, das Torfmoos verschwindet. Dort sollte eben die Bildung des Hoochmoores anfangen!

Auf nacktem Sand unter Wasser wuchs das *Sphagnum* im Wald bei Si Borong-Borong.

Aus dem vorigen, aus der Literatur und aus mündlichen Mitteilungen geht also hervor, dasz Torfbildung mittels Sphagnum selten ist, vielleicht garnicht vorkommt in Indien.

KEILHACK (1915) erwähnt *Sphagnum*moore im Gebirge Ceylons. Das von ihm wegen des Vorkommens von *Sphagnum* als Hochmoor angemerkte Gelände ist höchstens Sumpfmoor am Ufer eines verlandenden Tümpels. GATES (1915) beschreibt eine *Sphagnum*vegetation am Ufer eines Kratersees auf den Philippinen. Der Habitus hat viel Ähnlichkeit mit dem des Diëng-Plateaus, teilweise wuchs hier das *Sphagnum* über dem Wasser. MOHR (1922) erwähnt *Sphagnum* auf dem Hjang Plateau, sagt jedoch nicht klar in welcher Weise es dort wächst.

Nur wenn die *Sphagnum*vegetation künstlich zerstört ist, wie es der Fall war unter Einwirkung einer Solfatare bei Telaga Warna (Diëng) und auf der Toba Ebene bei Lintang Nihoeda, wo es gebrannt hatte, hat die noch nicht völlig zerstörte Schicht grosze Ähnlichkeit mit *Sphagnum*torf.

Das *Sphagnum* in den Tropen ist also beschränkt auf Stellen, wo die Temperatur niedrig ist und der Boden genügend Wasser enthält. Die Ursache, dasz dort dauerend wachsende, torfablagerende Sphagneta fehlen, liegt wahrscheinlich in der wechselnden Feuchtigkeit der Atmosphäre.

Schon JUNGHUHN (1853) beschreibt in folgender Weise das Gebirgsklima: „Die Feuchtigkeit des Dunstkreises nimmt ab auf eine deutlich erkennbare Weise; je höher wir steigen, desto weniger Wasserdampf enthält die Luft. Dieselbe wird nicht nur relativ trocken, doch auch im absoluten Sinn, je mehr wir uns vom Wolkensaum entfernen". „Trotz der herrschenden Kälte, wird man oft von Durst gequält, und wenn man sich dort in den trocknen Monaten des Jahres länger aufhält als einen Tag, so bekommt man eine berstende Haut an Gesicht, Lippen und Händen, welche schmerzend glüht".

BRAAK (1927) studierte das Klima des Pangrango, des höchsten Gipfels West-Javas. Ein Diagramm der Feuchtigkeitsverhältnisse von 15—20 August 1913 zeigt, dasz der Gehalt an Wasserdampf wechselt von 100 % am Morgen bis 30 % in der Nacht. Besonders während des Ost-Monsuns sind die Schwankungen grosz. BRAAK gibt an von 20—23 September 1913, dasz auf eine Nacht von 100 % Feuchtigkeit, solche mit 14 und 10 % folgten. (Fig. 7.)

In derselben Abhandlung wird ein Zitat Dr. DOCTERS VAN LEEUWEN entliehen: „Am Mittwoch, den 27 August 1924 war es sehr trocken in der Luft, das Hygrometer wies etwa 20 % Wasserdampf an; am folgenden Freitag, Samstag und Sonntag stieg es bis 100 %. Alles schaute wieder frisch aus, die Moospolster hatten sich vol Wasser gesogen." Hieraus darf man schlieszen, dasz vorher die Moose trocken gewesen waren.

Eine derartige Trockenheit in der Luft und die Intensität der Sonnenbestrahlung verhindern die *Sphagnum*torfbildung und dieses Moos kann deshalb nur in stagnierendem, saurem Wasser wachsen. Torfbildung kann in einem solchen Klima nur dort stattfinden, wo die Pflanzenreste unter Wasser vor Oxydation, Austrocknung und Zersetzung geschützt werden.

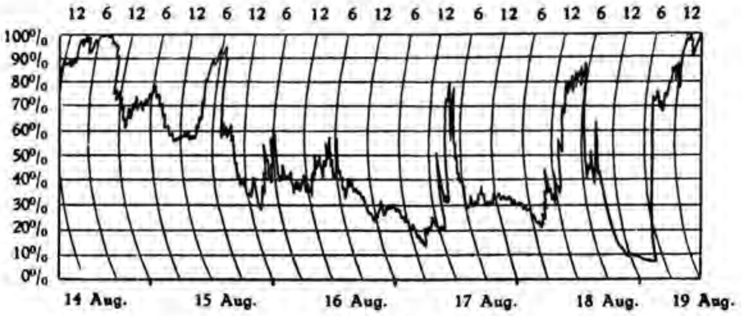

Fig. 7

Verlauf der Feuchtigkeitskurve auf dem Pangrango. (Nach BRAAK).

In den Torfproben wird Sphagnum nur ausnahmsweise und immer sehr spärlich gefunden.

SUMATRA.

DIE TOBA EBENE (1400 M. ü. M.).

Ringsum den groszen Toba See erstreckt sich die fast baumlose Toba Ebene. Man erfährt jedoch recht bald, dasz dieses Plateau in früheren Zeiten bewaldet war, denn der Boden ist reich an einer Art von Kienholz, Stämmen, Strunken, Wurzelmassen, die von der Bevölkerung ausgegraben und als Brennstoff verwendet werden. Auch weist die Toba-Ebene einige „Torfböden" auf; bei näherer Betrachtung stellt sich heraus, dasz dieselben ehemalige eingetrocknete, humusreiche Waldböden sind.

Dasz die Entwaldung aus verhältnismäszig rezenter Zeit datiert, hat schon JUNGHUHN (1847) zuerst bemerkt, und später auch RUTTNER (1930). Der steppenähnliche Charakter der heutigen Vegetation ist also ein sekundäres Merkmal, hervorgerufen nachdem der Baumwuchs den Boden nicht mehr vor Austrocknung und die Pflanzen vor der direkten Sonnenbestrahlung schützte.

Die Toba-Ebene gilt bei den botanischen Reisenden als heideartig und torfig. Drei Typen von moorartigen Formationen haben diesen Gedanken eingegeben: 1. Die sumpfigen Stellen, wo der Boden ein wenig eingesunken und feucht ist, und wo spärliches Gestrüpp wächst, Gräser, Cyperaceen, Orchideen, Farnen, viel *Nepenthes tobaica* DANS. und wo die Bodenschicht ganz von *Sphagnum* eingenommen wird. Torfbildung findet aber nicht statt, das *Sphagnum* wächst fast unmittelbar auf hartem Gestein. 2. Kleine in Verlandung begriffene Tümpel. Man findet hier typische Schwingrasen, oft mit *Sphagnum* bewachsen. 3. Eine Art nackter Torf- oder Humusablagerungen, teilweise als Reisfelder angebaut, oder von einer Kräutervegetation bedeckt. Letztere sind fossile Waldböden, reichlich mit Holz durchsetzt.

LINGTANG NIHOEDA.

Bei Lingtang Nihoeda war eine sumpfige Stelle, wo eine Art Torf an der Oberfläche sichtbar wurde. Es erwies sich, dasz die Vegetation von Brand vernichtet worden war; die tote Schicht hatte viel Ähnlichkeit mit *Sphagnum*torf, hatte aber nur 50 cm. Mächtigkeit. Eine neue Vegetation war schon im Anwachsen; *Sphagnum*, Farnen und *Juncus*. Die Stelle ist sehr feucht und weich, die torfähnliche Masse ist noch wenig zersetzt und hat eine bleichgelbe Farbe.

Vielleicht liegt hier ein erstes Stadium der Torfbildung vor, und ist die Formation noch zu jung, um eine deutliche Vertorfung und Anhäufung der Pflanzenreste zu zeigen.

SI GELAPANG.

Ein verhältnismäszig groszer Sumpf ist der von Si Gelapang, in der Nähe von Si Borong-Borong. Das Moor ist flach und feucht, die Bodenschicht wird von *Sphagnum* eingenommen, daneben gibt es *Pleopeltis incurvata* MOORE, *Schizoloma ensifolium* J.SM., *Xyris sumatrana* MALME, *Isachne albens* TRIN, *Cladium rubiginosum* K.DOMIN., *Dendrobium conostalix* RCHB.f. Eingestreut niedriges Gestrüpp, hauptsächlich *Leptospermum flavescens* SM., weiter *Ilex cymosa* BL., *Melastoma malabathricum* L., *Vaccinium lucidum* MIQ., *Rapanea arvensis* MEZ. Epiphytisch wachsen *Lycopodium squarrosum* FORST. forma *hippuroides* und *Pleopeltis incurvata* MOORE. Grosze Schlingen *Nepenthes tobaica* DANS. wanden sich um die Stauden. Die Humusschicht war noch weniger als 30 cm. mächtig. RUTTNER (1930) nimmt an, dasz diese Sümpfe entstanden sind, nachdem der Wald gerodet war, dasz also die kurze Zeit des Wachstums daran Schuld sei, dasz bis jetzt noch kein Torf gebildet ist.

DOLOK MARGOE.

Am Wegrand bei Dolok Margoe liegt ein kleiner Tümpel, dessen Wasser weisz gefärbt ist vom abgespülten Liparit-Tuff. Die Tiefe beträgt nur ½ à ¾ m. an der Stelle, wo ein Schwingrasen auf dem Wasser empordringt. Unter dem Schwingrasen findet man Holzreste, jedoch kleine Sträucher wachsen ebenfalls eingestreut zwischen den Kräutern desselben. Die Rhizomen von *Rhynchospora fusca* R.BR., *Cladium rubiginosum* K.DOMIN. und *Panicum repens* L. tragen die Vegetation. Die beiden letzten Arten sind auch wichtige Schwingrasenbilder am Diëngplateau. Eingestreut findet man zu Dolok Margoe in diesem Gräser-Cyperaceen Bestand *Lycopodium cernuum* L., *Gleichenia linearis* CLARKE (nur an einzigen Stellen, ziemlich selten), *Schizoloma ensifolium* J.SM., *Eriocaulon cinereum* R.BR., *Xyris sumatrana* MALME, *Isachne globosa* O.K.; an den trockneren Stellen *Arundinella setosa* TRIN., *Lypocarpha argentea* R.BR., *Fuirena umbellata* ROTTB., *Fimbristylis miliacea* VAHL., *Scirpus mucronatus* L., *Dendrobium conostalix* RCHB.f., *Spathoglottis aurea* LINDL., im Wasser *Brasenia purpurea* CASP., an feuchten Stellen *Burmannia disticha* L., *Centella asiatica* URB., *Utricularia* sp., *Limnophila villosa* BL. ebenso häufig als *Hypericum mutilum* L. Einige sehr kleine Stauden findet man eingestreut: *Viburnum coriaceum* BL., *Ficus diversifolia* BL., *Melastoma malabathricum* L. Der Schwingrasen ist tragfähig, sinkt jedoch am jüngsten Zuwachs sehr stark ein beim Betreten. Es hat allen Anschein, dasz das Ganze noch in Bildung begriffen ist und dasz am Ende der Tümpel ganz zuwachsen wird. Vielleicht würde dann Hochmoor darauf entstehen.

NEGRI DJANDI.

Die Ladangs zu Negri Djandi, Distrikt Dolok Sanggoel, sind angebaut auf einem torfigen Humus. Unter der Kulturschicht gibt es etwa 30 cm. Torf aus Reisern und Wurzeln, eingebettet in braunem plastischen Humus. Hierauf folgt eine hellgelbe Schicht, welche nach Aussage der Bevölkerung eine Mächtigkeit von etwa drei Mannshöhen erreichen kann. Diese Schicht hat nach den Behauptungen der Bataks den gröszten Wärmeeffekt, das Material wird von ihnen als Hausbrennstoff zum Kochen verwendet. Auch wird er auf den Ladangs angebracht und verbrannt, die Asche soll den Boden verbessern. Die gelbe Farbe dieser Erde verdunkelt rasch an der Luft und wird braun. Beim Verbrennen hinterlässt dieser „Torf" eine gelbe Asche mit vielen Quarzkrystallen. Wahrscheinlich hat JUNGHUHN auf seiner Reise in die Battaländer (1847) Ähnliches gesehen, wenn er beschreibt, dasz: „das Thonlager überall von einer meistens drei, oft fünf Fusz dicken Schicht fruchtbarer, dunkelbrauner, leichter humusreicher Erde bedeckt ist. Diese echt vegetabilische Erde, die in vielen Gegenden wahrer unvermengter Humus ist, und überall die oberste Plateaudecke darstellt, kann unmöglich aus der fortschreitenden Zersetzung und ferneren Umwandlung des unten ihr liegenden Thones, ohne Mitwirkung von organisch-pflanzlichen Kräften entstanden sein, sondern sich nur durch Vermoderung von vegetabilischen Substanzen, von Wurzeln und Holzteilen, in ruhiger Aufeinanderfolge von Jahrhunderten gebildet haben, — und deutet deshalb durch ihr Vorhandensein auf das vormalige Bestehen von Wäldern in diesen jetzt kahlen und baumlosen Grasebenen, von Wäldern unter deren Decke vielleicht Jahrtausende lang das Plateau beschattet lag, ehe ihnen die allesumschaffende Hand des Menschen den Untergang bereitete."

Diese Schilderungen JUNGHUHNs werden bestätigt von einer Wahrnehmung an einem Wegrand zu Negri Djandi. Dort war eine hohe Wand abgestochen worden, in diesem Profil war zu beobachten, dasz die obere Schicht hauptsächlich aus Holzresten zusammengesetzt war, ganze Stämme, und Wurzelstrünke, die untere Schicht mehr aus Wurzeln. Die Stämme hatten horizontale, aber auch vertikale Stellung und stammten gröszenteils her von *Dacrydium Junghuhnii* MIQ und *Podocarpus imbricata* BL.

Die gelbe Erde, im Laboratorium mit KOH gekocht und aufgeschlämmt im Siebe, weist einen groszen Reichtum auf an Pollen und Sporen. Ebenso pollenreich ist aber der braune Humus der oberen Schicht, die vielleicht dasselbe Material darstellt wie die untere, nur verfärbt unter Einwirkung der Luft. Es ist also einleuchtend, dasz hier ein ehemaliger Waldboden vorliegt, gebildet von einem Wald, ähnlich dem von Si Borong-Borong (Siehe Anfang dieses Abschnittes).

NEGRI DJANDI.

Probe der Oberfläche:

I. Stämme von *Podocarpus imbricata* BL. und *Dacrydium Junghuhnii* MIQ.

Wurzeln, Rinde, wenig Pilzreste, sehr viel Pollen von *Podocarpus imbricata* BL., wenig *Dacrydium*-pollen, *Calophyllum*-ähnliches Pollen, Ericaceen-Tetraden, *Dipterocarpaceen*-Pollen, Farnsporen.

II. Gelbe Erde.

Kleinere Würzelchen, Cyperaceenepidermis und Würzelchen, Pilzfäden und Sporen, *Podocarpus imbricata*-Pollen (sehr häufig), weniger *Dacrydium*-Pollen JUNGH. und DE VR., ? Pollen von *Pinus Merkusii* (2 St.), Farnsporen und Sporangien (sehr häufig), Moosblättchen.

ALAHAN PANDJANG (PADANGSCHE BOVENLANDEN, 1500 m. ü. M.)

Der bekannte Naturforscher EDW. JACOBSON sandte mir Material von einer torfigen Stelle zu Alahan Pandjang am Wege Solok-Alahan Pandjang, etwas nordlich von Danau di Atas. Die fotografischen Bilder, welche mir dazu geschickt wurden, zeigen dasz das Gelände nicht mehr mit der ursprünglichen Vegetation bewachsen ist. Der Boden ist flach, von einem Gräser-Cyperaceenbestand bedeckt mit eingestreuten kleinen Stauden; hier und dort trifft man kleine Tümpeln an. Pferde und Rinder weiden auf dem Grasgelände. Nach Mitteilungen des Herrn JACOBSON wird die obere Schicht öfters abgebrannt und verwendet man die Asche auf den Ladangs. Das torfige Material findet auch Verwendung als Brennstoff, ebenso die sehr zahlreichen Stämme und Wurzelstrunken, von welchen der Boden durchzogen ist. Die Mächtigkeit der Schicht wurde nicht bestimmt, übertrifft aber nach Aussage der Bevölkerung, die Höhe eines Menschen. Es gibt also in der Bezeichnung und in der Verwending dieser Erde grosze Übereinstimmung mit der der Toba Ebene. Die Proben zeigen viel Ähnlichkeit mit denen von Negri Djandi; Reiser, Rinde, Wurzeln, verkittet von einem plastischen braunen Humus. Besser als dieses Material Torf zu nennen, wäre es von Waldhumus oder Trockentorf zu reden. Die Reiser und Holzreste sind fast unzersetzt, die Grundmasse aber, in der dieselben eingebettet sind, ist ganz homogen. Nach vorheriger Behandlung mit Kalilauge, nach Absieben und Zentrifugieren, zeigt sich, dasz diese Erde ebenso reich ist an Pollen — besonders von *Podocarpus* — als diejenige von Negri Djandi. Auch hier hat ein ehemaliger Wald Humusschichten abgelagert. Der Wald ist gerodet worden, hat aber seine Spuren in diesen Ablagerungen hinterlassen.

BESCHREIBUNG DER PROBEN.

ALAHAN PANDJANG.

No. 1.

Holz, Wurzeln, Pilzfäden und Sporen, Farnsporen (häufig), *Eugenia*-ähnliches Pollen, Ericaceen-Tetraden, Schmetterlingschuppe, die Grundmasse ist ungeformte Humus, nur wenig organische Reste.

No. 2.

Holz, Wurzeln, Rinde, Pilzreste (spärlich), *Podocarpus*-Pollen (sehr häufig), *Dipterocarpaceen*-Pollen, *Eugenia*-ähnliches Pollen, *Ericaceen*-Tetraden (häufig), Gestacheltes Pollen, Farnsporen, auch dreieckige.

No. 3.

Holz, Wurzeln, Rinde, Pilzreste (spärlich), *Podocarpus*-Pollen (sehr häufig), *Pinus Merkusii*-Pollen? *Dacrydium*-Pollen, *Ericaceen*-Tetraden (häufig), Moosblättchen, Farnsporen, auch dreieckige.

No. 4.

Holz, Wurzeln, Rinde, Pilzreste, *Podocarpus*-Pollen (sehr häufig), ? *Pinus Merkusii, Ericaceen*-Tetraden (häufig), Farnsporen, auch dreieckige (häufig), Moosblättchen.

No. 5.

Holz, Wurzeln, Rinde, Reiser, Pilzreste, *Podocarpus*-Pollen (sehr häufig), *Ericaceen*-Tetraden (häufig), Farnsporen, viele dreieckige.

JAVA.

DAS DIENGPLATEAU (RESIDENZ BANJOEMAS UND KEDOE).

Das Diëngplateau stellt eine vulkanische Hochebene dar auf 2000 m. Hufeisenförmig wird es von einer Gebirgskette umschlossen, in der die Gipfel der Pagonan und Prahoe emporragen.

Auf der Ebene selbst kann man alle Stadien der Vermoorung beobachten. Es gibt eine Reihe von Seen, Telaga Balekambang, T. Warna, T. Troes, T. Loemoe und T. Pengilon. Die Ufer dieser Seen sind moorig, ebenso sind es die tieferen Stellen der Hochebene. Verlandung und Schwingrasenbildung kommt im groszen vor. Wenn es wirklich Hochmoorbildung gibt im Gebirge, dann findet man hier einen idealen Ort.

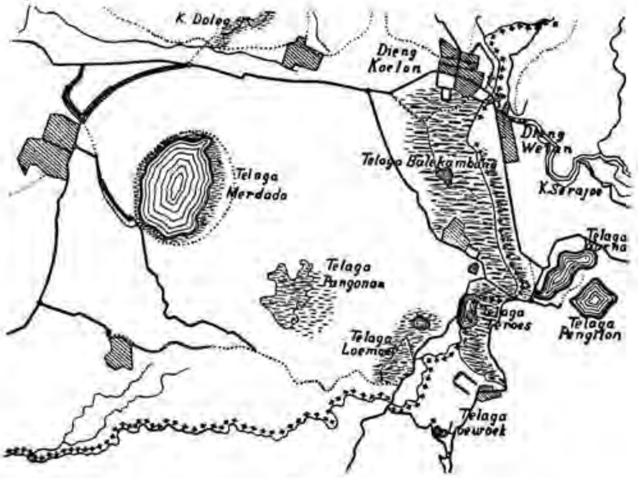

Fig. 8
Uebersichtskarte des Diëngkomplexes. (Nach VAN GENT).

Tatsächlich rufen die Atmosphäre der Landschaft, die braune Farbe der Vegetation, die groszen *Scirpus*-Bestände, die zahlreichen Sphagneta, die stillen, glänzenden Gewässer wie Moorblänken, die oft feuchte Luft und schwere Bewölkerung, schlieszlich die niedrige Temperatur, Erinnerungen wach an Hochmoorbildungen in Europa, und versetzen Einen ganz auszerhalb der tropischen Landschaft.

Wie schon erwähnt, haben MOHR (1922), VON FABER (1927) und UMBGROVE (1929) diese Formationen als Hochmoor bezeichnet. Wenn man aber diese Bildungen eingehender untersucht, stellt sich heraus, dasz an jedem von den Seen an sich zwar äuszerlich Ähnlichkeit mit Hochmoor vorliegt, dasz aber in Wirklichkeit keiner noch so weit fortgeschritten ist.

Das Diëngplateau ist jetzt eine baumlose Ebene; die wenigen Bäume die es noch gibt, sind angepflanzt worden. Noch in der Zeit JUNGHUHNS aber war es dort ganz anders. Telaga Tjebong ist jetzt in einem baumlosen Tal gelegen, unweit des Dorfes Semboengan. JUNGHUHN aber beschreibt die Gegend: „Von hier übersieht man den Spiegel des Sees, auf den die hohen Waldgebirge, die ihn eng umzingeln, einen düsteren Schatten werfen; wie leuchtende Punkte erscheint daher die weisze Brust der Wasserhühner, die auf der dunklen Fluth umherschwimmen".

In ähnlicher Weise war damals Telaga Dringoe von Wald umgeben, und von der jetzt ebenfalls in kahler Ebene gelegenen Solfatare Kawah-Kidang heiszt es: „Zwischen Wäldern von Eichen, *Podocarpus cupressifolia* und *Astronia spectabilis* dringen seine Dampfsäulen empor. Die Solfatare besteht aus zwei, nur durch ein Stück Wald getrennte, kahle Flächen".

Telaga Warna und Pengilon: „Ringsum von Bergen umschlossen, gehören sie ein und demselben Talgrunde an und sind nur durch einen Streifen, flachen morastigen Grundes auf dem sich inselförmig noch ein Stückchen Wald erhebt, von einander getrennt."

Die Entwaldung jedoch war weit fortgeschritten, JUNGHUHN beschreibt: „die Urwälder die auch keinen Flecken unbedeckt lieszen, erst in unseren Zeiten wieder von der Axt gelichtet wurden, was man an jenen Millionen Baumstümpfen erkennt, die auf allen Hügeln, in allen Tabaks- und Gemüsefeldern zerstreut stehen und noch lange nicht vermodert sind." Nach der groszen Frische der Baumstümpfe schätzt JUNGHUHN den Zeitraum, vor welchem die Rodung stattgefunden hat, auf fünfzig Jahre. Jetzt aber sind auch diese Reste ganz vermodert und verschwunden. Ob aber die Entwaldung die Vermoorung beeinfluszt hat, ist schwer zu sagen. Jedenfalls ist es nicht wahrscheinlich, dasz die Prozesse an der groszen Telaga Balekambang darauf reagieren. Der Boden des Ufers ist in einer weiten Strecke ringsumher so weich und sumpfig dasz der Wald nicht dicht ans Wasser herannahen, und die in Vermoorung begriffenen Stellen des Ufers beschatten kann.

Wichtiger jedoch ist die Steigung des Wassers, die nach den Geologen seit der Hinduzeit stattgefunden hat, und die schon mehr als zwei Meter beträgt. Die langsame Überschwemmung der tieferen Stellen des Plateaus hat dort die Pflanzenreste unter Wasser konserviert. Die Vegetation ändert sich in eine Sumpfflora, die Versümpfung breitet sich aus mit dem Heranwachsen des Wassers und in dieser Weise tritt Vermoorung ein, die Sumpfpflanzen vertorfen unter dem steigenden Wasser. Zwei Kräfte wirken einander entgegen. Einerseits die langsame Überschwemmung, wodurch trockner Boden versumpft wird und schlieszlich ganz unter Wasser kommt, und andrerseits die Neigung der sich jetzt bildenden Sumpfflora um Verlandung zu bewirken und um über die Oberfläche des Wassers zu wachsen, also die Neigung zur Bildung von Schwingrasen. Beide entgegengesetzten Prozesse zusammen aber, befördern die Entstehung des Torfes und die Verlandung.

Am klarsten zeigt Telaga Balekambang solches.

TELAGA BALEKAMBANG.

Telaga Balekambang, vor dem Pasanggrahan gelegen, ist der gröszte See und Sumpf des Plateaus. Das offene Wasser ist nur klein im Vergleich zum Sumpfgürtel, der es umgibt. Dieser Sumpfrand wird vom Wasser getragen, er schwingt beim Betreten unter dem Fusz, und sinkt desto mehr ein, je mehr man sich dem offenen See nähert. Am Rande desselben steht man bis zu den Knieen im Wasser. Die Ufervegetation besteht grösztenteils aus Gräsern und Cyperaceen. Ein verhältnismäszig dünnes aber festes Wurzelnetz hat sich über der Wasseroberfläche ausgebreitet, die Wasserschicht ist etwa in der Mitte des Gürtels ± 4.5 m. mächtig und war am Seeufer mit meinem Gerät nicht mehr zu sondieren. Die Vegetation schlieszt stets mehr den See ein, die freie Wasseroberfläche wird stets kleiner, die Tiefe des Sees jedoch ist noch immer beträchtlich und beträgt jetzt am Rande weit über 4.5 m., denn 10, 20, 30, 40, 50 Meter vom Ufer konnte ich mit meiner 4.5 m. langen Sonde den Boden nicht erreichen.

Die ersten Proben wurden entnommen auf etwa 50 à 70 m. vom Ufer. Noch immer ist die feste Vegetationsschicht dünn und schwimmt auf einem Wasserbett von ± 2 m. Erst an dieser Stelle bekam ich torfiges Material in die Sonde. Die Torfschicht lag unter dem Wasser auf etwa 3.20 m. Tiefe einem braunen festen Ton auf. Die mikroskopische Analyse zeigt, dasz dieser Torf nicht geschichtet ist, doch ganz homogen besteht aus einem Geflecht von Gräsern und Cyperaceen, Radizellen und Pustelradizellen zusammen mit vielen Diatomeen. Holzreste wurden nicht aufgefunden, der Torf gehört völlig zum Tiefmoortypus. Das reichliche Vorkommen von Diatomeen zeigt, dasz er im Wasser gebildet wurde (GAMS, 1927).

An einer zweiten Stelle, ungefähr 100 m. vom Ufer wurde gebohrt. Der Torf fing auf etwa 1.5 m. Tiefe an; auf etwa 3.80 à 4 m. lag er auf Ton. Die Zusammensetzung ist dieselbe wie die in der vorigen Probeserien, auch hier bleibt der Torf ganz homogen.

Die Wasserschicht unter dem Pflanzengeflecht ist keilformig, die Mächtigkeit nimmt nach innen zu, nach auszen ab (Fig. 9). Der Schwingrasen selbst aber ist an jeder Stelle gleich dünn, er hat ungefähr 150 à 200 m. Breite und wird mit der Zeit immer gröszer, da er über dem Wasser vordringt. Auf die Dauer wird vielleicht der offene See ganz schwinden.

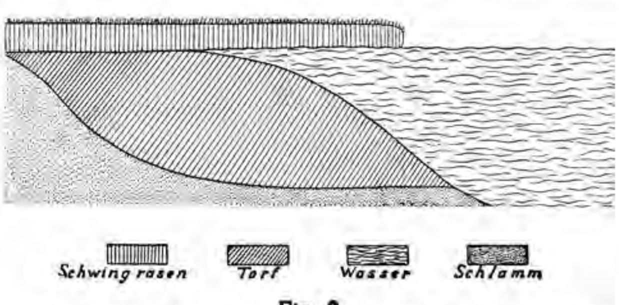

Fig. 9

Uferverlandung und Schwingrasen an Telaga Balekambang-Diëng.

Man kann sich fragen ob das Gräsergeflecht sich über die Oberfläche emporgedrängt hat, oder ob es einfach vom steigenden Wasser von der

Unterlage losgelöst worden ist. Wahrscheinlich wirkten beide Faktoren mit. GAMS (1927) zeigt, dasz im Lunzersee (Nieder-Österreich) die Schwingrasen ihre Entstehung der Steigung des Wassers verdanken und er hält dies im allgemeinen für die Ursache der Schwingrasenbildung.

Wasser und Sumpfpflanzen, welche imstande sind sich mittels Ausläufern über dem Wasser emporzudringen gibt es viele; in Europa wie in den Tropen. Ob in dieser Weise aber Torfbildung bewirkt wird, ist noch immer die Frage.

Am Diëng kann man das Überwachsen der lebenden Pflanzen beobachten, besonders *Panicum repens* L. ist wichtig in dieser Beziehung. Eine Torfschicht von 1 oder 2 m. findet man unter dem Schwingrasen am Boden des Wassers.

Es ist kaum anzunehmen, dasz die Würzelchen der Gräser und Cyperaceen zu Boden fallen und sich dort zu Torf anhäufen. Viel wahrscheinlicher ist es, dasz das steigende Wasser in die Uferflora eindringt, der Wasserkeil wird immer höher und dringt immer weiter vor, spaltet schlieszlich die Sumpfvegetation in eine schwimmende Oberflächeschicht und in ein unter Wasser stehendes Wurzelgeflecht. Die lebenden Pflanzen steigen mit dem Wasser, die toten, zum Teil schon vertorften bleiben am Boden liegen und erhalten sich dort als Torf. Da der in dieser Weise entstandene Schwingrasen im Wachstum bleibt, kann das Wasser steigen, während der See sich verkleinert. (Fig. 10). Diese Verkleinerung ist jedoch nur scheinbar, denn tatsächlich nimmt die Wassermasse zu, wie die fortschreitende Versumpfung am deutlichsten zeigt.

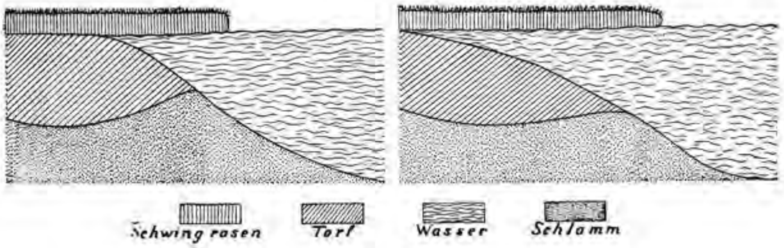

Fig. 10
Das Eindringen des Wassers zwischen Schwingrasen und Torflinse am Ufer der Telaga Balekambang-Diëng.

Der Vorposten der Schwingrasenbildung wird gebildet, wie schon erwähnt, von *Panicum repens* L., welches an Telaga Merdada zu beobachten ist. Die Rhizomen und Ausläufer sind stark und tragfähig. Die Pflanze hat die Alleinherrschaft an den äuszersten Zonen der Vegetation; gegen das Ufer kommen mehrere Arten dazu. An feuchten Stellen des Schwingrasens trifft man *Isachne pangerangensis* Z.M. und viele in Polstern wachsende Cyperaceen: *Carex pruinosa* BOOTT und *Carex Jackiana* BOOTT, die beiden Arten dringen nach vorne hin. *Rhynchospora* *glauca* VAHL, *Kyllinga brevifolia* ROTTB., *Fimbristylis complanata* LINK, *Heleocharis tetraquetra* NEES, *Eriocaulon Blumei* KOERN., *Galium innocuum* MIQ. und *Hydrocotyle* findet man an feuchten Stellen des schwimmenden Bestandes, aber nicht mehr in den äuszersten Zonen. Wo die Vegetation ganz zugewachsen ist, wird *Ischaemum aristatum* L., sehr wichtig.

Man hat also drei Vegetationszonen um den See Balekambang herum:

1. Die Vorderzone, sehr nasz und schwer zu betreten, besteht vorwiegend aus *Panicum repens* L. mit *Scirpus mucronatus* L. ohne Ausläufer.
2. Der Cyperaceengürtel, wo *Panicum repens* L. weniger wichtig wird.
3. Die Hinterzone, die verwachsen und fest ist, und wo *Ischaemum aristatum* L. vorwiegt. *Ischaemum aristatum* L. wächst in festen seichten Polstern, die dicht aneinanderstehen und dem Land ein gewelltes Ansehen verleihen, besonders in der Nähe der Ardjoena Tempel. Diese Tempel stehen am Rande des Sumpfes auf ziemlich trocknem Boden, der zusammengesetzt ist aus ½ m. festem Ton auf hartem Sand. Von hier aus erstreckt sich bis an den Cyperaceengürtel das von den Polstern gewellte Land. Augenscheinlich werden die Bulten nur von *Ischaemum* zusammengesetzt, denn bei oberflächlicher Betrachtung sieht man nur diese Grasart. Wenn man jedoch die Polster auseinanderzupft, dann zeigt sich, dasz die harte, feste Masse, das Gerüst des Polsters, gebildet wird von den braun-geschuppten seilartigen Rhizomen des *Panicum repens* L., die fest verflochten sind. Tatsächlich ragen an den Rändern des Bulten die spitzen schmalblättrigen Halme dieses Grases empor. Es hat den Anschein, alsob die Bulten anfangs nur aus *Panicum repens* L. gebildet waren; nachdem die Rhizomen sich zu einer trocknen Kuppel verwachsen hatten, wurden dieselben von *Ischaemum* überzogen; diese Pflanze stellt jetzt das Dach der Kuppel da, und *Panicum* ist an die Ränder, wo es am feuchtesten ist, gedrängt worden. Dazu findet man am Rande winzige Pflänzchen von *Lycopodium cernuum* L., *Parochetus communis* HAM. und viel *Mittenia Zollingerii* GOTTSCHE (ein Lebermoos), *Eriocaulon Blumei* KAERN., *Heleocharis tetraquetra* NEES, *Juncus prismatocarpus* R.BR., *Xyris melanocephala* MIQ., *Centella asiatica* URB. Am Gipfel zwischen dem *Ischaemum* wachsen trockne kleine *Gentiana quadrifaria* BL-Pflänzchen und vertrocknete *Isachne pangerangensis* Z.M., die vielleicht während des nassen Monsuns neu belebt werden. Vielleicht, dasz in dieser Periode die Vegetationsverhältnisse der Bulten mehr zu Gunsten des *Panicum repens* L. verschoben werden.

Die Bulten sind etwa 50 cm. lang, und 50 cm. hoch, etwa 20 cm. wellt sich vom Boden auf, etwa 30 cm. ist eingesunken. Alle Rhizomen waren lebendig. Torfbildung findet in dieser Zone nicht statt, die Bulten und Schlenken aber täuschen solches vor. *Sphagnum* wurde am Balekambang nicht beobachtet.

BESCHREIBUNG DER PROBEN.

TELAGA TROES.

Holzreste fehlen. Die Proben sind faserig von den Resten der Gräser und Cyperaceen, Schwefelgeruch, Cyperaceenfrüchte.

No. 1. Tiefe 2 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen (häufig), Gräserepidermis, vollständige Gräseranthere mit Pollen, Sternzellengewebe *(Juncus?)* Crustaceenreste (häufig), Moossporangium, dreieckiges Pollen, Diatomeen (sehr häufig; *Navicula* sp.) Rhizopodenschalen.

No. 2. Tiefe 2.15 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen (häufig), vollständige Gräseranthere mit Pollen, Gräser-Cyperaceen-Pollen, Farnsporen, Diatomeen (sehr häufig), Moossporangium.

No. 3. Tiefe 2.30 m.
Pilzreste spärlich), Radizellen, Pustelradizellen, Gräserepidermis, Sternzellengewebe, wenig Pollen, Diatomeen (sehr häufig), Ton.

No. 4. Tiefe 2.30 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Gräser-Cyperaceen-Pollen, Pollen (sonst spärlich), Sternzellengewebe, Diatomeen (sehr häufig), Schmetterlingsschuppe, Ton.

No. 5. Tiefe 2.45 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Gräser-Cyperaceen-Pollen, Pollen (sonst spärlich), Farnsporen, Diatomeen (sehr häufig).

No. 6. Tiefe 2.60.
Vulkanische Asche, Pilzreste (spärlich), Radizellen und Pustelradizellen, Crustaceenreste, Gräser-Cyperaceen-Pollen, Diatomeen (sehr häufig).

No. 7. Tiefe 2.75.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Gräser-Cyperaceen-Pollen, Crustaceenreste, Diatomeen (sehr häufig), Moossporangien.

No. 8. Tiefe 2.90 m.
Schlamm, Radizellen, Pustelradizellen, spärliche Pilzreste, Diatomeen (häufig), Farnsporen (häufig).

No. 9. Tiefe 3.05 m.
Idem.

No. 10. und weiter, reiner Schlamm.

PROFIL II.

No. 55. Tiefe 85 cm.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Sternzellengewebe, wenig Pollen, Crustaceenreste (häufig), Diatomeen.

No. 56. Ausgefallen.

No. 57. Tiefe 1.45 m.
Schlamm und Asche, Pilzreste (spärlich), Radizellen und Pustelradizellen,, Gräser-Cyperaceen-Pollen, Moosblättchen, Diatomeen.

No. 58. Tiefe 1.60 m.
Schlamm, Pilzreste (spärlich), Radizellen und Pustelradizellen, Gräser-Cyperaceen-Pollen (spärlich), Cyperaceenfrüchte, Sternzellengewebe, Diatomeen (sehr häufig).

No. 59. Tiefe 1.75 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Gräserepidermis, Sternzellengewebe *Podocarpus imbricata*-Pollen, nur wenig Pollen, Diatomeen (häufig).

No. 60. Tiefe 1.90 m.
Schlamm, Pilzreste (spärlich; *Endogone)*, Radizellen und Pustelradizellen, Farnsporen, Diatomeen (häufig), Crustaceenreste.

No. 61. Tiefe 2.05 m.
Schlamm, Pilzreste (spärlich), Radizellen und Pustelradizellen, Sternzellengewebe, Pollen (spärlich), Farnsporen, Crustaceenreste, Diatomeen (häufig).

No. 62. Tiefe 2.35 m.
Nur wenig Schlamm, Pilzreste (spärlich), Radizellen und Pustelradizellen, Sternzellengewebe, Gräser-Cyperaceen-Pollen, Schmetterlingsschuppe, Crustaceenreste, weniger Diatomeen.

No. 63. Tiefe 2.65 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, wenig Pollen, Sternzellengewebe, Farnsporen, Diatomeen, Crustaceenreste.

No. 64. Tiefe 2.95 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, wenig Pollen, Farnsporen, Sporangien, Diatomeen.

No. 65. Tiefe 3.25 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, wenig Pollen, Farnsporen (häufig), Moosblättchen, Diatomeen.

No. 66. Tiefe 3.55 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, wenig Pollen, *Podocarpus*-Pollen, dreieckiges Pollen, Farnsporen, Sporangien, Moosblättchen.

No. 67. Tiefe 3.85.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Gräser-Cyperaceen-Pollen, Baumpollen, Farnsporen, dreieckige Sporen, Diatomeen.

No. 68. Tiefe 4.15 m.
Viel Asche, Pilzreste (spärlich), Radizellen und Pustelradizellen, wenig Pollen, Farnsporen, Diatomeen, Crustaceenreste.

No. 69. Tiefe 4.45 m.
Viel Asche, Pilzreste (spärlich), Radizellen und Pustelradizellen, wenig Pollen, Farnsporen, Diatomeen (häufig).

TELAGA WARNA, T. TROES, T. PENGILON UND T. LOEMOE.

Diese vier Seen hängen gewissermaszen zusammen. Ein kontinües Wachstum der Uferzone wie an Telaga Balekambang hat nicht stattgefunden, denn unter dem Einflusz vulkanischer Wirkung wurde die Vegetation von Zeit zu Zeit zerstört.

Das Wasser der Telaga Warna ist vielfärbig von den Schwefelablagerungen und Lösungen die es enthält. Schwefelablagerungen, das Produkt kleiner Eruptionen, findet man ebenfalls in den Schichten getöteten Pflanzenmaterials am Ufer. Die Vegetation hat sich jedesmal wieder neu hergestellt nach der Zerstörung.

Der Habitus, die Farbe, das Wachstum der heutigen Uferflora dieser Seen hat grosze Ähnlichkeit mit europäischem Hochmoor, das mit Schwefel vermischte tote Pflanzenmaterial sieht aus wie Torf. Es ist jedoch unrichtig dieses mit dem Namen „Torf" zu bezeichnen, denn es ist nicht nach langsamer Verwesung vor völliger Zersetzung bewahrt worden, nachdem die Vegetation in stetem Wachstum ihr verbrauchtes Material hat abgesetzt, sondern mechanische Einflüsse von auszen her haben die Entwicklung gehemmt. Es ist aber oft schwer festzustellen, ob diese Ablagerungen ruhig vertorft sind, oder ob vulkanische Wirkungen die Ursache der Torfbildungen waren.

Die Ufervegetation der vier obengenannten Seen weist im Gegensatz zu der des Balekambangs reichlich *Sphagnum* auf, Gräser und Cyperaceen. Das *Sphagnum* wächst in Bulten und Schlenken, oft aber macht es lange hellgrüne Ausläufer, die in dichten Knäueln im Wasser schwimmen. *Sphagnum*-Torf aber wurde nicht gebildet, 40 cm. unter der wachsenden Schicht lag schon harter Ton.

Schwingrasen werden besonders an Telaga Warna gebildet von *Cla-*

dium rubiginasum DOMIN; zwischen den zähen Rhizomen wächst häufig *Sphagnum*. RUTTNER (1930) hat gezeigt dasz die p_H dieser Bestände 4—4.5 aufweist.

Am Nordufer der Telaga Warna befindet sich eine alte Solfatare, die aber noch vor kurzem gearbeitet haben musz, denn die Folgen noch ziemlich rezenter Eruptionen waren zu beobachten. Vor der Solfatare erstreckte sich ein breiter Streifen nackter, schwarzer Erde, welcher am Ufer feucht und sehr weich war. Er stellt eine Art Strandgelände dar, das damals (Ende August 1930), Ende der Trockenzeit, an der Oberfläche lag, das aber während der Regenzeit bestimmt unter Wasser steht, wie es der dünne schwarze Schlammüberzug zeigte. Dieser Strand ist fast pflanzenleer, nur einige winzige Kräuter wie *Scirpus fluitans* L., *Laurembergia coccinea* KAN. und ein Polsterbildendes Moos kommen spärlich vor. Hinter dieser Zone im Wasser, wächst *Cladium rubiginosum* DOMIN. Je mehr man sich dem Wasser nähert, desto weicher wird der Boden, bis man schlieszlich tief in eine bleichgelbe tote *Sphagnum*masse einsinkt. Das Wasser, das sogleich aus diesem Schlamm hervorquillt, ist gelb und trübe vom Schwefel, ein Schwefelgeruch steigt ebenfalls hervor. Ebenso sprudeln in dem See fortwährend Schwefelgase. Es zeigt sich, dasz die *Sphagnum*schicht, worin Schwefelteilchen eingestreut sind, noch sehr wenig zersetzt ist. Sie hat nicht viel Ähnlichkeit mit Torf. Der Brei ist durchflochten von *Cladium*rhizomen und es ist klar, dasz hier ein Schwingrasen von *Cladium* mit *Sphagnum* zerstört worden ist, von der Art, die wir jetzt noch im Wachsen begriffen am Seeufer beobachten können. Eingebettet in dem *Sphagnum*brei standen grosze Baumstämme, bewurzelte Strünke, ringsumher lagen Reiser und Äste und sehr viele Eicheln. Eine dünne Schicht (etwa 10 cm. mächtig) aus sehr wenig zersetzten, toten Blättern lag der *Sphagnum*masse auf. Wahrscheinlich stellt dieses einen Überrest dar des ehemaligen Waldes, der in JUNGHUHNS Zeit noch Telaga Warna beschattete. Da das Wasser stieg, wurde dieser Wald schon teilweise überflutet und vom *Sphagnum* (die jetzige Unterlage) erstickt. Die Schwefelproduktion der Solfatare hat ihn aber den Rest gegeben und hat plötzlich die letzten Bäume abgetötet. Die Wurzeln wurden mit giftigen Lösungen umspült, das Blätt fiel zu Boden, wo es im saurem Wasser sehr gut erhalten wurde. Die Erhaltung ist zwar so volkommen, dasz viele Arten noch mittels Vergleichung mit rezentem Herbariummaterial bestimmt wurden. Dr. VAN STEENIS verdanke ich die Benennung folgender Arten: *Elaeocarpus punctatus* HASSK. (Früchte mit Samen), *Vaccinium laurifolium* MIQ. (sehr viele Blätter), *Vaccinium ellipticum* MIQ. (einziges Blatt), *Vaccinium varingiifolium* MIQ. (Blätter), *Quercus pruinosa* BL. (Eicheln mit Cupula, Fragment einer Blütenachse). *Pleopeltis* sp., *Bulbophyllum* sp. (Blätter, Bulbi), *Rapanea affinis* MEZ, *Acer niveum* BL., Filices (sterile Blätter), *Perrottetia alpestris* LOES., *Rhododendron javanicum* BENN. *Bulbophyllum* wurde noch mit ganzen Bulben gefunden! Es zeigt sich, dasz dieser Wald aus ähnlichen Arten zusammengesetzt war, als derjenige, der jetzt noch den Prahoe bedeckt.

Das Ufer der Telaga Troes ist ebenfalls sehr sumpfig und *Sphagnum* kommt dort reichlich vor zusammen mit *Panicum repens* L., *Scirpus mucronatus* L., *Xyris melanocephala* MIQ., *Isachne pangerangensis* Z. et M., *Juncus prismatocarpus* R.BR. Richtiger Torf wurde nicht gefunden, unter dem Pflanzendeck trifft man Schlamm, auf verschiedener Höhe vermischt mit vulkanischer Asche.

Merkwürdig ist, dasz man Holz und Farnenreste tief unter der Oberfläche findet, ein Beweis dafür, dasz verschiedene Bestände und Wälder von Schlamm und Asche bedeckt wurden und dasz das Wasser gestiegen ist.

Telaga Loemoe zeigt ebenfalls *Sphagnum*bulten und Schlenken. Auszer den schon erwähnten Gräsern und Cyperaceen, wächst hier reichlich *Typha domingense* PERS. var. *javanica* GÈZE dazwischen, die sonst nirgends aufgefunden wurden. Torf wurde nicht beobachtet, jedoch wurden auf etwa 2 m. Tiefe reichlich Holzreste sondiert. Der Schwingrasen liegt auf einem Wasserbett von etwa 1.45 m. Mächtigkeit.

BESCHREIBUNG DER PROBEN.

TELAGA TROES.

Zusammensetzung der Proben Telaga Bakelambang ähnlich.

No. 11. Tiefe 85 cm.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Gramineenepidermis (*Panicum repens* L. ? und *Isachne* ?), *Sphagnum*blatt (vereinzelt), Pollen (spärlich), Diatomeen.

No. 12. Tiefe 1 m.
Asche.

No. 13. Tiefe 1.15 m.
Vorwiegend Asche, Pilzreste (spärlich), Radizellen und Pustelradizellen, Pollen (*Eugenia*-ähnlich), Baumpollen, Farnsporen, dreieckige Spore, Crustaceenreste, Diatomeen.

No. 14. Tiefe 1.30 m.
Schlamm und Asche, Pilzreste (spärlich), Radizellen und Pustelradizellen, *Quercus*-Pollen, Baumpollen, Farnsporen, dreieckige Spore, Diatomeen.

No. 15. Tiefe 1.45 m.
Vorwiegend Asche und Schlamm, Pilzreste (spärlich), Radizellen und Pustelradizellen, Gräser-Cyperaceen-Pollen, *Quercus*-Pollen, *Eugenia*-

ähnliches Pollen (dreieckige), Farnsporen, dreieckige Sporen, Diatomeen Schlamm.

No. 16. und weiter.
Schlamm,

TELAGA LOEMOE.

PROFIL I.

Schwingrasen aus Gräsern, Cyperaceen, *Typha domingense* PERS var. *javanica* GÈZE, *Sphagnum*. Probe No. 27 ist unter dem auf Wasser schwimmenden Schwingrasen genommen.

No. 27. Tiefe ± 2 m.
Schwefel, Holzreste, Äste, Reiser, Pilzreste, Blattreste von Dicotylen, *Sphagnum*blätter, Moosblätter, Farnsporen, dreieckige Sporen, Diatomeen.

No. 28. Tiefe 2 m.
Fast nur *Sphagnum*, Moosreste, Pilzreste, dreieckige Pollen, *Podocarpus*-Pollen, *Quercus*-Pollen, Farnsporen, Diatomeen.

II NEBEN PROFIL I.

No. 29. Tiefe 1.45 m.
Schwefel, Holzreste, Pilzreste, Baumwürzelchen, Farnsporen und Tracheiden, *Sphagnum*blättchen, Diatomeen.

No. 30. Tiefe 1.75 m.
Schwefel mit Holzsplitter.

No. 31. Tiefe 2.05 m.
Schwefel, Holzsplitter, Baumwürzelchen, *Sphagnum*.

No. 32. Tiefe 2.35 m.
Schwefel, Holzreste, Rinde, *Sphagnum*, Pilzreste, *Ericaceen*tetraden, Pollen, Farnsporen.

No. 33. Tiefe 2.65.
Asche und Schwefel, Holz, Reiser, Baumwürzelchen, Pilzreste, Farnsporen, dreieckige Spore, Diatomeen, Crustaceenreste.

No. 34. Tiefe 2.95 m.
Asche, Schwefel, Holz, Reiser (reichlich), Pilzreste, Farnsporangien, Tracheiden, *Quercus*-Pollen, *Sphagnum*, Diatomeen.

No. 35. Tiefe 3.25 m.
Fast nur Asche, Würzelchen, Moosreste, *Sphagnum*reste, *Quercus*-Pollen, Farnsporen.

No. 36. Tiefe 3.55 m.
Schwefel, Holzreste, Reiser, Äste, Baumwürzelchen, Rinde, Pilzreste, *Sphagnum* (spärlich), Diatomeen.

No. 37. Tiefe 3.85 m.
Fast nur Schwefel und Asche, Holzreste, Baumwürzelchen, Pilzreste, Diatomeen.

No. 38. Tiefe 4.15 m.
Asche (reichlich), Baumwürzelchen, Radizellen und Pustelradizellen, Farnsporen, Sporangien, dreieckige Sporen, Crustaceenreste, Diatomeen (häufig).

No. 39. Tiefe 4.45 m.
Gräsertorf als von T. Balekambang, Holzreste (spärlich), Pilzreste, Radizellen und Pustelradizellen, Gräserepidermis *(Isachne pangerangensis* Z.M. ?) *Quercus*-Pollen, Moosblättchen, *Sphagnum*, Farnsporen und Sporangien, dreieckige Spore, Crustaceenreste, Diatomeen (häufig).

TELAGA MERDADA.

Die Telaga Merdada ist ein richtiger Kratersee, eingeschlossen von einem hohen Ringwall. Der See gehört nicht zum Diëngkomplex, und wahrscheinlich hat hier die Steigung des Wassers nicht stattgefunden.

Die Verlandungsweise hat viel Ähnlichkeit mit der des Sees Balekambang. Die Schichten waren sehr homogen, die Zusammensetzung der Arten war ungefähr dieselbe.

Der Schwingrasen ist etwa 3 m. breit, also viel weniger als der der Balekambang. Man sieht aber jetzt denselben anwachsen mittels *Panicum repens* L., das sich über dem Wasser vorschiebt. Wahrscheinlich ist dieser Schwingrasen nur mittels Überwachsen gebildet worden, und hat das Wasser nicht die Vegetationsdecke losgelöst.

BESCHREIBUNG DER PROBEN.

TELAGA MERDADA.

Zusammensetzung der Proben Telaga Balekambang ähnlich.

No. 42. Tiefe 85 cm.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Gräser-Cypera-

ceen-Pollen, Anthere mit Pollen, Pollen sonst spärlich, Sternzellengewebe, Gestachelte Pollen (ähnlich Bild 72—74, Tafel II), Moosblätter und Sporangien, Crustaceenreste (häufig), Diatomeen (häufig).

No. 43. Tiefe 1 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Gramineenepidermis, Gramineen-Cyperaceen-Pollen, Farnsporen, Moosreste.

No. 44. Tiefe 1.15 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Gramineenepidermis *(Isachne?)*, Pollen (spärlich), Farnsporen, Crustaceenreste.

No. 45. Tiefe 1.30 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, *Cladium*epidermis, Crustaceenreste, Pollen (spärlich).

No. 46. Tiefe 1.45 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Pollen (spärlich), Moosreste.

No. 47. Tiefe 1.60 m.
Pilzreste (spärlich), Radizellen und Pustelradizellen, Anthere mit Pollen, Pollen sonst spärlich, Sternzellengewebe.

No. 48. Tiefe 1.75 m.
Schlamm, Pilzreste (spärlich), Radizellen und Pustelradizellen (weniger), Cyperaceenepidermis, *Quercus*-Pollen, Moosreste, Sternzellengewebe, Farnsporen, Rhizopodengehäuse, vereinzelte Diatomee, Crustaceenreste.

No. 49. Tiefe 1.90 m.
Schlamm, Pilzreste (spärlich), Radizellen und Pustelradizellen (weniger), *Scirpus mucronatus*epidermis ?, Farnsporen, Sporangium, *Closterium* (?), Schmetterlingschuppe.

SELEBES.

Herr. Dr. O. POSTHUMUS vermittelte mir freundlichst eine Probe eines Sumpftorfes von Selebes, Lindoe See (Unterabteilung Pala) im Gebirge in einer Höhe von etwa 1000 m. Dieser See hat zum Teil sumpfige Ufer, von einer dichten Sumpfvegetation bewachsen aus *Phragmites, Equisetum, Nephrolepis radicans* KUHN, *Dryopteris prolifera, Lygodium scandens* SW., *Dryopteris gongylodes* O.KTZE u.a. Eingestreut gibt es einige Bäume. An diesem Ufer findet Torfbildung statt, der Torf wird vom Wellenschlag zerstückelt, und es bildet sich eine steile Wand mit einem Strand aus Torfschlamm im Vordergrund.

Die mir gesandte Probe war der Steilwand entnommen. Es zeigte sich, dasz auch diese viel Schlamm enthielt, das Material war plastisch, die torfigen Bestandteile waren fragmentiert. Der Torf zeigte, wie zu erwarten war, die Reste einer typischen Sumpfflora und erhielt vorwiegend Radizellen und Pustelradizellen, Farnsporen und Sporangien, verästelte Zellen wie Tafel IV, No. 124, ein Gräserepidermis *(Leersia)*, nur wenig Pilzreste und Diatomeen. Wir dürfen diesen Torf also einreihen unter die Torfe der verlandenden Seeufer.

BOEROE.

L. J. TOXOPEUS (1924) beschreibt ein Moor im Gebirge Boeroes auf etwa 1000 m. ü. M. Östlich wird es eingenommen von Cyperaceeninseln, westlich traf er eine *Sphagnum*vegetation mit eingestreuten Xyridaceen, *Scirpus*, Farnen, *Cladonia* und *Rhododendron*. Ob Torf sich ablagerte, wird nicht erwähnt. Der Beschreibung nach hat diese Stelle Ähnlichkeit mit den topogenen Gebirgsmooren des Diëngs und der Tobaebene.

ZUSAMMENFASSUNG DER ERGEBNISSE.

1. Torf und Moor sind häufig in der Ebene und im Gebirge der Groszen Soenda Inseln.

2. Die Gebirgsmoore sind topogenen Charakters, die Moore der Ebene sind topogen oder ombrogen.

3. Auf Java wurden nur topogene Moore angetroffen. Diese Verlandungstorfe bestehen in der Ebene aus Kräutern: Gräsern, Cyperaceen, Farnen oder wasserliebenden Sträuchern und Bäumen, im Gebirge nur aus Kräutern mit eingestreuten Stauden.

4. *Sphagnum* ist häufig an feuchten Stellen über 1200 m., ist jedoch weder Torfbildner noch wächst es an bestimmten Hochmoorstellen. Es wurde immer im stehenden Bodenwasser wachsend gefunden.

5. Ombrogene Moore treten regional auf an den Küsten Sumatras und Borneos und wahrscheinlich auch Neu-Guineas.

6. Es sind Waldmoore, deren Oberfläche sich emporwölbt, deren Unterlage aber tiefer als das umgebende Gelände liegt.

7. Bis auf etwa 4 m. Tiefe findet man Baumreste, die im unterliegenden Ton gewurzelt sind.

8. Der rezente Wald empfängt nur Niederschlagswasser, das vom humösen Waldtorf, der über 7 m. Mächtigkeit erreichen kann, festgehalten wird.

9. Der Überschusz flieszt ab in den sauren, braunschwarzen Moorflüszen.

10. Das Wasser des Torfes und der Ströme weist einen Säuregrad auf von etwa 3.

11. Diesen Waldmooren musz also oligotropher, ombrogener Charakter zugeschrieben werden.

12. Die von mir aus jenen Mooren untersuchten Torfproben bestehen nur aus Baumresten, Farnen und Pilzen, eine stratigraphische Gliederung war ich nicht imstande zu zeigen.

Am Ende dieser Abhandlung möchte ich dem Vorstand des holländischen Tropenstipendiums und der Gesellschaft „Ter Bevordering van het Natuurkundig Onderzoek der Koloniën" Dank sagen für ihre Unterstützung, der Direktion des Botanischen Gartens, des Treub-Laboratoriums, des Laboratoriums für Bodenkunde und des Herbars zu Buitenzorg für ihr Entgegenkommen bei der Arbeit. Groszen Dank verschulde ich im besonderen Herrn Dr. C. G. G. J. VAN STEENIS für die Bestimmung des Pflanzenmaterials, Fräulein M. J. A. DIELL für die Korrektion des Deutschen, und schlieszlich denjenigen, die mir auf meinen Reisen oft in so ausgezeichneter Weise geholfen und mich geführt haben.

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INHALTSVERZEICHNIS.

ON THE ANALYSIS OF OCULAR MOVEMENTS

(THIRD PAPER)

BY

C. D. VERRIJP

(WITH 12 TEXTFIGURES)

VERHANDELINGEN DER KONINKLIJKE AKADEMIE
VAN WETENSCHAPPEN TE AMSTERDAM
AFDEELING NATUURKUNDE
(TWEEDE SECTIE)
DEEL XXX, No. 4

UITGAVE VAN DE N.V. NOORD-HOLLANDSCHE
UITGEVERS-MAATSCHAPPIJ, AMSTERDAM 1933

In the first of my former papers on this subject[1]) I have set forth, how we have to analyse ocular movements, if we consider a motion, in which all points of the eye describe paths which are parallel to a flat plane. The location of the eye has to be determined in a number of successive positions. If, for a certain motion, this number is sufficiently large, we may consider the displacement which carried the eye from one position to the next one as a rotation around one single axis, perpendicular to the plane. We may call the point of intersection of such an instantaneous axis with the plane, an instantaneous centre of rotation. The smaller we choose the interval between two determined positions, the larger is the accuracy of the analysis. Full accuracy is only reached, if these intervals are infinitely small. This is of course impossible in experiments; the purpose of the *practical* analysis is to find as many instantaneous centres of rotation, as are compatible with the experimental possibilities.

I located the eye in its successive positions by means of the direction of one line, and by the position of one point, which were both fixed with respect to the eye.

The formulae which I derived in my first paper for the relations between the coordinates b_n and c_n of one position of this fixed point, the coordinates b_{n+1} and c_{n+1} for the next position, the angle of rotation, δ_n, between the fixed line in the first position and in the second one, and the coordinates ξ_n and η_n of the corresponding instantaneous centre of rotation, were:

$$\xi_n = \tfrac{1}{2}(b_{n+1} + b_n) + \tfrac{1}{2}(c_{n+1} - c_n) \cot \tfrac{1}{2}\delta_n \quad . \quad . \quad . \quad . \quad (1)$$

$$\eta_n = \tfrac{1}{2}(c_{n+1} + c_n) - \tfrac{1}{2}(b_{n+1} - b_n) \cot \tfrac{1}{2}\delta_n \quad . \quad . \quad . \quad . \quad (2)$$

The methods of experimentation were described in my second paper[2]). The line of sight was taken as the fixed line from which the direction was determined. The accuracy, with which in the experiment the line of sight may be located in the eye, or conversely, the accuracy with which we may locate the eye by means of the line of sight, is found by ascertaining the exactness with which a certain position may be reproduced in sighting. In the experiments with an emmetropical subject, which were described in the former paper, this reproduction was possible within an angle of around one half of a minute. The subjects about which I purpose to give data in the present paper, gave similar results.

As it is difficult to realise a fixed point in or at the eye, the analysis was

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[1]) Proceedings, Kon. Akad. v. Wetensch. Vol. XXXI, p. 357.

[2]) Verhandelingen der Kon. Akad. van Wetensch. Afd. Natuurk., Deel XXVI, No. 6.

primarily based upon the motions of a vertical spider-thread, which could be arranged to occupy the same position with respect to the eye after every turn. The horizontal projection of this spider-thread constituted the fixed point, connected with the eye, and was, kinematically speaking, one with it. The displacements of this point could be calculated from the experimental data. This was done, and then the coordinates of the centres of rotation were calculated by means of the formulae (1) and (2), just written down.

It was moreover possible to locate the spider-thread with respect to a hypothetical point of the eye, e.g. the point of intersection of the line of sight with the anterior surface of the cornea. This location was however less exact than the location of the thread in the apparatus; and so, the manipulation of the data which purposed to give a description of the motion of a point of the eye itself, was separated from the former one.

In the present paper, the data are not handled in this way. It is possible, first to calculate the relative situation of the instantaneous centres of rotation, immediately from the experimental data, and without the intermediary of the motions of the spiderthread. Indeed, for this purpose the knowledge of the situation of the latter in the apparatus is not of any special importance, and we may consider just as well the motions of any other point of the apparatus if this point is maintained in an invariable position with respect to the eye.

So, for our present treatment we consider the motions of a point, which lies, in the *zero-position*, in the centre of rotation of the theodolite, (i.e. the point M_0 in fig. 6 of my former paper. As the centre of the theodolite is *not* maintained in an invariable position with respect to the eye, the point which is considered only coincides with this centre in the zero-position; we have to imagine that the point is "attached" to the telescope K for which the same position in relation to the eye is realised after every turn.

Again, the point of intersection of the axes of coordinates is made to fall upon the zero-position of the point which is considered. These axes are drawn parallel to the X- and Y-axes, the direction of which was settled in the former paper (page 6).

In order to get formulae for the coordinates of the instantaneous centres of rotation in function of the experimental data, we might try to substitute the relations of b_{n+1} and c_{n+1} to these data in the equations (1) and (2), which I wrote down above. The symbols b_{n+1} and c_{n+1} represent the coordinates of a point which is considered after the $(n+1)$st turn of the apparatus, every turn including the rotation of the theodolite and the displacements by means of the screws. The equations (13) and (14), which I derived in my former paper, give the relations of b'_{n+1} and c'_{n+1} to the experimental data[1]). In trying the substition we meet certain difficulties. First, the formulae (13) and (14) contain r_n and φ_n, which are the values of r and φ, preceding the $(n+1)$st rotation of the theodolite; I may

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[1]) Symbols b'_{n+1} and c'_{n+1}, because the motions of the spider-thread were considered.

remember, that r is the distance between the point which is considered and the centre of rotation of the theodolite, and φ is the angle, at which the line which connects these two points, is inclined towards the X-axis. The formulae (11) and (12) of the former paper give the relations of r_n and φ_n to certain of the experimental data, and to r_0 and φ_0.

Now, in our present treatment, r_0 is zero, and so φ_0 is indefinite. Therefore, the formulae (11) and (12) cannot be used as such. It is possible to eliminate r_0 and φ_0 from these formulae. We then get: $\varphi_n = - \alpha_n$, and $r_n = \sum\limits_0^{n-1} \bar{\bar{x}}_k$. This is at once evident, if we imagine, how the point which is considered at present, moves during the experimentation. With the theodolite it is subjected to all the motions of the larger screws of the apparatus; these motions do not change its relative position with respect to the centre of the theodolite; nor do the rotations of the theodolite, to which the telescope K is attached, change the distance r. The path through which the point moves when we move the telescope K by means of the smaller antero-posterior screw, in order to give to it the invariable position with respect to the eye, is always directed towards the centre of rotation of the theodolite; it is the direction of r. Every displacement $\bar{\bar{x}}_k$ of the telescope K gives a displacement of the hypothetical point, which has the same extent, and the distance r increases just as much[1]). On the other hand, the direction of the line which connects the point and the centre of rotation of the theodolite, is only changed by the rotations, δ, of the theodolite[2]), and the angles are identical.

Even with our present expressions for r_n and φ_n, the formulae (13) and (14) are, as such, not fit for a substitution in the equations (1) and (2), as they also contain b'_n and c'_n. The manipulation, which might enable us to perform the substitution, is somewhat cumbersome, and it is better to build up our formulae in much the same way as we did, in the former paper, for (13) and (14).

I will further indicate the coordinates of the point which is considered now with b''_k and c''_k, in order distinguish them from the symbols b'_k and c'_k which were used, in the former paper, for the coordinates of the spider-thread. Besides the symbols ξ''_k and η''_k will be used for the corresponding coordinates of the centres of rotation, which relate to the present system of axes of coordinates; these axes are called X''-axis and Y''-axis. The symbols b_k, c_k, ξ_k and η_k will be retained for the case in which a point of the cornea is considered[3]). As before, the symbols $\bar{x}_k$, $\bar{y}_k$ and $\bar{\bar{x}}_k$ will be used for the displacements by means of the screws of the apparatus; again ε is the deviation of the transverse larger screw from the positive Y-axis.

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[1]) r_1 corresponds to $\bar{\bar{x}}_0$, and so r_n to $\bar{\bar{x}}_{n-1}$.

[2]) The sum of n rotations σ is expressed by α_n.

[3]) The intersection of the axes of coordinates being laid in the zero-position of this point of the cornea.

In connection with the preceding exposition, it will be comprehensible that we now have:

$$\left.\begin{aligned}
b_0'' &= 0\\
b_1'' &= \bar{x}_0 - \bar{y}_0 \sin \varepsilon + \bar{\bar{x}}_0 \cos \alpha_1\\
b_2'' &= (\bar{x}_0 + \bar{x}_1) - (\bar{y}_0 + \bar{y}_1) \sin \varepsilon + (\bar{\bar{x}}_0 + \bar{\bar{x}}_1) \cos \alpha_2\\
b_n'' &= \sum_0^{n-1} \bar{x}_k - (\sum_0^{n-1} \bar{y}_k) \sin \varepsilon + (\sum_0^{n-1} \bar{\bar{x}}_k) \cos \alpha_n
\end{aligned}\right\} \quad . \quad . \quad (15)$$

$$\left.\begin{aligned}
c_0'' &= 0\\
c_1'' &= \bar{y}_0 \cos \varepsilon - \bar{\bar{x}}_0 \sin \alpha_1\\
c_2'' &= (\bar{y}_0 + \bar{y}_1) \cos \varepsilon - (\bar{\bar{x}}_0 + \bar{\bar{x}}_1) \sin \alpha_2\\
c_n'' &= (\sum_0^{n-1} \bar{y}_k) \cos \varepsilon - (\sum_0^{n-1} \bar{\bar{x}}_k) \sin \alpha_n
\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

We now can substitute in the equations (1) and (2) the relations, expressed by the formulae (15) and (16). This substitution gives:

$$\xi_0'' = \tfrac{1}{2} \bar{x}_0 + \tfrac{1}{2} \bar{\bar{x}}_0 (\cos \alpha_1 - \sin \alpha_1 \cot \tfrac{1}{2} \delta_0) + \tfrac{1}{2} \bar{y}_0 (\cos \varepsilon \cot \tfrac{1}{2} \delta_0 - \sin \varepsilon).$$

$$\eta_0'' = - \tfrac{1}{2} \bar{x}_0 \cot \tfrac{1}{2} \delta_0 - \tfrac{1}{2} \bar{\bar{x}}_0 (\sin \alpha_1 + \cos \alpha_1 \cot \tfrac{1}{2} \delta_0) + \\ + \tfrac{1}{2} \bar{y}_0 (\sin \varepsilon \cot \tfrac{1}{2} \delta_0 + \cos \varepsilon).$$

$$\xi_1'' = \bar{x}_0 + \tfrac{1}{2} \bar{x}_1 + \tfrac{1}{2} \bar{\bar{x}}_1 (\cos \alpha_2 - \sin \alpha_2 \cot \tfrac{1}{2} \delta_1) - \bar{y}_0 \sin \varepsilon + \\ + \tfrac{1}{2} \bar{y}_1 (\cos \varepsilon \cot \tfrac{1}{2} \delta_1 - \sin \varepsilon).$$

$$\eta_1'' = - \tfrac{1}{2} \bar{x}_1 \cot \tfrac{1}{2} \delta_1 - \tfrac{1}{2} \bar{\bar{x}}_1 (\sin \alpha_2 + \cos \alpha_2 \cot \tfrac{1}{2} \delta_1) + \bar{y}_0 \cos \varepsilon + \\ + \tfrac{1}{2} \bar{y}_1 (\sin \varepsilon \cot \tfrac{1}{2} \delta_1 + \cos \varepsilon).$$

$$\xi_2'' = \bar{x}_0 + \bar{x}_1 + \tfrac{1}{2} \bar{x}_2 + \tfrac{1}{2} \bar{\bar{x}}_2 (\cos \alpha_3 - \sin \alpha_3 \cot \tfrac{1}{2} \delta_2) - (\bar{y}_0 + \bar{y}_1) \sin \varepsilon + \\ + \tfrac{1}{2} \bar{y}_2 (\cos \varepsilon \cot \tfrac{1}{2} \delta_2 - \sin \varepsilon).$$

$$\eta_2'' = - \tfrac{1}{2} \bar{x}_2 \cot \tfrac{1}{2} \delta_2 - \tfrac{1}{2} \bar{\bar{x}}_2 (\sin \alpha_3 + \cos \alpha_3 \cot \tfrac{1}{2} \delta_2) + (\bar{y}_0 + \bar{y}_1) \cos \varepsilon + \\ + \tfrac{1}{2} \bar{y}_2 (\sin \varepsilon \cot \tfrac{1}{2} \delta_2 + \cos \varepsilon).$$

$$\xi_n'' = \sum_0^{n-1} \bar{x}_k + \tfrac{1}{2} \bar{x}_n + \tfrac{1}{2} \bar{\bar{x}}_n (\cos \alpha_{n+1} - \sin \alpha_{n+1} \cot \tfrac{1}{2} \delta_n) - (\sum_0^{n-1} \bar{y}_k) \sin \varepsilon + \\ + \tfrac{1}{2} \bar{y}_n (\cos \varepsilon \cot \tfrac{1}{2} \delta_n - \sin \varepsilon). \quad . \quad (17)$$

$$\eta_n'' = - \tfrac{1}{2} \bar{x}_n \cot \tfrac{1}{2} \delta_n - \tfrac{1}{2} \bar{\bar{x}}_n (\sin \alpha_{n+1} + \cos \alpha_{n+1} \cot \tfrac{1}{2} \delta_n) + (\sum_0^{n-1} \bar{y}_k) \cos \varepsilon + \\ + \tfrac{1}{2} \bar{y}_n (\sin \varepsilon \cot \tfrac{1}{2} \delta_n + \cos \varepsilon). \quad . \quad (18)$$

It is necessary to realise, that the knowledge of the situation of the instantaneous centres of rotation is not the first purpose of our analysis,

MEASUREMENTS OF FULLY ADULT SPECIMENS (INTERORBITAL RIDGES JOINED).

		Sex	Head and body	Tail (—pencil)	Hindfoot (—claws)	Cond.-basal length	Zygom breadth	Interorbit. constr.	Occipital breadth	Occipital depth	Nasals	Diastema	Mandible	Max tooth-row (alv.)	Mand. tooth-row (alv.)
ARVICOLA SCHERMAN SHAW															
Heerlen *	10.1924	♂	165	70	25	34.1	21.2	4.7	15.8	9.3	8.5	11.9	23.4	8.1	8.3
Heerlen *	10.1924	♀	170	69	25	36.0	22.6	4.5	17.4	9.5	9.1	12.0	23.6	8.4	8.7
Schinnen *	12.1926	—	166	70	25	35.7	—	5.0	16.7	9.8	9.0	12.1	23.4	8.7	8.7
Heerlen (in formaline) . .	10.1929	♀	160	75	25	32.9	19.2	4.5	15.2	9.4	8.5	11.2	21.2	8.5	8.6
Heerlen (.. ..) . .	10.1929	♀	157	77	25	33.9	20.2	4.4	15.3	9.4	8.6	11.8	22.8	8.3	8.4
Heerlen (.. ..) . .	10.1929	♂	147	73	26	33.2	20.0	4.7	15.4	9.0	8.5	11.3	22.1	7.9	8.1
Denekamp (garden) . .	5.1931	♂	155	95	26	35.5	22.1	4.5	16.4	10.7	9.0	11.4	23.5	9.1	9.2
Denekamp (garden) * . .	12.1929	♂	158	70	27	35.7	21.6	4.3	16.7	9.4	8.9	12.1	23.6	9.	9.0
Denekamp (Dinkel) . .	4.1931	—	168	82	27	—	—	—	—	9.0	—	—	22.6	8.8	9.0
Denekamp (Dinkel) . .	5.1932	♂	172	101	29	37.8	24.2	4.9	17.5	10.3	10.0	12.0	24.1	10.0	10.1
Amersfoort	1889	—	—	—	—	35.5	21.9	4.6	16.3	9.7	9.6	12.2	23.3	8.7	8.5
Zevenaar	5.1932	—	—	—	—	36.4	22.7	4.8	16.9	10.6	—	12.0	25.6	9.4	9.3
Worth-Rheden (in alc.) .	10.1918	—	140	80	29	35.2	20.7	4.5	15.6	10.2	—	12.2	23.7	8.3	8.4
ARVICOLA TERRESTRIS L.															
St. Pancras (in alc.) . .	?	♀	170	120	30	39.1	23.2	4.4	16.9	11.2	—	12.6	—	9.5	—
Best *	12.1927	♀	190	—	29	39.0	24.3	4.3	17.7	10.6	11.2	12.5	26.0	9.7	9.4
Dedemsvaart	4.1931	♂	175	105	30	38.5	23.8	4.7	16.9	11.4	10.4	12.8	26.1	9.8	9.8
Aalsmeer	6.1931	♀	163	102	29	37.5	23.8	4.8	16.7	10.7	10.5	12.8	24.7	9.3	9.0
Aalsmeer	1.9.1931	♀	184	95	30	36.6	22.6	4.5	16.6	10.7	9.9	12.3	24.0	9.2	9.4
Aalsmeer	11.9.1931	—	175	114	31	38.2	22.7	5.1	16.8	10.3	10.0	12.5	24.4	9.3	9.5
Aalsmeer	1.2.1932	♂	185	115	30	38.5	22.5	4.6	17.0	10.5	10.6	12.7	25.6	9.4	9.6
Measurements taken . .			21	21	21	42	46	34	29	29	31	33	34	34	34
Average			166	101	30	37.3	22.4	4.6	16.7	10.3	9.8	12.4	24.6	9.1	9.2
Maximum	—		201	120	32	39.4	24.3	5.1	18.4	11.4	11.2	14.1	26.2	10.3	10.4
Minimum	—	—	153	85	29	34.6	20.5	4.1	15.1	9.4	8.9	11.4	23.0	8.5	8.6

* The external measurements have been taken on the skin here.

apart from the fact, that we want to know the situation of the centres with respect to the eye, and not so much in relation to a point of the apparatus.

The centres are hypothetical points; important as the knowledge of their situation may be for the judgment and the analysis of the motion of the eye, it is this motion itself, which the experiment has to give above all. I again emphasize this consideration because the evidence of it was overlooked in almost every work on ocular movements. The analysis has to describe the motions as they are, and not as they should be. The present investigation is, of course, only a first attempt in that direction, and for the most simple kind of motion which occurs. The results of the experiments show clearly, that several particularities in the motion are not at once apparent from the situation of the centres of rotation.

The relative situation of the instantaneous centres of rotation is, of course ,the same for every point of the rotating system, i.e. the eye, and the present treatment has the advantage, that once we know this relative situation, we may calculate the path of every point of the eye, for which we know the coordinates with respect to the X''- and Y''-axes. It is obvious, that here again we have to use the formulae (1) and (2), from which, for this purpose, we derive:

$$b_{n+1} = \xi_n - (\xi_n - b_n) \cos \delta_n - (\eta_n - c_n) \sin \delta_n \quad . \quad . \quad . \quad . \quad (19)$$

$$c_{n+1} = \eta_n - (\eta_n - c_n) \cos \delta_n + (\xi_n - b_n) \sin \delta_n \quad . \quad . \quad . \quad . \quad (20)$$

In my second paper [1]) I described the way, in which I determined 1° the relative position of the spiderthread with respect to the centre of rotation of the theodolite in the zero-position (measurement of r and φ), and 2° the position of the spiderthread in relation to the eye. As now the point of intersection of the X''- and Y''-axes is put in the zeroposition of the centre of the theodolite, these same determinations have to be used; the spider-thread served as an intermediary in the estimation of the situation of the foremost point of the eye with respect to the apparatus.

The measurement of r and φ was performed exactly in the way which I described. The other determination was somewhat improved. A reticle was attached to the apparatus and adjusted in the same way as was described in the second paper. The telescope K was then focussed on the centre of this reticle. For the measurement of the antero-posterior distance $A\ Q$, from the spider-thread A to the centre of the reticle, the telescope K' was adjusted in a transverse direction. The thread A and the centre of the reticle were successively focussed by the telescope K', the displacements being made and measured by means of the antero-posterior larger screw. For the measurement of the transverse distance from the spider-thread A to the reticle, the telescope was adjusted, as formerly, in the antero-posterior direction, and the transverse larger screw was used. In this way the

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[1]) Verhandelingen, Deel XXVI, Nr. 6, page 16, paragraph 6; page 18, paragraph 7.

measurement of $A\,Q$ is more exact than it was before, when the telescope K' occupied the same antero-posterior position for both measurements.

As I have set forth in the former paper, the centre of the reticle, upon which the telescope K was focussed, does not occupy exactly the same position as the foremost point P of the cornea in the experiment; 1° P does not lie in a horizontal plane with the line of sight, and 2° the optical axis of the telescope K is not perpendicular to the line of sight. In fact, with all the subjects, the inverse image of the cornea in the telescope K showed a foremost point, which was situated somewhat lower than the point of intersection of the threads of the reticle in the telescope. This point of intersection is situated in the optical axis of the telescope. The optical axis lies in a horizontal plane with the line of sight. The distance in the vertical direction is however not large enough to influence the 0.001 mm place of the data. As for the second deviation, the data were all corrected with the product $\varrho_c \sin 2'$ in which ϱ_c is the measured radius of the centre of the anterior surface of the cornea; $2'$ is the deviation from perpendicularity, which the optical axis of the telescope K shows with respect to the line of sight[1]).

New experiments were performed with eight subjects. Results are shown in the Tables, and many of the data are represented in the figures. The motions of the screws, $\overline{x}, \overline{y}$ and ^{x}, are given in only a few Tables. Except for the Tables I and II, data are given for the point P of the cornea, which is the foremost one with respect to the line of sight as antero-posterior direction. As I have set forth in my former paper, the line of sight, fixed by means of the sighting-apparatus, was, in the zero-position, always parallel to the direction of the larger antero-posterior screw, and the X-axis was taken in that direction. The intersection of the axes of reference is put in the zero-position of the point P which is just mentioned, and, as it is a point of the cornea which is considered, the symbols b, c, ξ and η are used. Again every rotation of the theodolite is indicated by δ, and the total angle of rotation which is obtained by α. The coordinates of the points M_r and M_l are the averages of the values of ξ and η for the right and for the left side respectively. The coordinates of the points M are averages of the coordinates of M_r and M_l. The symbols ϱ indicate the "radii", i.e. the distances from the "average centres of rotation" to the successive positions of the point P. With ϱ_r the distances from M_r are indicated, with ϱ_l those from M_l and with ϱ_m those from M. These radii were calculated for the Tables I, II, XV, XVI, XXXIII and XXXIV; for the other Tables they were measured on drawings. The Tables I, II, XV, XVI, XXXIII and XXXIV also contain columns, giving ξ_H and η_H. These are the coordinates of hypothetical centres of rotation for 0°—15° and 0°—30° to the left and to the right side. I have mentioned in my former paper, that coordinates of

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[1]) Compare second paper, p. 19.

similar points were computed by H. HARTINGER from his data. Here again it is apparent, that these values differ much less from each other than the values of ξ and η do, so that their knowledge alone would give a much too favourable impression about the regularity of the motion.

The last columns of the Tables contain values of ϑ_{2m}. These were computed from the data obtained in the experiments by the adjustments of the larger transverse screw. In the former paper I have set forth how, after turning the theodolite over the desired angle, and changing, if necessary, the position of the larger antero-posterior screw, the apparatus was brought in the "sighting-position" by means of the larger transverse screw. The subject gave a signal if the position was the right one, and the adjustment was made several times. If the number of adjustments is n, the mean error, m, of the average of these adjustments will be: $\sqrt{\frac{\Sigma(y^2)}{n(n-1)}}$, in which the values y are the deviations of each measurement from the average. If we may assume, that a large number of observations would be distributed according to GAUSS' Law, the probability, that the real result will be within the interval which is equal to the average $\pm$ m, is 0.683; the probability, that the real result will be within the average $\pm$ 2 m, is 0.954. The number of adjustments was never very large, — eight at the utmost —, in order to avoid fatigue of the subject. As the relation only holds for a larger number of observations, I have used 2 m; m might give a too favourable impression about the exactness of sighting. Now ϑ_{2m} is the angle, which corresponds to 2 m; in the computation, the distances from the eye, of the crosses Kr and Kr' (of the sighting-apparatus), are used[1]). In each of the series, ϑ_{2m} was calculated for at least two positions of the apparatus, i.e. those in which the individual adjustments differed least and most. In the former case the number of adjustments which was performed was always smaller than in the latter.

Generally, the accuracy of sighting has a tendency to decrease in the course of a series; the larger values of ϑ_{2m} are mostly found in the lateral adjustments. On the other hand, in some of the series, the lowest values are found here. It is probable, that sighting is not so much more difficult in the peripheral positions, but that the smaller accuracy is mainly caused by fatigue. The first adjustment has almost never the lowest value of ϑ_{2m}; the subject always had to get accustomed again to the act of sighting. For this same reason, I never wrote down the first one or two readings of an adjustment. It is the factor fatigue which makes it doubtful that we will get a "better" value for the position of the transverse screw, by enlarging the number of adjustments. Besides, fatigue would influence the exactness of sighting in the next position of the theodolite. On the other hand, the result of a larger number of adjustments is not so very much different from

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[1]) $\tan \vartheta_{2m} = \frac{2m}{OKr} - \frac{2m}{OKr'}$, (compare fig. 5, second paper).

that, which a smaller number gives. I have specially investigated this point. The following data may illustrate it.

A range of successive readings on the head of the transverse screw was: 36.0; 33.3; 36.0; 33.8; 34.8; 32.1; 30.2; 30.5; 31.9; 30.3; 25.3; 33.5; 32.4; 32.4; 33.3; 37.4; 32.6; 36.2; 33.5; 31.8; 35.3; 36.4. If we take the first five readings only, we get 34.78 ± 1.11 (two times mean error). The value of ϑ_{2m} which corresponds to this error is 8″. If we take the whole range, we get 33.14 ± 0.90. The corresponding value of ϑ_{2m} is 6″. So, the averages for the adjustments do not differ much, and the exactness of sighting which is obtained, is about the same.

Some of the subjects could not stay in the apparatus, with the biting-plate in their mouth, during the whole series. They went out between the successive turns of the theodolite. This introduces an other possibility of error. It is not large however. The subject, for instance, after having made the range just described, went out, and, after a short rest, in again. He then made the following range: 31.7; 30.0; 34.5; 34.3; result 32.63 ± 2.16; $\vartheta_{2m} = 15''$. The smaller exactness of sighting is apparently caused by fatigue. The errors in the *antero-posterior* direction of the adjustments are within the limits of the ordinary instantaneous fluctuations (compare second paper, page 21).

Tables I and II of this paper contain again data about the emmetropic subject of the former paper, subject I. The columns 3, 4 and 5 contain the same numbers as are tabulated in the Tables I and II of the former paper. As I had, however, made an error in the computation of the situation of the point *W* of the eye, the motions of which are tabulated in the columns 8 and 9 of the present Tables, the correct numbers for these coordinates are given here[1]). The correct values for the corresponding coordinates of the instantaneous centres of rotation are given in columns 6 and 7. I may emphasize the fact, that the point to which the numbers of these Tables refer, and with respect to the "zero-position" of which (the subject looking straight forward) the coordinates are calculated, is not, like in the other Tables, the foremost point *P* of the cornea, but the point of intersection *W* of the cornea with the line of sight. In this subject the point *W* lies 0.34 mm more to the right than the point *P*, and 0.01 mm behind it. In subjects IV, V, VII, VIII, IX, the point *W* is also at the right side of the point *P*; the distances are respectively: 0.09, 0.69, 0.12, 0.59, 0.34 mm. In subjects II, III, VI, the point *W* is at the left side of the point *P*; the distances are: 0.66, 0.26, 0.02 mm. The antero-posterior distances, corresponding to the numbers just mentioned, are: 0.00, 0.03, 0.00, 0.02, 0.01, 0.03, 0.00, 0.00 mm. The measurement of these data was explained in the former paper. The hundredth mm place is not quite trustworthy.

Data about the refraction etc. of the subjects are the following:

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[1]) The former numbers are, of course, only so far incorrect, that they relate to an other point of the rotating system.

Subject II: V.O.D. = 9/10, with cyl. — 0.5, axis vert. = **10/10**; V.O.S. = 10/10. About orthophoria when looking near (± 30 cm. distance).

Subject III: V.O.D. = 6/4; V.O.S. = 6/4; emmetropia; exophoria 7^{Δ}—8^{Δ}, (prim-dioptres), looking near; esophoria 2^{Δ} at 5 meters. Pupillary distance 68 mm. Dominating eye: O.S. 1)

Subject IV: V.O.D. = 12/10, with sph. + 2 ⊂ cyl. + 0.75, axis 10° temp. = 15/10; V.O.S. = 15/10, with sph. + 2.5 = "better". Exophoria 3^{Δ} looking near, with correction of the refractive errors. Pupillary distance 62 mm. Dominating eye: O.D.

Subject V: V.O.D. = 8/10, with sph. + 2.5 ⊂ cyl. + 1.75 axis vert. = 10/10; V.O.S. = 10/10, with sph. + 3.75 = 10/10. About orthophoria, looking at 5 meters, with correction; without correction: esophoria 1.5^{Δ}. Looking near: with correction: exophoria $6^{\Delta}-8^{\Delta}$; without corr.: esophoria ± 3^{Δ}. Pupillary distance: 64 mm. Dominating eye O.D.

Subject VI: V.O.D. = 15/10, with sph. + 1.5 = "better"; V.O.S. = = 12/10, with sph. + 1.5 ⊂ cyl. + 0.5 axis vert. = 15/10. Esophoria 4^{Δ}, looking near, without corr.; with corr.: exophoria 1^{Δ}. At 5 meters: esophoria 0.5^{Δ}, with corr.; esophoria 2^{Δ} without corr. Pupillary distance 63 mm. Dominating eye: O.D.

Subject VII: V.O.D. = 1.5/10, with sph. — 2.25 = 10/10; V.O.S. = = 2/12, with sph. — 1.5 ⊂ cyl. — 0.5 axis hor. = 12/10. Exophoria 12^{Δ}—14^{Δ}, near, without corr.; with corr.: exophoria 5^{Δ}. At 5 meters: about orthophoria. Pupillary distance 61 mm. Dominating eye O.S.

Subject VIII: V.O.D. = 1/20, with sph. — 5 ⊂ cyl. — 0.75 axis hor. = 12/10; V.O.S. = 1/20, with sph. — 4.5 ⊂ cyl. — 0.75 axis hor. = 15/10. Exophoria 8^{Δ}, near, without corr.; with corr.: ± 1^{Δ}; at 5 meters, with corr.: esophoria ± 0.25^{Δ}. Pupillary distance 64 mm. Dominating eye: O.S.

Subject IX: V.O.D. = 1/60, with sph. — 6 ⊂ cyl. — 0.75 axis hor. = = 10/10; V.O.S. = 2/300, with sph. — 6.5 ⊂ cyl. — 0.75 axis hor. = = 10/10; exophoria 1.5^{Δ}, near, with complete corr.; with sph. — 1.5 (minimum): exophoria 6^{Δ}; at 5 Meters, with corr.: exophoria 0.25^{Δ}. Pupillary distance 64 mm. Dominating eye: O.S.

They are all masculine; age 23—28; subjects IV and V are brothers. With the ametropic subjects, the correcting lens was attached to the sighting apparatus, between the latter and the eye, so as about to neutralize the subject's refractive error. None of the subjects showed any other important anomaly of the eyes.

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1) Determined with MILES' ocular dominance test; W. MILES, Journal of experimental Psychology, Vol. XII, 1929, p. 113.

RESULTS.

A. *Experiments, in which the left eye was covered, and in which a glass, correcting the refractive error, was attached to the sighting-apparatus.*

The successive situations of the foremost point P of the cornea (respectively, for subject I, the point of intersection W, of the cornea with the line of sight, see p. 10) are represented by crosses in the upper part of the figures 1—11. I have set forth, that in the experiment the motion to the left side was separated from the motion to the right side, as a different position of the apparatus was necessary. Now, the anteroposterior position of the eye with respect to the skull is variable and the daily variations which were found, generally amounted from about 0.1 to 0.6 mm. In the figures however, the zero-positions of the point are put upon the same place. This is justified by the constancy of the "average radius" ϱ_m, which will be discussed later (see p. 28).

The general result of the experiments[1]) is, conform to what could be expected, that the successive situations of the point which is considered, lie more or less around circles. The motions, however, are not completely charactized by this statement. Even if the points would lie exactly *on* a circle, this in itself would not prove, that the motion would have happened around the centre of that circle. As the individual points correspond to positions of the eye, between which equal partial angles of rotation were moved through, the centre of the circle will only be the centre of rotation, if the arcs of the circle, lying between the points, are equal. This condition is the cause of the fact, that generally the "average centre of rotation" will not be identical with the centre of the circle which fits the points best. I have already set forth, how I have computed the coordinates of my "average centres of rotation" by taking the averages of the coordinates of the instantaneous centres. The radii of the circles which are drawn in the figures were obtained, by taking the averages of the distances between the average centres and the points representing the path of the point of the cornea. It is comprehensible, that the smaller we find the spread of the instantaneous centres, the more complete will be the correspondence between the circle which is obtained in the described way, and the circle which fits the points best. It is not difficult, to test this on the facts. If $b^2 + c^2 = bA + cB + C$ is the equation of a circle, and A, B and C are constants, the coordinates of the centre of the circle will be $\frac{1}{2}A$ and $\frac{1}{2}B$, and the radius of the circle is $\sqrt{\frac{1}{4}A^2 + \frac{1}{4}B^2 + C}$. If we substitute the experimental data for b and c in the equation of the circle, we get a series of equations, from which we may calculate, by means of the method of least squares,

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[1]) Only in the experiments with subject VII the small refractive error was not corrected, as this would have given experimental difficulties in series C.

the coordinates of the centre of a circle which most probably fits the points, and its radius.

If we take the data of Table XXV (fig. 9), where the spread of the instantaneous centres of rotation is rather large, we get for the coordinates of the centre of the circle: $\frac{1}{2}A = 4.003$; $\frac{1}{2}B = -2.696$; the radius is 4.362. The corresponding values of the centre M_l of the other circle, which are found in the Table, are $\xi = 13.111$; $\eta = 0.320$; $\varrho_l = 13.35$. So the correspondence is poor1). If we take the data from Table XVI (fig. 6), where the spread of the instantaneous centres was the smallest one which occurred, we get for the coordinates of the centre of the circle $\frac{1}{2}A = 12.209$; $\frac{1}{2}B = 1.146$; radius: 12.157. The corresponding values of M_r are: $\xi = 13.978$; $\eta = 0.677$; $\varrho_r = 13.88$. The correspondence is much better; it is comprehensible however, that even here it cannot be complete.

In my former paper I have discussed, for subject I, the possible errors, which might partly explain the deviations from a circular path. It was set forth, that even the improbable assumption of an accumulation of all the maximal errors would not be able to account for the deviations of circular motion. This applies to the other subjects as well, and sometimes their deviations are still larger.

If we look at the path of the point P, there is a phenomenon, which is especially obvious in fig. 9, i.e. that the points around the primary position show a retraction with respect to the adjacent ones. All the other paths also show this phenomenon to a certain degree, and it is improbable, that it should be accidental. It is certainly remarkable, that the path of the cornea which I computed from KOSTER's data, and which was represented in fig. 4 of my first paper, shows the same phenomenon.

I suppose that it is due to a condition of relatively increased tonus of the united eye-muscles, which maintains the eye in the primary position. By means of active inhibition 2) a part of these muscles will relax when the eye leaves the primary position; we may expect that this will influence the position of the eye in the anteroposterior direction. The total amount of relaxation however, cannot last when in a more lateral position a new fixation is effected; it is necessary to distinguish between the innervation during motion and the innervation during fixation. The passive resistances in the complete apparatus of suspension of the eye also play a part in the mechanism of fixation. We may suppose that these resistances, as far as the structures of connective tissue in the orbit are concerned, have the general tendency to draw or keep the eye forward; the contraction of the muscles, at least of the recti, will mostly tend to a traction backward. Any-

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1) Of course, the correspondence is much better, if right and left are taken together. We then get: $\frac{1}{2}A = 11.196$; $\frac{1}{2}B = 1.005$; radius 11.983.

2) C. S. SHERRINGTON, Proc. of the Royal Society, Vol. LIII, 1893, p. 413.
—————— Journal of Physiology, Vol. XVII, 1894, p. 27.

how, the results of the experiments seem to suggest, that the new fixation is realised upon a lower level of tonus in the muscles.

The phenomenon fits in with the conception of A. TSCHERMAK 1) and M. H. FISCHER 2), according to which the primary position does not imply a state of minimal tonus of the extrinsic eye-muscles; in stead of being a position of rest, it is a sort of "Zwangslage", which is kept up by means of an individually different distribution of perhaps a considerable tonus of the muscles.

It is obvious, that the phenomenon is not at once apparent from the situation of the instantaneous centres of rotation. Nor is this the case with the discontinuity in motion which is shown in fig. 10 and which did not only happen with this subject when the eye fixated with a slight accommodation, but with 6 *D* extra accommodation as well. The situation of the fourth point on the left of the primary position, which is located, at once, more outside, and which causes the lying off of the instantaneous centre —4, is not alone responsible for the "break" in the path. Even if it were located more inside, and, consequently, the instantaneous centre would lie in the group of the others, a discontinuity would subsist. The explanation of the phenomenon is probably the same as that of the former one; the difference with the ordinary course is, that then the relaxation is not so brusque.

The spread of the instantaneous centres of rotation is somewhat larger in the myopic subjects VII, VIII, and IX, than in two of the emmetropic ones, I and II; the emmetropic subject III shows a larger spread however. The hypermetropic subjects IV, V and VI showed about the same spread as the emmetropic ones. Intelligent subjects with a higher degree of hypermetropia, and with a good visual acuity, were not available. Except for one subject (Table III, fig. 2) the spread was never so large, that it took the instantaneous centres out of the eyeball. There is no clear parallelism between the accuracy of sighting and the extent of the spread.

The hypothetical average centre of rotation M (for subject II only M_r is tabulated) lies, in the emmetropic subjects I, II and III, at a distance of about 13½ — 14 mm behind the foremost point P of the cornea in its primary position. In the eyes with higher myopia, subjects VIII and IX, this distance was about 14½—16 mm 3). It is probable, that there is a relation between this distance and the size of the antero-posterior anatomical axis of the eye. So this axis might be larger in subject IX than in subject VIII. In harmony with this supposition the radius of the anterior surface of the cornea is

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1) A. TSCHERMAK, Handbuch der normalen und pathologischen Physiologie, 12 Band, 2 Hälfte, p. 1033.

2) M. H. FISCHER, Pflügers Arch., 188 Band, 1921, p. 227.

3) The fact, that in higher myopia a larger distance was found, seems to be in agreement with the results of other investigators. It is however difficult to compare the numbers which are communicated here with the other ones, as most of the latter are based upon incorrect experiments.

larger in subject IX than in subject VIII. Similar considerations may be made for the other subjects. It is however not a purpose of this paper, to give special information about this question. Moreover, an exhaustive treatment would have to include data about the properties of the total optic system of the eyes.

The average radius ϱ_m is almost always somewhat larger than the distance from the average centre to the primary position of the point P; this is caused by the retraction of the eye in the primary position and around it. Consequently, the largest difference is found where the retraction is most obvious.

In all the experiments, the results of which are tabulated in this paper the angle of three degrees was chosen for the rotations between succeeding fixations. I have however performed series with smaller and with larger angles. The smaller angle (e.g. one degree) is less practical in so far, that the total range of rotation cannot be extended to the same amount as in the case of 3°, in view of the fatigue of the subject. The interesting issue is however, that under these circumstances partial rotations may occur, the centre of which is found to be situated *before* the eye-ball. This means, that in such a case the foremost point of the cornea — and together with it, the whole eye — has performed a transverse displacement, the direction of which is opposite to the direction of the rotation. In the next rotation such a displacement is corrected, but the irregularity of the corneal path is none the less striking.

As moreover the displacements in the anteroposterior direction may equal those which occur with the angle of three degrees, the spread of the instantaneous centres of rotation may get larger than in any of the experiments which are tabulated in this paper. The mutual distance of those instantaneous centres can attain such values as 100 mm or more.

The disadvantage of larger partial angles of rotation is of course, that then local systematic changes in the anteroposterior position of the eyeball will escape the observation. For the analysis as it was conceived in the present investigation, the angle of three degrees was evidently most satisfactory.

B. *Experiments, in which the left eye was covered, and in which a glass, attached to the sighting-apparatus, necessitated an extra accommodation of 6—7.5 D.*

This series of experiments was performed with five of the subjects (Tables VII, VIII, XIII, XIV, XIX, XX, XXXI, XXXII, XXXV and XXXVI). The situations of the point P are drawn in the figures 3, 5, 7, 10 and 11 (circles) together with the points of the former series (crosses).

The primary positions of the point, without and with extra accommodation are made to coincide. I have investigated if this is justified. The result was, that in the primary position the extra accommodation caused a difference in situation of the point, which would be hardly noticeable in the figures. Moreover it did not seem to have a systematic direction, although it was more often directed backward than forward.

The result of these experiments is, *that the extra accommodation may cause a distinct retraction of the path of the cornea.* This is most apparent in figures 3, 5 and 11, and concerns one side especially, while at the other side the points lie more or less scattered amongst the points of the former series. Only in subject IX (fig. 11) the left part of the path is situated somewhat more foreward than the path without extra accommodation.

I suppose, that the explanation of the phenomenon has to be found in the association between accommodation and convergence. This association will cause an increase of the degree of contraction of the internal rectus; consequently the eye can only occupy the desired position with respect to the sighting-apparatus if the tonus of the external rectus is also increased. The final result is a retraction of the eye.

It may surprise, that the increase of the degree of contraction of the eye-muscles, which I hold responsible for the retraction of the path of the cornea, influences the primary position so little, that the difference in situation would be hardly noticeable in the figures. This becomes comprehensible however, if we remember, that there are good reasons to assume that the primary position implies a state of increased tonus of the extrinsic eye-muscles. So a further increase of this tonus will be more difficultly obtained in the primary position than in an other one. I found the same phenomenon in the influence of the fixation with both eyes, which will be described in the next paragraph, and the same reasoning is applicable to that case.

The influence of the state of accommodation upon the anteroposterior position of the eye was studied by DONDERS [1]) and by TUYL [2]). DONDERS found a distinct motion to the front every time his subject accommodated for a point of the visual line near to his eye; DONDERS however added the special remark, that, at the same time, the upper eyelid lifted up, and the eye got, at least in older persons, an expression of gravity and strained attention. TUYL, who took care that the slit between the eyelids did not change, found a retrograde motion which varied in his different subjects between 0.15 and 0.2 mm. TUYL has examined the eyes of his subjects in a position which will not have differed very much from the primary position. It is highly probable that the motion which DONDERS found was caused by the elevation of the upper eyelid.

It is apparent in figures 3, 5, 7, 10, 11 that the path of the cornea is a more irregular one, when the external muscles of the eye are under the influence of the extra-accommodation, than when this influence is not

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[1]) F. C. DONDERS, Graefe's Arch. f. Ophthalmologie, 17 Band (1), 1871, p. 100.

[2]) A. TUYL, Graefe's Arch., 52 Band, 1901, p. 252.

present. For the explanation of this phenomenon we might suppose that perhaps the relative maximum of accommodation which was demanded was not always actually produced. In this case the subject would not get a perfectly sharp image of the second cross of the sighting apparatus upon his retina. As I could not use in my experimentation a diaphragm with two holes, in order to avoid this cause of errors by means of SCHEINER's principle, there remains a certain possibility that some of the points do not correspond to the maximum of accommodation. If is improbable however, that this will be perceptibly responsible for the irregularities, as for accurate sighting the production of a sharp image of the sighting apparatus is essential, and the sighting was always performed as carefully as possible. It is true that the accuracy of sighting was almost always somewhat smaller than in the corresponding series without extra-accommodation. There is however no clear parallelism between the accuracy of sighting and the extent of the irregulaties. Moreover, the accuracy always remained a comparatively high one.

There is an other explanation which might be proposed in order to explain inconstancies in the degree of contraction of the external eye-muscles, i.e. the comparative looseness which exists in the association between accommodation and convergence, and which may eventually go further than the ordinary range of convergence. ROELOFS [1]) found with binocular fixation that an esophoria of 26 prism degrees, which he had provoked by means of an accommodation of seven dioptres, was already reduced to 12 prism degrees after five minutes, to 8 degrees after ten minutes; it went down as far as 4 degrees after half an hour. The downfall of the esophoria was very steep at the outset; after five to ten minutes it was much slower. Here the relaxation of the tonus of the interni is caused by the fusion tendency. Fusion tendency was however not evoked in series *B* of my experiments. The left eye of the subject was covered and it could occupy a convergent position without giving discomfort. According to the principle of the equal innervation of both eyes the internal rectus of the left eye may receive an extra innervation because of its double function: i.e. as a muscle of convergence, and as a muscle for turning to the right side. The second part of the innervation will be caused by the innervation of the external rectus of the right eye. This strong double innervation at the left eye means a considerable nervous impulse, which is not maintained by means of a process of attention, as there is no fixation. Although it is, on the other hand, not particularly counteracted either, it does not seem to be improbable that this nervous impulse will relax if possible. If the association between accommodation and convergence will permit such a relaxation, the tonus of the muscles of the right eye will also decrease.

Another cause which might be taken into consideration for the

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[1]) C. O. ROELOFS, Graefe's Arch., 85 Band, 1913, p. 75.

explanation of irregularities in the path of the cornea is a variable tension of the eye-lids, and consequently, changes in the width of the slit. I have already mentioned such changes in the discussion of the observations of DONDERS and TUYL. Care was always taken to avoid such influences, and it is very improbable that they would have to enter in the explanation here.

In the experiments the subject only produced the extra-accommodation during the time which was necessary for sighting and for the determination of the position of the cornea. The final degree of contraction of the external eye-muscles, which finds expression in the data, will be a function of the variable disposition of the subject during these periods, of their duration, etc.

In consequence of the larger irregularity of the path of the cornea, the accommodation always enlarged the spread of the instantaneous centres. As their mutual distance may mount up to about 40 millimeters, some of them get out of the eyeball in such a case.

As the retraction is most apparent on the right side in certain cases, and on the left side in other cases, the hypothetical average centre did not show a systematic displacement; it was usually somewhat more displaced in the tranverse direction than in the anteroposterior one.

It is remarkable, that in four of the subjects the extra accommodation did almost not change the "average radius" ϱ_m. Only in subject IX it changed somewhat more, and it got about 1 mm. smaller. I will deal again with this phenomenon in the discussion of the influence of binocular fixation, where the same result was found.

C. *Experiments, in which both eyes were open, and in which the subject sighted with his right eye, while he fixated the cross Kr′ of the sighting-apparatus with his left eye.*

These experiments were performed with five of the subjects (Tables IV, XI, XII, XVII, XVIII, XXIII, XXIV, XXVII and XXVIII). The situations of the point *P* are drawn in the figures 3, 4, 6, 8 and 9, together with points of the first series. Again the primary positions of the point *P* were made to coincide. This was justified for the same reason, as was set forth in the discussion of the series with extra accommodation[1]).

The subjects easily learned to practice the binocular fusion of the two unequal images, which stood apart because of the heterophoria. The whole process was distinctly a reflectory one. Of course, the subject *tried* to unite the images, in directing his attention upon them. Then the image of the

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[1]) The influence upon the primary position may eventually be stronger here than in the case of extra-accommodation. This holds especially for subject VII. So the whole series of circles in fig. 9 might be drawn perhaps 0.5 mm. (see scale) more "inward"; this would make the phenomenon of retraction, which will be discussed in this paragraph, still more marked. In the drawing this effect was not carried through, as the daily variations in the primary position of subject VII were also larger than in the other subjects.

left eye slowly moved towards the other one. It was impossible for the subject to accelerate this motion; he just could evoke the proces by means of his attention. If he was tired, and especially — in case of exophoria — if he had previously exhausted his power of convergence by long reading, the joining of the images could be impossible at all, notwithstanding every effort. A last small part of the joining motion was always fast. The images, which were already very near to each other, then fused at once. The same phenomenon was observed by HOFMANN and BIELSCHOWSKY 1), when they studied the fusion of vertically disparate images. This phenomenon may be a part of the "Einschnappmechanismus", which KESTENBAUM 2) assumes in fixation. A sharp image is supposed to provoke a reflectory contraction of all the extrinsic eye-muscles, as soon as it is projected upon the fovea centralis of the retina. We might assume, that a reflex mechanism of the same kind as that which holds for each eye apart, gets into action, when the position of the eyes which is necessary for the joining of the images is almost reached, so that both already fall upon the double fovea of the "cyclops-eye".

The convergence which led to fusion, and which was necessary because of exophoria, was almost always accompanied with some rotation around the line of sight. The amount of this torsion was individually different; the largest torsion was shown by subject VII, who also showed the largest exophoria. With him I studied the course of the phenomenon more extensively. As an objective method of investigation could not be introduced into the apparatus, I had to use the less accurate method of after-images. A set of lines radiating from the centre of the first cross, *Kr*, was fixed upon the anterior brass plate of the sighting-apparatus, so that the angle of torsion could be estimated. Rather intense after-images appeared to be necessary for the investigation. They were evoked by means of a 40 Watt lamp which was placed just behind the anterior brass plate of the sighting apparatus. The subject was fixed with respect to the apparatus by means of the biting-plate. The room was darkened. During one to two minutes, he fixated the centre of the illuminated cross *Kr*. The state of accommodation of the eye was about the same during the production of the after-image as afterwards, when the subject fixated the cross *Kr'*. No torsion was observed when the subject now sighted with his right eye, while the left eye remained covered. Then the primary position in monocular fixation could be checked by watching the eventual torsion during the motion towards the left and the right side. Under the given experimental conditions, none of the subjects showed considerable deviations of LISTING's law in this respect. I mentioned however that the accuracy of the method with after-images is not very large. Moreover, the conditions of the experimentation were not especially favourable, as the observation of the position of the after-image

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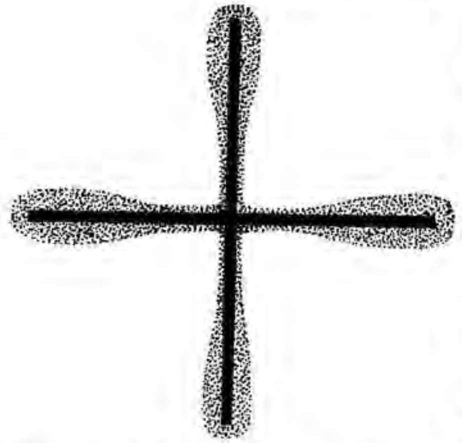
1) F. B. HOFMANN and A. BIELSCHOWSKY, Pflüger's Arch. 80 Band, 1900, p. 4.

2) A. KESTENBAUM, Graefe's Arch., 105 Band, 1921, p. 808.

with respect to the crosses of the sighting-apparatus, which cannot be seen sharp simultaneously, is rather difficult. This applies to the conditions in binocular fixation to a still higher degree.

The dark negative after-image has a peculiar aspect, about which the more or less schematic figure gives an impression. The rather sharp image of the cross is surrounded by a much less dark zone, the boundary-lines of which are not parallel to the lines of the cross, but are curvilinear, and converge to the centre of the cross. The explanation of the less dark surrounding zone is certainly found in the motions which the eye makes during fixation and which were described by several investigators. The rather sharp image of the cross is produced during the short periods of real fixation, the "Elementarfixationen" (ÖHRWALL), when the eye is comparatively still. The existence of the surrounding zone is a proof that although the motions between the elementary fixations do not get into our consciousness, the light nevertheless may exert a lasting action upon the retina, at least after repeated exposures. The form of the zone leads to a conclusion on the nature of these motions, which does not follow from the data that have been published about this phenomenon. The simplest explanation of the convergence of the boundary lines towards the centre of the cross is certainly, that there has been a rotation around the line of fixation. As the surrounding zone also envelops the ends of the lines of the dark cross, these small torsions are apparently combined with translatory motions. The fact, that this combination does not show up in the data of previous investigators is caused by their methods of experimentation, which, with perhaps the exception of those of DODGE[1]), made it impossible to detect the torsion. The surrounding zone is an other cause of inaccuracy in the estimation of the angle of torsion, above mentioned. It could however be established easily, that this angle did not surpass two degrees in the motions towards the left and the right side. It was usually smaller.



A larger torsion could be observed during the change of monocular into binocular fixation. I mentioned already, that subject VII showed this most clearly. As the phenomena which occur very pronouncedly here may enter into the explanation of changes in the motion of the eye, I will describe

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[1]) A rotation around the visual axis would be detectable with the similar registration methods of DOHLMAN or STRUYCKEN—KUILMAN; as however the cornea of the eye, the motions of which are observed, is covered in these methods, they do not seem to be suited to the present purpose.

them somewhat more in detail. The course of the experimentation was as follows. During the production of the after-image in the right eye, the left one was closed. The subject then sighted with his right eye, and the left one was allowed to fixate the second cross, *Kr'*. To the subject, the second cross appeared on the right side of the image of the right eye, and it was rotated over an angle of about five degrees, in the sense of the hands of the clock. The image of the right eye was appreciated as vertical. The distance of the centres of the two images was about one and a half times as large as the length of an arm of the cross, so that the angle between the two visual lines could be evaluated at about five degrees. As the subject's exophoria at 30 cm. distance was about seven degrees, when measured without fusion tendency, apparently the latter already neutralised a part of the exophoria. The centre of the right image was almost always somewhat higher than the centre of the left one.

The different and disparate images gave no particularly disagreeable sensations, but the involuntary fusion motion set in as soon as the subject directed his attention upon them. The course of the fusion supports the conception according to which this kind of ocular movements originate — as "psycho-optical" reflexes[1] — if corresponding stimuli which draw a predominant attention in each of the visual fields, are projected upon disparate parts of the retinae.

During the fusion motion the tilt of the right image did not change very much in the beginning; most of it disappeared in the last fast part of the fusion. During this rotation against the clock the vertical left image of the right eye made no apparent rotation at all, so that it could seem that the right eye did not make any torsion. The after-image however showed that this supposition would be incorrect. After the fusion the after-image was tilted in the same direction as was shown by the motion of the image of the left eye. The angle of this rotation could be evaluated at about one half of the angle at which the image of the left eye was tilted before the fusion motion. The simultaneous observation of the two crosses and the after-image, combined with the binocular fixation, was rather difficult.

It follows from the situations and the motions of the images 1° that apart from the divergence of the visual lines, exophoria, there was a cyclophoria in the sense of extorsion (about 5°) and 2° that in consequence of the fusion adjustment (Fusionseinstellung HOFMANN[2]) a torsion in the sense of the clock was performed not only by the left eye, but by the right eye as well. The rotation of the right eye was smaller than that of the left eye, and so the final result could be a correction of the cyclophoria.

This effect of torsion synergy giving an unequal rotation in the same sense has not been described up to now, as far as I can see, and a few remarks about it may be made here. In view of the large frequency of more

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[1] F. B. HOFMANN, Raumsinn, p. 312 ff. Graefe-Saemisch's Handbuch der Augenheilkunde, 2 Aufl., III Band.

[2] F. B. HOFMANN, l.c. p. 315.

or less pronounced degrees of cyclophoria it is of general interest. Torsion synergy in the same sense as the reflectory effect of a lateral inclination of the head is a well known phenomenon. It was recently proved [1] that the optical evocation of such a synergy is also possible. For that purpose an after-image in the form of a vertical line was evoked in one of the eyes of the subject, and the latter could manage to produce a permanent fusion of this after-image with the images of vertical lines upon the discs of a haploscope, if these discs were rotated slowly. This was also possible if the line was only present upon the disc of the contralateral eye; it could be proved in this way that the torsion concerned both eyes in the same extent, as the subsequent presentation of an equally inclined line upon the equilateral disc now showed that this line had the same direction as the after-image [2]. In the present observation the amount of torsion of both eyes was apparently *not* equal, and this is comprehensible, as by an equal rotation the cyclophoria would never have been compensated.

We may suppose, that this kind of torsion synergy is a very common one, although generally the extent will not be so large as in the present case, where a rather considerable cyclophoria existed. It is possible to explain the phenomenon quite easily from the viewpoint of the equal innervation of both eyes. Every torsion of one eye is apt to involve a torsion of the other eye in the same sense, "dextroclination" or "levoclination", especially as this kind of synergy must be a very common one because of its reflectory use in the compensatory motions after lateral inclinations of the head. As now however the purpose of the torsion is to correct a cyclophoria, the just mentioned synergy will be counterbalanced by a synergy with a contralateral sense — a "conclination" in the present case. The algebraic sum of these two synergies may always cause *some* rotation of the leading eye, if there is no special reason why this should not happen [3]. Here is a difference with the system of synergies which comes into action in asymmetrical motions of the visual axes, i.e. asymmetrical convergence, or corrections of exophoria and esophoria. In those cases the position of the leading eye is firmly bound up with the point of fixation, while in the case of torsion the orientation of the eye around the visual axis is more free; the vertical-perception (Vertikalempfindung) can then be taken over by an other retinal meridian, which seems especially

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1) R. NOJI, Graefe's Arch. f. Ophthalm. 122 Band, 1929, p. 562.

2) Probably the exactness of the judgment of bilateral equality would have been higher if in stead of vertical lines horizontal ones would have been chosen. With vertical lines a stereoscopic effect is always apt to interfere with the exact observation.

3) I cannot agree with NOJI's remark (l.c.p. 569) according to which the two synergies would necessarily compensate each other on the leading eye. Although NOJI is apparently cyclophoric, he has very probably not observed a resulting torsion of the eye with the after-image because he *always* wanted to fuse the vertical after-image with the vertical lines upon the discs of the haploscope.

probable in view of such a strong empirical point of contact [1] as was constituted by the sighting-apparatus in my experiments.

Several considerations enter in the judgment of the question if the original tilt of the image of the left eye actually corresponds to the total amount of relative rotation around the visual axis which this eye performs in the fusion adjustment. Errors in the observation, which would be caused by the fact, that the centres of the images were fused but not the more peripheral parts, can be excluded. The relative extent of the *areas* around corresponding points (the "PANUMsche Empfindungskreise"), within which disparate elements provide singular vision, might have to be taken into account; no stereoscopic effect was observed however. Another consideration might enter here, which is of a different nature. SACHS and MELLER [2] have defended the conception according to which we have to distinguish between a monocular and a binocular visual correspondence ("Sehrichtungsgemeinschaft"), the first of which would be congenital, while the second one would be acquired. This difference would be especially pronounced in cases where the retinal meridian which in primary monocular fixation supplies the sensation of vertical ("Längsmittelschnitt"), deviates much from the perpendicular one. A clear distinction should be made between retinal incongruency and cyclophoria. This conception is certainly attractive from a viewpoint of pathology, in comparison with the anomalous visual correspondence in cases of squint [3]. I do not think however, that the observations of SACHS and MELLER are absolutely conclusive with respect to their view; moreover, these authors do not seem to exclude torsion motions in their case either (l.c. p. 9). As for the present case, the explanation of the phenomena in the sense of a correction of cyclophoria is certainly the simplest and the most probable one.

The simultaneous observation of the binocular images and the after-image of the right eye was also performed in lateral positions. When however the angle of rotation of the line of sight increased, towards the right or towards the left side, it got more and more difficult to unite the disparate images; this increase in difficulty was individually different, and it was also connected with eventual fatigue of the subject. The difference between the distances from the left and the right eye to the second cross of the sighting-apparatus was probably mainly responsible for this difficulty of fusion. In the primary position of the right eye the difference of the

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[1] Comp. M. SHODA, Pflüger's Arch., 215 Band, 1927, p. 603. The easiness, with which such a revaluation of the retinal meridans takes place, also follows from NOJI's experiments; l.c. p. 568.

[2] M. SACHS and J. MELLER, Graefe's Arch., 57 Band, 1904, p. 1—23.

[3] The case of strabismus rotatorius which was described by OHM (Centralbl. f. prakt. Augenheilk. 32 Jahrg., 1908, p. 194), and which has been cited in this connection, is apparently of a different nature; OHM at least assumes a torsion in the change of binocular into monocular vision. "Der ursprünglich schief gerichtete, mit dem Nachbild geladene, vertikal empfindende Meridian hatte sich der Lotrichtung sehr genähert" (l.c. p. 199).

distances was about 6 mm., in the rotation to the left it went up to about 26 mm, in the rotation to the right to about 34 mm. In consequence of the larger difficulty of observation and fusion, observations which included the situation of the after-image could not be made satisfactorily in positions, which differed more than about twenty degrees from the primary position. The single combination of sighting and binocular fixation of the second cross, without observation of an after-image, could usually be continued some ten degrees farther. The lateral positions did not show clear changes in the divergence of the retinal meridians. This is in agreement with the results of HERING[1]) who found, that in asymmetrical convergence the angle at which the retinal meridians of the eyes are relatively inclined towards each other does not change very much, if during the motions of the visual axes the angle of convergence did not vary. In my experiments, it varied from about 8° to about 11°, so that no clear changes in disclination could be expected. HERING only obtained them when the angles of convergence changed much more.

The other subjects showed essentially the same phenomena as subject VII, although mostly much less pronounced. Subject IV only showed an opposite direction in the tilt of the image of the left eye.

If we now consider the results of the experiments of series C, which are represented in figures 3, 4, 6, 8 and 9, it is apparent, that *in every case the simultaneous fixation with both eyes causes a retraction of the path of the cornea.* This happens in the motion to the right side as well as to the left side.

The increase of the tonus of the external muscles, which must be responsible for this phenomenon, is very probably caused by the correction of heterophoria.

In order to get insight in the mechanism which comes into action here, we have to review the motions which the eyes perform for this correction, and which were amply discussed in the preceding pages. Just as in paragraph *B* (page 16/17) I will base the explanation upon the conception of the equal innervation of both eyes.

For the correction of the exophoria, in the first place the convergence synergy is necessary. As thus both internal recti are innervated, a compensatory action of the synergists which turn the eyes to the right will follow. The result is, that both the internal and the external rectus of the right eye are innervated, while the internal rectus of the left eye gets a double innervation.

As for the cyclophoria, we have seen that in fusion two involuntary torsion synergies may be supposed to act. The first of these, dextroclination, involves, at the right eye, the actions the inferior rectus and the inferior oblique; the second one, conclination, is effected by the actions of the superior rectus and the superior oblique. In both synergies the actions of

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1) E. HERING, Die Lehre vom binocularen Sehen, p. 98.

the two muscles cooperate in such a way, that their vertical components (transverse axis of rotation) neutralise each other, whereas the torsion components (anteroposterior axis of rotation) add. It is however highly probable, that the actions of these four muscles always each have a horizontal component (vertical axis of rotation) [1].

The following very schematic reasoning may give some idea about the relative forces which the different muscles have to put forth in this complex of synergies. Conformable to a current procedure in mechanics, the moments

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[1] These horizontal components are neglected by A. TSCHERMAK in his recent motor analysis of ocular movements in the Handbuch der normalen und pathologischen Physiologie, 12 Band, 2 Hälfte, p. 1001—1094. They are however large enough to be taken into account (see page 26). Their approximate value follows from A. W. VOLKMANN's data (Ber. über die Verh. der Kgl. Sächs. Ges. d. Wissensch., 21 Band, 1869, p. 28). Although these data are based upon still the most reliable observations which are made up to now, a remark must be made concerning the reliability of the numbers, which are finally given (VOLKMANN, p. 56) for the angles, which the axes of rotation of the individual muscles make with the axes of a system of coordinates, the zero-point of which is laid in the "centre of rotation" of the eye. A very current error consists in the idea, that if a certain magnitude is measured in a number of individuals, the probability of the arithmetic mean should be necessarily higher than that of any other individual measure which is found. Indeed, the supposition of the arithmetic mean holds for measurements of one magnitude in one individual, if the errors of the observations may be supposed to spread symmetrically, and according to Gauss' Law. Here the fact is often overlooked, that the certainty of the exactness of the arithmetic mean is only proportional to the square root of the number of observations, so that it is much better to increase the precision of the measurements than to augment their number. As for measurements in different individuals, we cannot expect that their frequency distribution will be necessarily symmetrical. As soon as it is not, the value which is most frequent or typical, the "mode" is not equal to the arithmetic mean. As long as the dispersion is small, the difference between mean and mode is likely to be insignificant. In larger dispersions however, this difference has to be taken into account. VOLKMANN states repeatedly (l.c. p. 45, p. 50) that the situation of the muscles is individually very different; this also follows clearly from the maxima and minima of the measurements, which he gives. VOLKMANN has mixed certain of his data with numbers from another material; from a statistical viewpoint this cannot be allowed either. Unfortunately VOLKMANN did not communicate the measurements of the individual eyes, so that we cannot reconstruct the situation in each eye apart. The *existence* of horizontal components in the actions of the recti and the obliqui is however beyond all doubt, and this existence is decisive in the controverse about the question if vertical motions of the eye can be made by means of the cooperative action of two muscles only — which certainly cannot. It is obvious, that the well-known scheme of HERING (Die Lehre vom binokularen Sehen, p. 115) is erroneous, attractive as it may be from a mnemothechnical viewpoint; it is however based upon the assumption of horizontal axes of rect. sup. and inf., obliq. sup. and inf. Curiously HERING himself states the existence of the components in question (HERMANN's Handbuch der Physiologie III Band, 1 Theil, p. 518). The problem of the axes was already clearly discussed by CARL WEILAND in 1898 (Archives of Ophthalmology, Vol. 27, p. 46), who also calculated the relative values of the different components in the primary positions, on the base of VOLKMANN's data about the angles of the axes of rotation. HAROLD WILSON has recalculated these angles (Archives of Ophth., Vol. 29, 1900, p. 416); he found, that VOLKMANN had made errors in the computation. The values of the components which I have used in the text are based upon these recalculated data.

of rotation of the different muscles are imagined as vectors which are erected in the "centre of rotation", perpendicular to the planes of action of the muscles. Their direction is always such, that they coincide with that half of the axis of rotation which extends to the side from which a rotation in the sense of the clock is seen. As the attachments of the muscles are supposed to lie at equal distances from the centre of rotation, the size of these vectors may be taken equal to the forces of the corresponding muscles. The vectors are resolved and composed along the axes of a system of coordinates, the zero-point of which is in the centre of rotation. These axes coincide with the "main" axes of rotation of the eye, which were just mentioned. It is assumed that although the rotations which come into consideration are not infinitely small, nothing changes at the vectors during these rotations; finally the vectors are supposed to be proportional to the angles of rotation for which they are responsible. Of course this schematic presentation deviates from reality in almost every detail; without doing so, such a treatment would however be hardly possible.

Let us put *100* for the force which is required from the superior oblique of the right eye. According to the data of VOLKMANN-WILSON (see footnote p. 25) the component along the transverse axis will be 57. For conclination synergy the neutralising component of the superior rectus along this axis has to be equally large. So the required force of the superior rectus has to be represented by the number *66*, (which is 57/87 × 100). As for the relation between dextroclination and conclination, we have to remember that the angle between the corresponding meridians of the eyes before fusion was evaluated at about five degrees in subject VII, while the torsion of the right eye after the fusion was estimated at 2.5 degrees. So the left eye made a positive rotation, dextroclination *plus* conclination, of $5° + 2.5° = 7.5°$, while the right eye made a positive rotation, dextroclination *minus* conclination, of $5° - 2.5° = 2.5°$. According to this reasoning and to the above assumptions, the force required for the dextroclination is twice as large as that for the conclination. The latter is the sum of the torsion components of the superior oblique and the superior rectus. These are respectively 80 and $40/100 \times 66 = 26$, which makes 106. So we have to put 212 for the force of dextroclination. It follows from a simple reasoning that the force of the inferior oblique has now to be represented by $212/107 \times 100 = 198$, and that of the inferior rectus by $212/107 \times 73 = = 145$. It is interesting to examine the size of the components along the vertical axis. Three of them have the same direction, which points downward: superior rectus $29/100 \times 66 = 19$; inferior rectus $32/100 \times 145 = 46$; inferior oblique $11/100 \times 198 = 22$; sum: 87. The vertical component of the superior oblique has an opposite direction; its size is $17/100 \times 100 = 17$. So the algebraic sum of the components along the vertical axis is *70*. The action which would be exerted by this sum of components is an inward rotation; this has to be compensated by an equally strong action of the external rectus. It is clear that the force which is thus required from the external rectus is of the same order of magnitude as all the other forces, while it is even larger than one of them. As for the correction of the exophoria, the angle of the latter was about equal to the dextroclination and so we can put, in agreement with the above assumptions, for the applied force of the left internal rectus the numerical value of 212. Each of the forces of the right internal and external recti which are required here corresponds to half of this value. All together the force of the external rectus of the right eye gets the number *176*.

It follows from the preceding discussions, that all the external muscles got into action for the correction of the heterophoria, and already five of them for the cyclophoria alone. The forces which were required would vary from one (superior rectus) to three (inferior oblique) 1). In these circumstances, the retraction of the path of the cornea is quite comprehensible, and it is certainly in harmony with the explanation that the largest retraction was found in the subject where the largest heterophoria existed.

The importance of heterophoria for the tonus of the eye-muscles is thus clearly demonstrated. In this connection I may mention the distribution curves which are obtained by means of the examination of individuals upon the different degrees of eso- and exophoria. No large groups have been examined in this respect 2), but the results are unambiguous. The frequency curve which corresponds to a population with a good binocular vision deviates in a typical way from the "normal" Gaussian curve, as it is what is called *leptokurtic*; the maximum of the curve is situated around orthophoria. The curve demonstrates without any doubt that there exists in these eyes a strong tendency towards the formation of apparent muscular balance. The statement of some authors (BIELSCHOWSKY, TSCHERMAK) that the ideal case of orthophoria is a rare exception, does not do justice to this tendency. It is obvious from a general statiscal viewpoint, that even in the presence of a strong regulating mechanism only a small part of the individuals will reach the state of real orthophoria or its more immediate environment; the number of these individuals which is found depends in the first place upon the size of the class-intervals. In the measurements of ROELOFS about one third or one fourth of the individuals were found to have orthophoria or heterophoria < 1 prism degree. In individuals with a worse binocular vision a still higher percentage of heterophoria seems to occur. Moreover the observations of MARLOW 3) show, that it is probable

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1) In the lateral positions of the line of sight the relations change, as in adduction the horizontal actions of the muscles (vertical axis) are increased into the same direction, and in abduction they are reversed. (O. ZOTH, Sitzungsber. d. Kaiserl. Akad. der Wissensch., Wien, Mathem.-Naturw. Cl., Bd. CIX, Abth. III, 1900, p. 1; J. VAN DER HOEVE, Klin. Monatsbl. f. Aug. 69 Band, II, 1922, p. 620).

2) C. O. ROELOFS l.c. 1913, p. 107; Archiv für Augenheilkunde, 97 Band, 1926, p. 231/232.

3) F. W. MARLOW, The relative position of rest of the eyes and the prolonged occlusion test, Philadelphia 1924, and other publications.

that at least a part of muscular imbalance may remain concealed and latent if the duration of the abolishment of binocular vision is only extended over the short period which is necessary for the test itself. We may indeed be sure that the large majority of even emmetropic eyes are subject to a distinct degree of heterophoria and to the kinetic consequences thereof.

A phenomenon may be observed in the figures, which is similar to that which I have discussed in the former paragraph, i.e. that the retracted path of the cornea is less regular than that of the first series. The accuracy of sighting is generally somewhat smaller in the series with binocular fixation, but this cannot explain the irregularities any more than in the former series. The difference is too small, so that the accuracy of sighting still remains high. Moreover the inaccuracy only influences the adjustment of the larger transverse screw in the experiment, and transverse shifts of the point would never regularise the path. One might suppose, that perhaps binocular fusion was not always complete; in this way we could explain for instance the situation of the last points on the left in fig. 9. This however would only apply to these outmost points, and even there the explanation is improbable, as much care was always taken, that only those situations were registered, in which the subject very consciously perceived one image. Moreover the all-or-none character of the fusion reflex is a guarantee against deviations. It is improbable that "Empfindungskreise" (see page 23) should play an important part in the explanation of the phenomenon, as the extent of those areas is smaller than the distances, which would come into consideration here. So we have to assume, that *within the bounds of fusion* a fluctuation of the tonus of the muscles occurs. A similar supposition might also apply to the case of extra-accommodation.

In consequence of the larger irregularity of the path of the cornea the spread of the instantaneous centres of rotation is somewhat larger than in the series where one eye fixated.

It appears from the Tables, that the "average radius" ϱ_m was only slightly different from that, which was found in the first series. I have already pointed to this relative constancy in the discussion of the influence of extra accommodation, where the same phenomenon was found. It seems that this physiological measure is fixed by the anatomical conditions of the motor apparatus of the eye, and that the temporary state of tension in the extrinsic muscles gives only small changes in these conditions. In any case, it seems logical, that *if* we want to give a number which should characterize the motion quantitatively, we should adopt the average radius for that purpose; we should not take, for instance, the distance between the point of the cornea in the primary position and an average centre of rotation ¹), or a radius which is calculated from two or three divergent situations of the eye.

In the preceding discussion two guiding principles in our knowledge of

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¹) I may refer to what I remarked in paragraph A, page 15.

ocular movements came up, and I want to make some concluding remarks as to the relations which exist between thoses principles and the results of the experiments which were described.

I. LISTING's Law. This law may be defined in the sense of a possibility of motions of the visual line in flat planes, starting from the primary position, while the eye turns around approximately fixed and constant axes, which are perpendicular to the planes of motion and which altogether lie in the primary axis plane. Ordinarily the validity of this law is tested in the final positions of the eye-ball *after* a motion, by means of the examination of an eventual torsion around the visual line with respect to the plane of motion. We know that the free motions between two fixations are generally much less regular than a simple rotation of the eye around one axis would involve. For this reason the notion of a *possibility* is introduced in the above definition. Fairly realised however is this possibility only in the most regular type of motion, the "pursuit movement" (DODGE), in which the line of regard follows an object moving across the field of vision. DODGE assumes that during pursuit movements clear vision of a moving object is possible. As however, the line of regard lags behind the line of interest 1), so that it has to overtake the latter from time to time by short auxiliary jerks, a constant projection of the object of fixation upon a definite place of the retina is apparently never realised. So a real fixation cannot be established 2) ; it still remains to be investigated in how far the clearness of vision of which DODGE speaks, differs from that which is found in the fixation of an object in rest 3).

In all the other types of ocular movements more or less irregular and jerky sweeps alternate which short periods of rest, in which real fixation happens. As for the existence of the latter a well balanced tonus of all the ocular muscles is necessary, it is comprehensible that the fixations are mostly preceded by one or more corrective motions 4).

The "purpose" of ocular movements is certainly always to reach a state of fixation which is as adequate as possible. This involves in binocular fixation the absence of a disturbing relative torsion of the eyes. Nothing is changed to the modal conception of the motions by the insight, that most of these motions are not purposely performed because they are reflexes. The

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1) R. DODGE, American Journ. of Physiol. Vol. VIII, 1903, p. 320.

2) A real fixation *might* be maintained during the relative motion which the eye makes with respect to the orbit when one looks at an object while the head is turned slowly.

3) Naturally, the power of discrimination decreases when the velocity of the object which is regarded increases. There are a few data about this question, which were obtained by ZEEMAN (Arch. f. Augenheilk. Band 100/101, 1929, p. 6) for a somewhat different purpose. As however the angular velocity and the corresponding visual acuity are not communicated in this paper, the data give no further information with respect to the above question. An investigation of this complex problem would have to involve a careful objective registration of the motions of the eye.

4) C. G. SUNDBERG, Skandinav. Arch. f. Physiol. 35 Band, 1918, p. 10 etc.

behavioristic consideration which is based upon this insight, i.e. that we can just as well pretend that the environment fixates us, as we do the environment, has essentially a philosophical value, without further consequences in view of an experimental analysis. As for the latter, there is no advantage in the premise that the motion should be "primary" and more "natural" than the standstill; we never can understand a motion otherwise than as a sequence of successive positions of rest. It is in this sense that I have developed the mathematical analysis in my first paper. The mathematical process of integration finally remains unimaginable; our *knowledge* consists only of static relations, which may be expressed by numbers.

So a *static* conception always has a primary importance; LISTING's Law is best understood as the static description of the relations which exist between any position of the eye and one central position, the primary one. If this description should be correct, it would involve that: 1⁰ no torsion around the visual axis exists in the relation between the two positions; 2⁰ it is always possible to put a flat plane through the primary position of the visual axis (or any other fixed line in the eye) and the same line in the secondary position; 3⁰ in this flat plane the two lines always touch the same circle, the centre of which is the centre of rotation of the eye; of course the radius of this circle may be zero; 4⁰ there is constant distance between a fixed point of the fixed line and the point of contact with the circle.

The first point involves DONDERS' Law of constant orientation around the visual axis. Most of the experimental work which has been done in this field, concerned the verification of this point; individually different deviations have been described by several authors.

The principles of simplest innervation and of the smallest muscular labour (FICK), the principle of the largest horopter (MEISSNER) the principle of the avoided apparent motion (HERING), which have been connected with LISTING's Law, all relate to this first point. HERING already[1]) has pointed out that it is rather difficult to combine these principles, especially if convergent positions of the visual axes are considered as well as parallel positions. In fact, certain deviations of the Law seem to fit the principles better than its fulfilment would do; so an increase of disclination in convergence will change the horopter in such a way that it gets in better agreement with the plane in which near work is usually performed[2]). As for the first one of this series of more or less teleologic principles, HERING stated that it never would be decisive for the motility, but that it only would determine *the way* in which motions are performed wich are necessary because of other reasons — i.e. because of the fulfilment of the other principles. I do not think however, that too much stress should be laid upon the latter. The problem of apparent motions is closely related with

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[1]) E. HERING, Beiträge zur Physiologie, IV Heft, 1864, p. 269.

[2]) E. HERING, Lehre vom binocularen Sehen, p. 107; TSCHERMAK l.c., p. 1051.

that of the localisation of directions. The existence of apparent motions of the environment during ocular movements always indicates the existence of a series of successive different retinal projections which do not fit in with the instantaneous system of "space-values" ("Raumwerte"). Here the distinction between voluntary and involuntary motions, and between motions, which are caused by optical motives and those which are not, is only in so far important as it relates to the possibility of an adequate "Umwertung" of the space-values. It is indeed probable, that this revaluation occurs more quickly and, consequently, more gradually in voluntary motions, and in those which are caused by optical motives, than in the other kinds of movements, *during* which such a revaluation is supposed not to take place at all. But *in every motion* the complete and definitive revaluation is only developed when the eye comes to rest in a new state of fixation [1]). This statement follows naturally from the experimental facts; it is not coercive with respect to the conceptions about the way in which the revaluation proceeds. Here again the importance of fixation in the physiology of ocular movements is obvious. *Some* apparent motion could originate from every ocular movement, even if this movement were a rotation around one single axis, which is perpendicular to the plane of motion; we only are accustomed to these sensations and even expect them. This holds for quick movements especially; then the duration of the instantaneous retinal projections is too small, to be able to bring about an image which would be sharp enough, to draw attention in a troublesome way. Moreover, we should not forget, that although a movement in the sense of LISTING's Law involves the absence of a torsion around the visual axis with respect to the plane of motion, this does not imply that the orientation of the eye with respect to the environment remains the same. Every motion which starts from the primary position, except the motion in the vertical and the horizontal directions, involves definite inclinations of the originally vertical and horizontal meridians of the eye. If no revaluation of directions would take place at all, vertical and horizontal lines would no more be perceived as such in those tertiary positions. It follows from the experiments, published by M. SHODA [2]) that such a corrective revaluation may really take place, at least partly and for certain directions even excessively. The possible perception of apparent motions then depends upon the relative quickness with which the revaluation is established and upon its adequateness.

On the other hand, *deviations* from the schematic Law may be caused by resistances in the apparatus of suspension of the eye, i.e. the — partly antagonistic — muscles which do not act in the motion which is intended, the check ligaments and the other connective tissue structures of the orbit. In general we may not assume, as HERING [3]) did, that the active or passive

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[1]) Comp. F. B. HOFMANN l.c., pp. 374, 378 etc.

[2]) M. SHODA, Pflüger's Arch., 215 Band, 1927, p. 589.

[3]) Die Lehre vom binocularen Sehen, p. 123.

resistance of antagonistic muscles is just opposite to the intended action of the contracting muscles themselves, so that *no* deviations would be caused by this resistance. A difference in the direction of the axes of antagonists exists especially in the case of the superior and inferior recti. In binocular fixation the avoidance of disturbing *relative* torsions of the eyes, will probably be more important than the avoidance of torsions at all. This principle will be counterbalanced by the principle of the smallest muscular labour. All together we may expect that even torsions which do not follow from LISTING's Law itself will not always be avoided.

So a complex of muscular synergies, which varies with the positions of the visual axes, will frequently come into effect; it will cause an increase of the tonus of several extrinsic muscles. This variable increase again causes deviations of the other parts in which I have artificially subdivided LISTING's Law.

I have treated the first point somewhat more extensively in order to elucidate once more, how many reasons which we have to expect a variability in the tonus of the extrinsic eye-muscles. In the preceding pages I have amply discussed the influence of heterophoria in this respect. The experimental data give a clear picture of the variability. The influences of reflexes, originating from the static organ, or those of postural reflexes etc. do not even come into consideration in this paper.

The second point was artificially realised in the present investigation by means of the rotating sighting-apparatus. Large deviations of this point however cannot be expected in free motions either; the apparatus of suspension of the eye is a guarantee in this respect.

As for the third and fourth points, the experimental results show evidently that large deviations eventually may occur here. The causes therefore have now been amply exposed. In fact the primary axis plane is only a fiction, and especially here LISTING's Law has no more than a schematic meaning.

II. *The principle of equal innervation of both eyes.* In its original form, as it was developed by HERING [1]), this principle had a simpler aspect than it got afterwards, when because of the explanation of experimental and clinical facts the introduction of a series of synergies was necessary. HERING, in his original publication, only mentions one synergy of contralateral sense, i.e. the convergence synergy. He later added a "negative" synergy of contralateral vertical sense. This would only cause a difference in the innervation of the vertical motors of the eyes, which innervation is otherwise equal. It is however hardly imaginable how such a "negative" synergy actually would have to take place binocularly, without involving positive factors. Moreover such an assumption does not seem to be logical in comparison with the other synergies all of which are assumed, in view of

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[1]) E. HERING, Die Lehre vom binocularen Sehen, p. 2 ff.

the experimental facts[1]), in the sense of purely "positive" binocular innervations. In its elaborated form the principle has lost its simplicity and its immediate surveyability. In a general way we only can state now, that a certain innervation in one eye will always be accompanied with a certain innervation in the other eye. These innervations need not to be equal at all, especially in cases where different muscles have to be innervated in both eyes, and in asymmetrical positions of the visual axes. I have also investigated this point by means of prisms, placed before the left eye, base outward. If then a binocular fixation is performed, the convergence synergy and the synergy for dextroversion get an extra-innervation, in the same way as in a case of exophoria. It could thus be expected that the right eye would undergo a stronger inward pull than when under the influence of a single binocular fixation without a prism. The difference may indeed be noticeable, but I could not attain such marked changes in position, as were shown for instance by subject VII. The binocular fixation with the prism is still more difficult however, and no prisms stronger than 12^{Δ} could be used; nor could the angle of rotation be extended very far.

In view of the existing data it does not seem to be justified, to draw the conception of the functional unity of both eyes so far, that even the small motions during fixation should always be bilaterally equal[2]). As far as I can judge, nobody has ever performed the three-dimensional and simultaneous registration of the motions of both eyes, which would be necessary in order to answer this question. It is questionable if it would be worthwhile either. The somewhat more restricted principle still has, by means of the system of synergies which is connected with it, a very large importance for the motility of the eyes.

The apparatus was built, and the experiments were performed, in the Physics Laboratory of the Leiden University. It is a pleasure to thank Professor KEESOM for the most kind way, in which he put the facilities of his excellent workshop at our disposal and for his permanent hospitality.

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[1]) BIELSCHOWSKY (Graefe's Arch., 125 Band, 1931, p. 495) apparently assumes a "positive" contralateral vertical synergy, combined with an equilateral one, in the case of monolateral vertical motions. TSCHERMAK (l.c., p. 1072/73) seems to do the same, but it is not quite clear from the text, in which sense the difference between positive and negative synergy has to be taken. As every synergetic action necessarily involves a "positive" innervation of the muscles in question, it is better not to use the words positive or negative at all in this connection.

[2]) TSCHERMAK, l.c., pp. 900, 1047, 1056.

TABLE I: Subject I — Left.

(In all the Tables the lengths are in mm.)

α	δ	$\bar{x}$	$\bar{y}$	$\bar{\bar{x}}$	ξ	η	b	c	ϱ_l	ϱ_m	ξ_H	η_H
0°							0	0	13.377	13.551		
	—3°	0	—6.162	0.067	11.859	—3.082						
—3°							—0.145	—0.625	13.506	13.673		
	—3°	0	—6.334	0.610	14.271	1.011						
—6°							—0.040	—1.377	13.421	13.579		
	—3°	0	—6.266	0.616	12.360	—5.241						
—9°							—0.225	—2.031	13.656	13.806		
	—3°	0	—6.456	1.126	13.614	—2.115						
—12°							—0.210	—2.755	13.734	13.874		
	—3°	0	—6.643	1.790	13.132	3.439						
—15°							0.132	— 3.445	13.521	13.651	13.152	—1.221
	—3°	0	— 6.942	1.941	16.303	—1.043						
—18°							0.280	—4.288	13.578	13.695		
	—3°	0	—7.061	2.825	11.103	7.276						
—21°							0.900	—4.839	13.147	13.253		
	—3°	0	—7.294	2.164	17.756	—12.572						
—24°							0.581	—5.732	13.813	13.908		
	—3°	2.483	—6.372	0.558	12.632	—0.588						
—27°							0.804	—6.359	13.798	13.880		
	—3°	6.003	—4.520	—2.685	10.580	6.436						
—30°							1.487	—6.853	13.398	13.470	13.531	—0.651
M_l					13.361	—0.648	Average of ϱ_l : 13.541					
M					13.527	—0.812			Average of ϱ_m : 13.667			

Total average of ϱ_m, to left and right: 13.704

TABLE II: Subject I — Right.

α	δ	$\overline{x}$	$\overline{y}$	$\overline{\overline{x}}$	ξ	η	b	c	ϱ_r	ϱ_m	ξ_H	η_H
0°							0	0	13.727	13.551		
	3°	−0.075	6.327	0	14.996	3.320						
3°							−0.153	0.789	13.957	13.773		
	3°	0	6.190	0.336	11.830	1.744						
6°							−0.187	1.417	14.084	13.894		
	3°	0	6.446	0.525	15.904	4.525						
9°							−0.328	2.263	14.389	14.192		
	3°	0	6.393	1.496	10.984	−7.211						
12°							0.183	2.842	14.038	13.835		
	3°	0	6.527	1.736	11.000	−4.894						
15°							0.603	3 398	13.801	13.592	13.210	−0.594
	3°	0	6.880	1.878	15.283	−0.332						
18°							0.818	4.161	13.862	13.647		
	3°	0	7.079	2.352	14.264	−1.301						
21°							1.122	4.857	13.858	13.639		
	3°	0	7.486	2.844	16.233	−1.847						
24°							1.494	5.639	13.877	13.656		
	3°	0	7.506	3.189	11.169	0.859						
27°							1.757	6.139	13.895	13.669		
	3°	0	8.292	4.074	15.258	−4.628						
30°							2.339	6.831	13.779	13.549	13.917	−0.952
M_r					13 692	−0.976						
M					13.527	−0.812						

Average of ϱ_r: 13.933

Average of ϱ_m: 13.727

Total average of ϱ_m. to left and right: 13.704

TABLE III: Subject II — Right

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	10.997	−0.889			
3°				5″	0.062	0.574
	3°	16.448	−0.630			
6°					0.147	1.430
	3°	10.996	−10.452			
9°					0.784	1.982
	3°	13.958	9.224			
12°					0.423	2.681
	3°	8.296	−14.194			
15°					1.317	3.070
	3°	22.202	16.640			
18°					0.635	4.182
	3°	10.828	−14.894			
21°					1.647	4.689
	3°	20.807	0.673			
24°					1.883	5.686
	3°	9.687	13.356			
27°					1.492	6.105
	3°	10.979	−19.243			
30°				32″	2.832	6.567
M_r		13.520	−2.041			

Average of ϱ_r: 13.80

TABLE IV: Subject III — Left,
fixation with both eyes

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	8.946	0.668			
− 3°				3″	0.047	−0.467
	−3°	15.099	−1.290			
− 6°					0.025	−1.256
	−3°	12.361	0.586			
− 9°				20″	0.138	−1.899
	−3°	14.452	2.274			
−12°					0.376	−2.642
	−3°	14.289	−0.351			
−15°					0 515	−3.367
	−3°	13.985	−0.764			
−18°					0.670	−4.068
	−3°	13.429	2.257			
−21°					1.019	−4.727
	−3°	11.707	1.171			
−24°					1.342	−5.278
	−3°	16.711	2.307			
−27°					1.760	−6.072
	−3°	11.975	3.976			
−30°					2.300	−6.593
M_l		13.295	1.083			

Average of ϱ_l: 13.45

TABLE V: Subject III — Left.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	4.673	−0.848			
−3°					−0.038	−0.246
	−3°	12.085	−0.800			
−6°					−0.050	−0.881
	−3°	13.843	−0.899			
−9°					−0.032	−1.608
	−3°	12.036	1.474			
−12°					0.146	−2.235
	−3°	15.062	−2.720			
−15°				18″	0.141	−3.016
	−3°	16.532	4.335			
−18°					0.548	−3.864
	−3°	13.935	−0.867			
−21°					0.723	−4.561
	−3°	12.534	0.731			
−24°				7″	1.016	−5.172
	−3°	14.066	−3.703			
−27°					1.111	−5.853
	−3°	17.195	0.616			
−30°					1.472	−6.686
M_l		13.196	−0.268			
M		13.973	0.235			

Average of ϱ_l: 13.21

Average of ϱ_m: 14.10

TABLE VI: Subject III — Right.

α	δ	ξ	η	ϑ_{2m}	b	c
0°				11″	0	0
	3°	15.823	−0.088			
3°					0.026	0.828
	3°	16.317	3.353			
6°					−0.084	1.684
	3°	18.012	1.241			
9°					−0.036	2.631
	3°	11.138	−1.548			
12°					0.198	3.210
	3°	14.431	2.068			
15°					0.277	3.953
	3°	11.633	0.157			
18°					0.491	4.542
	3°	11.660	1.091			
21°				38″	0.687	5.122
	3°	16.268	0.599			
24°					0.945	5.931
	3°	17.469	−0.227			
27°					1.290	6.787
	3°	(22.332)	(25.421)			
30°					0.344	7.914
M_r		14.750	0.738			
M		13.973	0.235			

Average of ϱ_r: 14.71

TABLE VII: Subject III — Left,
7 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°				68″	0	0
	−5°	14.298	−0.999			
−5°					−0.033	−1.250
	−5°	13.545	0.971			
−10°				7″	0.212	−2.425
	−5°	11.652	−2.017			
−15°				25″	0.291	−3.421
	−5°	16.769	0.428			
−20°					0.689	−4.843
	−5°	9.662	−1.309			
−25°					1.031	−5.612
	−5°	18.798	2.867			
−30°					1.838	−7.128
M_l		14.121	−0.010			
M		14.646	−1.738			

TABLE VIII: Subject III — Right,
7 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	14.343	−4.423			
3°					0.251	0.745
	3°	15.992	−5.592			
6°					0.604	1.560
	3°	12.650	−6.173			
9°					1.025	2.180
	3°	17.524	1.853			
12°				10″	1.065	3.043
	3°	14.835	−9.422			
15°					1.736	3.747
	3°	17.678	6.649			
18°				43″	1.606	4.585
	3°	8.534	−19.976			
21°					2.901	4.914
	3°	22.552	10.216			
24°					2.650	5.950
	3°	12.429	−4.335			
27°					3.202	6.448
M_r		15.171	−3.467			
M		14.646	−1.738			

Average of ϱ_m : 14.15

TABLE IX: Subject IV – Left.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	14.305	−7.404			
−3°				6″	−0.368	−0.759
	−3°	13.707	−5.678			
−6°				6″	−0.606	−1.502
	−3°	13.332	−2.007			
−9°					−0.613	−2.232
	−3°	11.349	1.481			
−12°					−0.402	−2.853
	−3°	14.524	4.252			
−15°					−0.010	−3.624
	−3°	14.070	−4.697			
−18°					−0.047	−4.362
	−3°	12.943	1.857			
−21°					0.296	−5.033
	−3°	15.175	−3.415			
−24°					0.401	−5.810
	−3°	11.934	4.110			
−27°					0.936	−6.400
	−3°	18.823	−4.362			
−30°				40″	1.067	−7.333
M_l		14.016	−1.586			
M		13.889	−0.876			

Average of ϱ_l: 14.32.   Average of ϱ_m: 14.21.

TABLE X: Subject IV — Right.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	15.521	−2.053			
3°				2″	0.129	0.810
	3°	14.677	−1.550			
6°					0.272	1.568
	3°	13.005	3.354			
9°					0.196	2.237
	3°	13.977	−1.325			
12°					0.401	2.953
	3°	13.969	3.691			
15°					0.381	3.664
	3°	13.525	−4.898			
18°					0.847	4.340
	3°	12.685	0.753			
21°				39″	1.051	4.955
	3°	13.481	3.517			
24°					1.143	5.604
	3°	13.194	−2.971			
27°					1.608	6.223
M_r		13.782	−0.165			
M		13.899	−0.876			

Average of ϱ_r: 13.76.

TABLE XI: Subject IV — Left,
fixation with both eyes.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	15.913	4.063			
−3°					0.234	−0.827
	−3°	14.963	−1.153			
−6°				7″	0.237	−1.598
	−3°	13.059	1.043			
−9°				7″	0.393	−2.265
	−3°	14.907	−4.577			
−12°					0.292	−3.028
	−3°	12.273	3.265			
−15°					0.638	−3.646
	−3°	14.565	−6.178			
−18°					0.525	−4.378
	−3°	13.987	1.165			
−21°					0.834	−5.075
	−3°	14.732	−1.224			
−24°					1.055	−5.797
	−3°	14.031	−4.994			
−27°					1.115	−6.475
	−3°	16.464	−0.462			
−30°				32″	1.451	−7.270
M_l		14.489	−0.905			
M		14.829	−0.511			

TABLE XII: Subject IV — Right,
fixation with both eyes.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	13.479	−8.616			
3°					0.469	0.694
	3°	13.824	−9.100			
6°					1.000	1.380
	3°	16.433	−3.229			
9°				42″	1.262	2.181
	3°	14.041	−6.909			
12°					1.755	2.837
	3°	11.605	15.901			
15°					1 085	3.370
	3°	13.232	−4.648			
18°					1.521	3.995
	3°	16.916	−0.557			
21°				3″	1.780	4.795
	3°	17.489	3.835			
24°					1.852	5.616
	3°	19.512	12.265			
27°					1.528	6.549
	3°	(10.409)	(−43.785)			
30°					4.175	6.945
M_r		15.170	−0.118			
M		14.829	−0.511			

Average of ϱ_m: 14.40

TABLE XIII: Subject IV — Left, 7.5 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	12.629	5.613			
−3°				7″	0.311	−0.653
	−3°	12.652	6.581			
−6°					0.707	−1.289
	−3°	10.563	−2.146			
−9°					0.676	−1.806
	−3°	16.295	−8.889			
−12°					0.327	−2.633
	−3°	12.974	7.531			
−15°				7″	0.876	−3.281
	−3°	11.977	3.114			
−18°					1.226	−3.853
	−3°	17.381	−11.917			
−21°				36″	0.826	−4.710
	−3°	11.594	5.213			
−24°					1.360	−5.260
	−3°	16.476	−10.036			
−27°					1.131	−6.058
	−3°	24.477	−8.183			
−30°					1.052	−7.283
M_l		14.702	−1.312			
M		14.518	−1.035			

TABLE XIV: Subject IV — Right, 7.5 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	15.595	1.517			
3°					−0.058	0.818
	3°	14.069	−0.560			
6°				6″	0.033	1.556
	3°	13.352	−6.183			
9°				40″	0.456	2.243
	3°	10.438	2.791			
12°					0.441	2.766
	3°	14.053	−2.223			
15°					0.721	3.472
	3°	15.319	0.481			
18°					0.898	4.232
	3°	15.460	2.039			
21°					1.033	4.991
	3°	15.086	0.676			
24°					1.278	5.721
	3°	15.381	−2.513			
27°					1.728	6.448
	3°	14.583	−3.608			
30°					2.272	7.107
M_r		14.334	−0.758			
M		14.518	−1.035			

Average of ϱ_m: 14.32

TABLE XV: Subject V — Left.

α	δ	$\bar{x}$	$\bar{y}$	$\bar{\bar{x}}$	ξ	η	b	c	ϱ_m	ξ_H	η_H	ϑ_{2m}
0°							0	0	13.723			
	−3°	0	−6.015	0.096	11.186	−1.367						
−3°							−0.056	−0.587	13.795			
	−3°	0	−6.091	0.398	12.098	−1.672						
−6°							−0.096	−1.225	13.879			
	−3°	0	−6.267	0.884	13.860	1.316						
−9°							0.056	−1.952	13.815			
	−3°	0	−6 441	1.065	15.688	−1.772						
−12°							0.087	−2.770	13.928			
	−3°	0	−6.495	1.720	12.766	3.705						
−15°							0.443	−3.425	13.731	13.227	−0.031	21″
	−3°	0	−6.653	1.800	13.697	−1.845						
−18°							0.544	−4.117	13.827			
	−3°	0	−6.934	2.241	14.549	−1.246						
−21°							0.713	−4.846	13.906			
	−3°	0	−7.089	2.693	12.122	−1.080						
−24°							0.926	−5.438	13.930			
	−3°	0	−7.569	3.387	13.132	2.473						
−27°							1.357	−6.066	13.802			
	−3°	0	−7.936	3.556	15.592	−3.970						
−30°							1.486	−6.808	14.035	13.445	−0.632	5″
M_l					13.469	−0.546						
M					13.723	0.065			13.852			

Total average of ϱ_m, to left and right: 13.857

TABLE XVI: Subject V — Right.

α	δ	$\bar{x}$	$\bar{y}$	$\bar{\bar{x}}$	ξ	η	b	c	ϱ_m	ξ_H	η_H	ϑ_{2m}
0°							0	0	13.723			
	3°	0	6.078	0.277	12.290	−2.441						
3°							0.145	0.640	13.590			
	3°	0	6.224	0.352	14.680	2.301						
6°							0.078	1.403	13.710			
	3°	0	6.270	0.746	14.217	1.124						
9°							0.112	2.143	13.769			
	3°	0	6.311	1.093	13.046	1.016						
12°							0.189	2.818	13.811			
	3°	0	6.514	1.383	14.550	2.275						
15°							0.237	3.569	13.934	13.672	0.887	
	3°	0	6.661	1.905	13.180	−0.336						
18°							0.459	4.241	13.906			
	3°	0	6.996	2.254	15.529	0.807						
21°							0.659	5.025	13.974			
	3°	0	7.172	2.839	12.499	−1.620						
24°							1.023	5.636	13.868			34″
	3°	0	7.570	3.145	14.979	1.641						
27°							1.251	6.361	13.971			
	3°	0	7.960	3.672	14.809	1.999						
30°							1.498	7.065	14.087	13.930	0.737	3″
M_r					13.978	0.677						
M					13.723	0.065			13.849			

Total average of ϱ_m, to left and richt: 13.857

TABLE XVII: Subject V — Left, fixation with both eyes.

α	δ	ξ	η	ϑ_{2m}	b	c
0°				32″	0	0
	−3°	11.198	−2.531			
−3°					−0.117	−0.590
	−3°	12.947	2.793			
−6°					0.078	−1.269
	−3°	15.261	−2.160			
−9°					0.052	−2.065
	−3°	13.803	4.799			
−12°					0.430	−2.766
	−3°	16.202	−1.591			
−15°				10″	0.513	−3.590
	−3°	12.650	−0.230			
−18°					0.705	−4.221
	−3°	12.251	−1.445			
−21°					0.866	−4.822
	−3°	15.367	4.594			
−24°					1.379	−5.568
	−3°	14.103	0.967			
−27°					1.738	−6.225
	−3°	12.706	−4.742			
−30°					1.831	−6.797
M_l		13.649	0.045			
M		13.908	−0.398			

TABLE XVIII: Subject V — Right, fixation with both eyes.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	11.649	−2.878			
3°					0.167	0.606
	3°	17.469	−1.265			
6°					0.289	1.509
	3°	14.870	−1.296			
9°					0.456	2.268
	3°	12.304	1.194			
12°					0.528	2.887
	3°	14.966	−0.986			
15°					0.750	3.637
	3°	12.583	3.995			
18°				3″	0.747	4.257
	3°	13.089	−2.930			
21°					1.140	4.893
	3°	14.637	−3.287			
24°				29″	1.587	5.588
	3°	19.110	6.400			
27°					1.569	6.506
	3°	10.991	−7.356			
30°					2.307	6.980
M_r		14.167	−0.841			
M		13.908	−0.398			

Average of ϱ_m: 13.77

TABLE XIX: Subject V — Left,
6 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	11.886	2.528			
−3°				2″	0.149	−0.619
	−3°	20.633	−3.617			
−6°					0.020	−1.695
	−3°	5.548	0.794			
−9°					0.158	−1.981
	−3°	12.947	−0.665			
−12°				28″	0.244	−2.649
	−3°	14.381	1.021			
−15°					0.455	−3.384
	−3°	11.078	1.276			
−18°				2″	0.713	−3.934
	−3°	16.578	0.902			
−21°					0.988	−4.758
	−3°	10.993	2.861			
−24°					1.400	−5.271
	−3°	16.428	− 5.353			
−27°					1.416	−6.058
	−3°	12.608	7.542			
−30°					2.143	−6.625
M_l		13.308	0.729			
M		13.586	0.562			

TABLE XX: Subject V — Right,
6 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°				30″	0	0
	3°	15.353	−2.757			
3°				2″	0.165	0.800
	3°	15.639	2.070			
6°					0.120	1.612
	3°	13.538	3.262			
9°					0.052	2.317
	3°	13.881	3.333			
12°					0.018	3.042
	3°	13.303	−0.285			
15°					0.210	3.733
	3°	12.592	0.204			
18°					0.412	4.376
	3°	13.395	−2.324			
21°					0.780	5.046
	3°	16.001	−0.253			
24°				2″	1.078	5.835
	3°	9.501	−7.167			
27°				2″	1.770	6.258
	3°	15.423	7.860			
30°					1.705	6.975
M_r		13.863	0.394			
M		13.586	0.562			

Average of ϱ_m: 13.66

TABLE XXI: Subject VI — Left.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	15.631	−0.568			
−3°					−0.008	−0.819
	−3°	10.965	3.546			
−6°					0.235	−1.387
	−3°	14.152	−1.814			
−9°					0.232	−2.116
	−3°	14.791	1.542			
−12°					0.443	−2.873
	−3°	15.798	−0.657			
−15°					0.580	−3.674
	−3°	14.297	0.098			
−18°					0.796	−4.387
	−3°	14.642	1.558			
−21°					1.126	−5.104
	−3°	14.242	0.290			
−24°				2″	1.426	−5.783
	−3°	15.337	−3.853			
−27°				15″	1.546	−6.508
	−3°	13.825	0.134			
−30°					1.910	−7.142
M_l		14.368	0.028			
M		14.340	0.443			

TABLE XXII: Subject VI — Right.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	14.613	3.951			
3°					−0.187	0.770
	3°	15.756	1.577			
6°					−0.207	1.606
	3°	14.838	−0.912			
9°					−0.055	2.390
	3°	16.235	2.658			
12°					−0.047	3.243
	3°	14.999	6.952			
15°				2″	−0.221	4.036
	3°	10.443	−7.090			
18°					0.376	4.579
	3°	14.466	0.196			
21°				19″	0.625	5.310
	3°	15.285	1.925			
24°					0.822	6.073
	3°	13.202	−0.185			
27°					1.167	6.712
	3°	13.285	−0.503			
30°					1.561	7.336
M_r		14.312	0.857			
M		14.340	0.443			

Average of ϱ_m: 14.46

TABLE XXIII: Subject VI — Left, fixation with both eyes.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	16.605	3.778			
−3°					0.220	−0.864
	−3°	15.662	−2.442			
−6°					0.159	−1.674
	−3°	15.257	2.957			
−9°					0.422	−2.458
	−3°	16.307	0.890			
−12°					0.619	−3.285
	−3°	13.590	0.500			
−15°				9″	0.835	−3.959
	−3°	13.669	3.597			
−18°					1.248	−4.620
	−3°	15.601	−3.825			
−21°					1.309	−5.370
	−3°	12.632	10.822			
−24°					2.172	−5.940
	−3°	17.978	2.781			
−27°				68″	2.650	−6.755
	−3°	9.892	11.461			
−30°				49″	3.613	−7.109
M_l		14.719	3.052			
M		14.469	1.264			

TABLE XXIV: Subject VI — Right, fixation with both eyes.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	13.167	3.377			
3°					−0.159	0.694
	3°	13.361	−0.122			
6°				4″	−0.098	1.401
	3°	13.868	−2.548			
9°					0.128	2.127
	3°	16.088	−14.565			
12°				3″	1.024	2.939
	3°	12.758	9.156			
15°					0.715	3.562
	3°	15.446	4.395			
18°					0.692	4.334
	3°	20.004	1.543			
21°					0.865	5.341
	3°	9.782	−2.397			
24°					1.282	5.797
	3°	13.489	−3.566			
27°				66″	1.789	6.423
M_r		14.218	−0.525			
M		14.469	1.264			

Average of ϱ_m: 14.35

TABLE XXV: Subject VII — Left.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	13.291	2.205			
−3°				4″	0.134	−0.693
	−3°	12.069	3.815			
−6°					0.386	−1.312
	−3°	14.234	−12.790			
−9°					−0.196	−2.053
	−3°	14.017	−10.112			
−12°					−0.598	−2.808
	−3°	14.743	2.347			
−15°				28″	−0.307	−3.604
	−3°	10.292	10.358			
−18°					0.438	−4.140
	−3°	12.351	−9.368			
−21°					0.181	−4.771
	−3°	14.000	5.596			
−24°					0.743	−5.480
	−3°	13.942	4.064			
−27°					1.261	−6.158
	−3°	12.169	0.680			
−30°					1.634	−6.720
M_l		13.111	−0.320			
M		13.302	0.853			

Average of ϱ_l: 13.35 Average of ϱ_m: 13.93

TABLE XXVI: Subject VII — Right.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	14.090	0.145			
3°					0.012	0.738
	3°	14.470	10.532			
6°				28″	−0.481	1.508
	3°	13.632	3.238			
9°					−0.552	2.249
	3°	15.678	−2.070			
12°					−0.304	3.093
	3°	12.630	9.424			
15°				1″	−0.618	3.779
	3°	14.446	6.969			
18°					−0.764	4.572
	3°	10.953	−0.989			
21°					−0.457	5.178
	3°	13.562	1.146			
24°					−0.227	5.906
	3°	10.312	−0.646			
27°					0.130	6.449
	3°	15.153	−7.504			
30°					0.881	7.216
M_r		13.493	2.025			
M		13.302	0.853			

Average of ϱ_r: 13.95

TABLE XXVII: Subject VII — Left,
fixation with both eyes.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	11.345	6.566			
−3°					0.359	−0.585
	−3°	15.250	−6.487			
−6°					0.070	−1.372
	−3°	14.945	−1.303			
−9°					0.094	−2.150
	−3°	10.041	6.480			
−12°				29″	0.559	−2.659
	−3°	16.695	−1.456			
−15°					0.644	−3.502
	−3°	11.394	9.812			
−18°					1.356	−4.046
	−3°	26.999	−12.454			
−21°					0.951	−5.400
	−3°	6.997	−2.878			
−24°					1.091	−5.713
	−3°	12.496	−0.653			
−27°				4″	1.371	−6.303
	−3°	13.983	−10.152			
−30°					1.187	−6.968
M_l		14.014	−1.253			
M		14.273	−1.758			

TABLE XXVIII: Subject VII — Right,
fixation with both eyes.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	13.627	−6.584			
3°				54″	0.363	0.704
	3°	13.208	8.278			
6°				8″	−0.016	1.387
	3°	9.273	3.139			
9°					−0.095	1.876
	3°	17.828	−13.523			
12°					0.736	2.793
	3°	18.362	−7.784			
15°					1.314	3.701
	3°	10.665	13.825			
18°					0.797	4.204
	3°	7.566	−11.586			
21°					1.633	4.537
	3°	25.725	−3.869			
24°					2.106	5.786
M_r		14.532	−2.263			
M		14.273	−1.758			

Average of ϱ_m: 14.09

TABLE XXIX: Subject VIII – Left.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	13.004	−4.157			
−3°				8''	0.235	−0.675
	−3°	13.903	−1.804			
−6°					0.195	−1.392
	−3°	14.555	−2.527			
−9°					0.155	−2.145
	−3°	15.200	−25.493			
−12°					−1.046	−2.964
	−3°	16.348	6.443			
−15°					−0.529	−3.862
	−3°	10.756	−1.214			
−18°				33''	−0.375	−4.449
	−3°	16.922	0.628			
−21°					−0.086	−5.347
	−3°	14.112	−2.103			
−24°					0.103	−6.086
	−3°	14.515	−1.346			
−27°					0.371	−6.834
	−3°	12.262	3.783			
−30°					0.943	−7.442
M_l		14.158	−1.948			
M		14.628	−0.901			

TABLE XXX: Subject VIII — Right.

α	δ	ξ	η	ϑ_{2m}	b	c
0°				4''	0	0
	3°	11.911	1.229			
3°					−0.048	0.625
	3°	17.663	−0.590			
6°					0.040	1.550
	3°	16.806	−3.005			
9°					0.301	2.421
	3°	16.155	2.526			
12°					0.317	3.251
	3°	11.691	−0.820			
15°					0.546	3.841
	3°	14.622	−3.075			
18°				50''	0.927	4.568
	3°	17.116	4.544			
21°					0.950	5.415
	3°	17.537	−0.542			
24°					1.285	6.275
	3°	12.680	4.031			
27°				48''	1.418	6.868
	3°	14.794	−2.842			
30°					1.945	7.555
M_r		15.098	0.146			
M		14.628	−0.901			

Average of ϱ_m: 14.99

TABLE XXXI: Subject VIII — Left,
6 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	14.298	−0 798			
−3°				33″	−0.022	−0.749
	−3°	16.015	3.024			
−6°					0.200	−1.632
	−3°	11.482	−0.189			
−9°					0.291	−2.221
	−3°	16.867	−12.795			
−12°					−0.240	−3.103
	−3°	13.934	−2.402			
−15°					0.068	−3.837
	−3°	14.807	−6.017			
−18°					−0.026	−4.611
	−3°	14.395	6.558			
−21°					0.578	−5.350
	−3°	14.754	−6.664			
−24°					0.529	−6.094
	−3°	12.676	1.671			
−27°				5″	0.952	−6.719
	−3°	17.765	−4.970			
−30°					1.067	−7.597
M_l		14.699	−1.778			
M		15.023	−0.817			

TABLE XXXII: Subject VIII — Right,
6 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	15.004	−3.074			
3°					0.181	0.781
	3°	14.802	0.753			
6°					0.202	1.546
	3°	14.432	0.943			
9°				21″	0.253	2.290
	3°	17.516	0.201			
12°					0.386	3.191
	3°	14.385	−2.599			
15°					0.708	3.916
	3°	15.196	−12.078			
18°				4″	1.565	4.652
	3°	17.544	8.823			
21°					1.369	5.494
	3°	16.645	−6.555			
24°					2.021	6.277
	3°	14.841	1.664			
27°					2.280	6.942
	3°	13.102	13.364			
30°					1.959	7.517
M_r		15.347	0.144			
M		15.023	−0.817			

Average of ϱ_m: 15.14

TABLE XXXIII: Subject IX — Left.

α	δ	$\overline{x}$	$\overline{y}$	$\overline{\overline{x}}$	ξ	η	b	c	ϱ_m	ξ_H	η_H	ϑ_{2m}
0°							0	0	15.951			
	—3°	0	—6.058	0.396	14.043	3.992						
—3°							0.228	—0.730	15.720			67″
	—3°	0	—6.237	0.015	17.646	—9.426						
—6°							—0.203	—1.654	16.194			
	—3°	0	—6.143	1.123	13.082	5.362						
—9°							0.182	—2.340	15.878			
	—3°	0	—6.340	0.719	17.150	—8.637						
—12°							—0.124	—3.237	16.312			4″
	—3°	0	—6.385	1.669	13.079	2.497						
—15°							0.194	—3.920	16.132	14.979	—1.223	
	—3°	6	—6.621	1.856	14.968	—1.007						
—18°							0.367	—4.689	16.149			
	—3°	—4.525	—8.670	7.283	15.473	2.143						
—21°							0.745	—5.470	16.013			
	—3°	0	—7.458	3.004	14.558	2.327						
—24°							1.172	—6.182	15.852			
	—3°	2.094	—6.619	0.670	16.044	—6.212						
—27°							1.191	—6.960	16.133			
	—3°	0	—8.213	4.060	16.044	3.034						
—30°							1.734	—7.724	15.972	15.279	—0.626	
M_l					15.209	—0.593						
M					15.945	—0.434	Average of ϱ_m:		16.028			

Total average of ϱ_m, to left and right: 15.932

TABLE XXXIV: Subject IX — Right.

α	δ	$\bar{x}$	$\bar{y}$	$\bar{\bar{x}}$	ξ	η	b	c	ϱ_m	ξ_H	η_H	ϑ_{2m}
0°							0	0	15.951			
	3°	0	6.174	0.467	16.214	− 6.367						
3°							0.355	0.840	16.642			
	3°	0	6.207	0.144	16.853	5.999						
6°							0.108	1.710	15.981			4″
	3°	0	6.339	0.808	17.565	− 0.283						
9°							0.236	2.621	16.005			22″
	3°	0	6.328	1.343	14.686	− 3.872						
12°							0.596	3.368	15.813			
	3°	0	6.279	1.411	12.124	1.447						
15°							0.712	3.969	15.857	15.431	− 0.721	
	3°	0	7.069	1.966	22.825	− 1.657						
18°							1.037	5.119	15.909			
	3°	0	6.819	2.897	10.226	−10.875						
21°							1.887	5.578	15.289			
	3°	0	7.476	2.271	24.641	8.376						
24°							1.772	6.773	15.900			
	3°	0	7.318	3.330	10.831	− 1.565						
27°							2.221	7.236	15.722			
	3°	0	8.043	3.425	20.830	6.053						
30°							2.308	8.208	16.145	16.470	− 0.202	
M_r					16.680	− 0.274						
M					15.945	− 0.434	Average of ϱ_m:		15.838			

Total average of ϱ_m, to left and right: 15.932

TABLE XXXV: Subject IX — Left,
7 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	−3°	11.485	6.231			
−3°					0.342	−0.593
	−3°	14.575	−8.283			
−6°					−0.041	−1.348
	−3°	19.053	0.926			
−9°					0.104	−2.344
	−3°	11.616	9.857			
−12°					0.758	−2.930
	−3°	14.728	−17.448			
−15°				28″	0.017	−3.681
	−3°	17.994	−3.441			
−18°				10″	0.054	−4.622
	−3°	11.706	−1.847			
−21°					0.215	−5.228
	−3°	15.446	1.656			
−24°					0.596	−6.016
	−3°	10.288	1.200			
−27°					0.987	−6.513
	−3°	14.377	−11.113			
−30°					0.765	−7.220
M_l		14.127	−2.226			
M		15.094	−2.090			

TABLE XXXVI: Subject IX — Right,
7 D extra accommodation.

α	δ	ξ	η	ϑ_{2m}	b	c
0°					0	0
	3°	17.754	−9.473			
3°					0.520	0.916
	3°	15.549	−2.977			
6°					0.744	1.697
	3°	19.541	1.486			
9°				17″	0.781	2.681
	3°	14.177	−17.230			
12°					1.841	3.355
	3°	18.000	9.425			
15°					1.545	4.209
	3°	15.237	−10.249			
18°					2.320	4.906
	3°	24.754	1.337			
21°					2.538	6.075
	3°	16.478	3.315			
24°					2.702	6.801
	3°	15.062	6.326			
27°				33″	2.744	7.447
	3°	4.063	−1.489			
30°				12″	3.214	7.504
M_r		16.062	−1.953			
M		15.094	−2.090			

Average of ϱ_m: 14.98

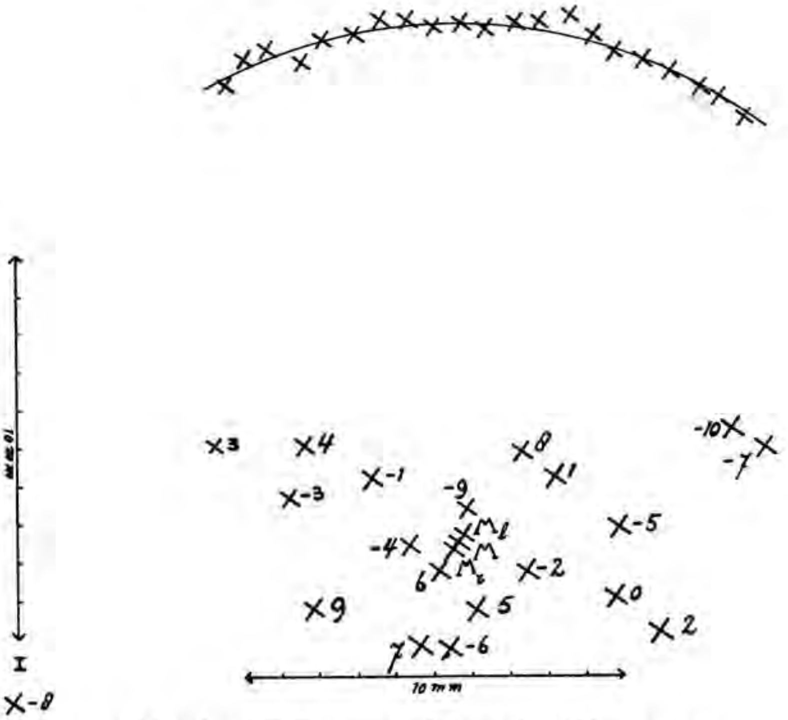

Fig. 1. Tables I and II. The centre of the circle is M, its radius ϱ_m.

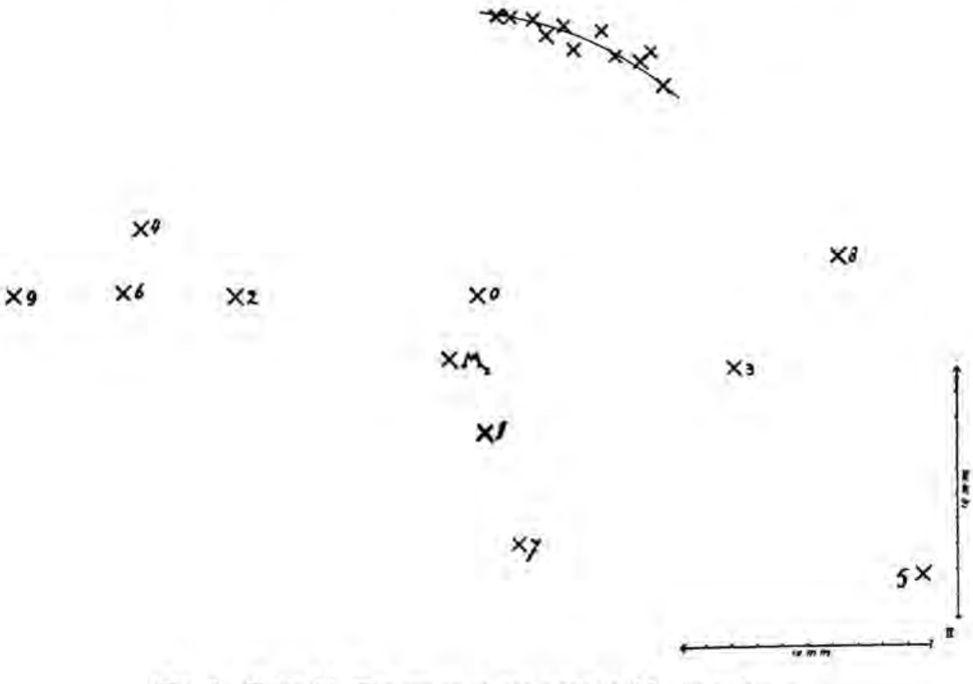

Fig. 2. Table III. The centre of the circle is M_r, its radius ϱ_r.

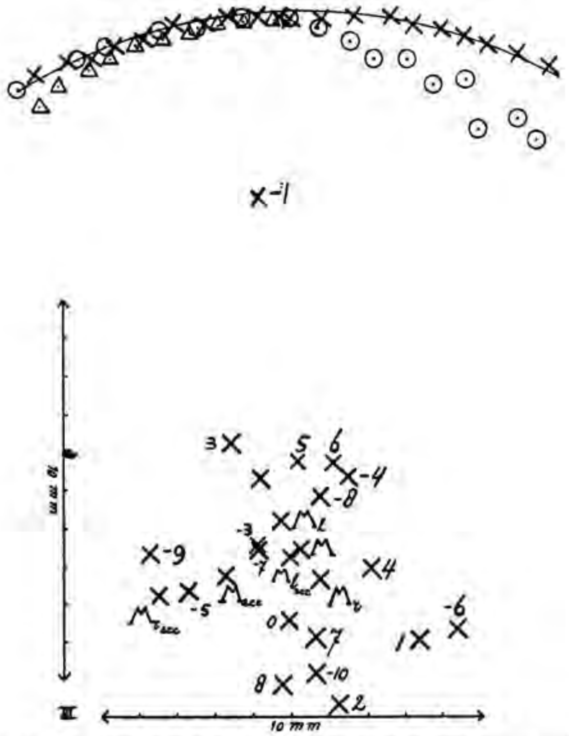

Fig. 3. Tables IV, V, VI, VII, VIII. Crosses: situations of the point P of the cornea in monocular fixation and corresponding instantaneous centres of rotation, to which the average centres with extra accommodation are added; small circles: situations of P with extra accommodation; small triangles: situations of P in binocular fixation. The centre of the larger circle is M, its radius ϱ_m. Tables V, VI.

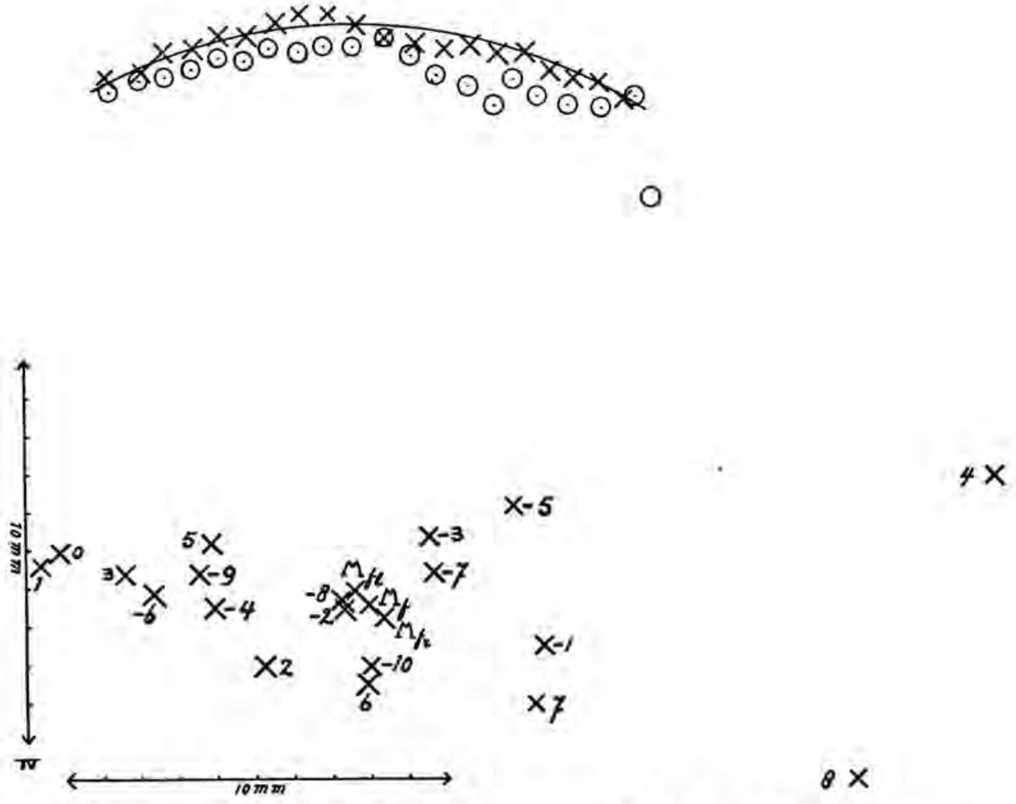

Fig. 4. Tables IX, X, XI, XII. Crosses: situations of the point P of the cornea in monocular fixation; small circles: situation of P in binocular fixation. The instantaneous centres of rotation are those, which were obtained with binocular fixation. The centre of the larger circle is M_f, its radius ϱ_m, Tables IX, X.

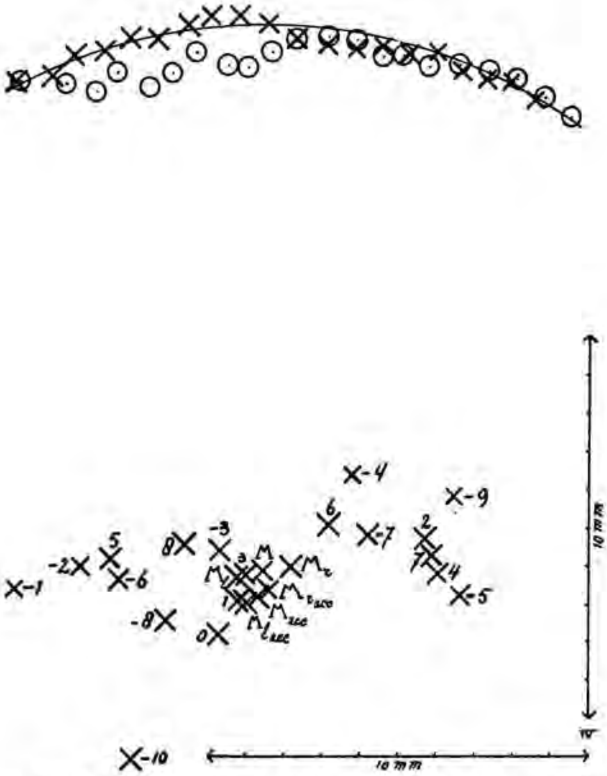

Fig. 5. Tables IX, X, XIII, XIV. Crosses: situations of the point P in monocular fixation and corresponding instantaneous centres of rotation, to which the average centres with extra accommodation are added; small circles: situations of P with extra accommodation. The larger circle is the same as in fig. 4. The points which correspond to the last five small circles at the right side, are situated about 0.2 mm. more "inward" than is indicated in the figure. As the magnification in the latter is five times, the points should be displaced about one millimeter downward.

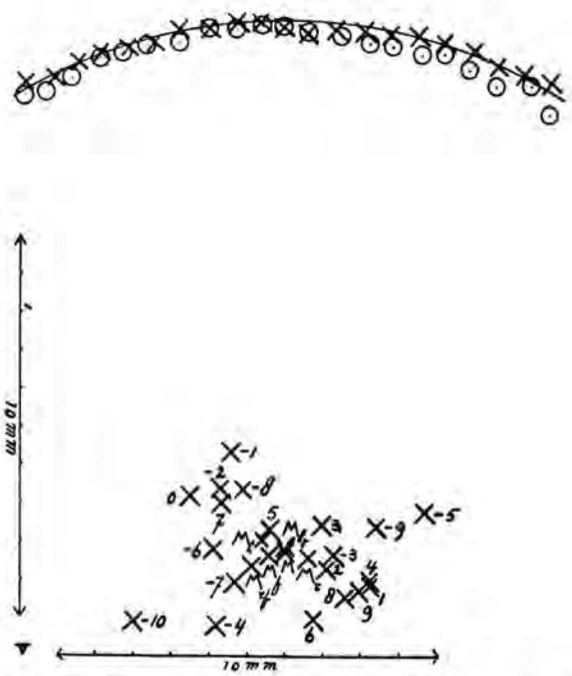

Fig. 6. Tables XV, XVI, XVII, XVIII. Crosses: situations of the point *P* of the cornea in monocular fixation, and corresponding instantaneous centres of rotation, to which the average centres in binocular fixation are added; small circles: situations of *P* in binocular fixation. The centre of the larger circle is *M*, its radius ϱ_m. Tables XV, XVI.

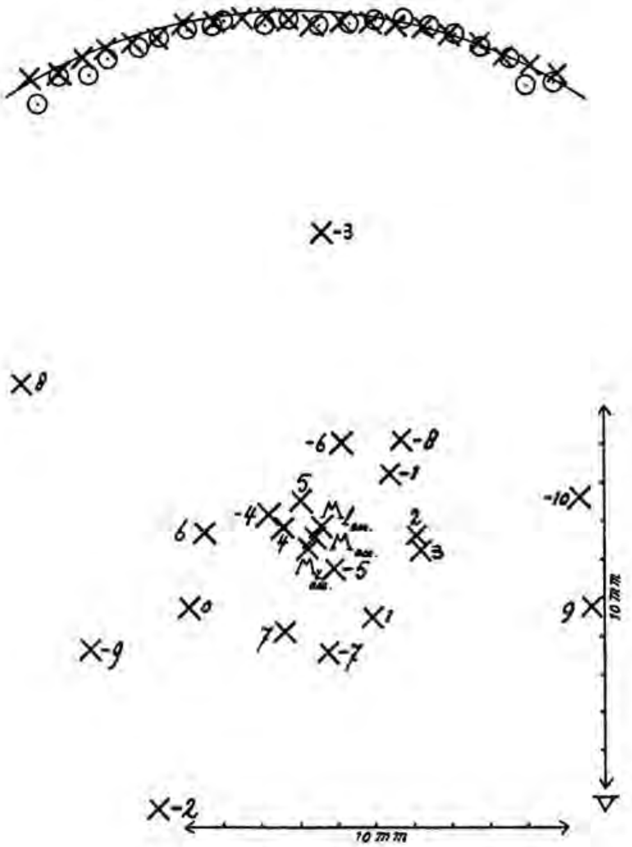

Fig. 7. Tables XV, XVI, XIX, XX. Crosses: situations of the point *P* in monocular fixation; small circles: situations of *P* with extra accommodation. The instantaneous centres of rotation are those, which were obtained with extra accommodation. The larger circle is the same as in fig. 6.

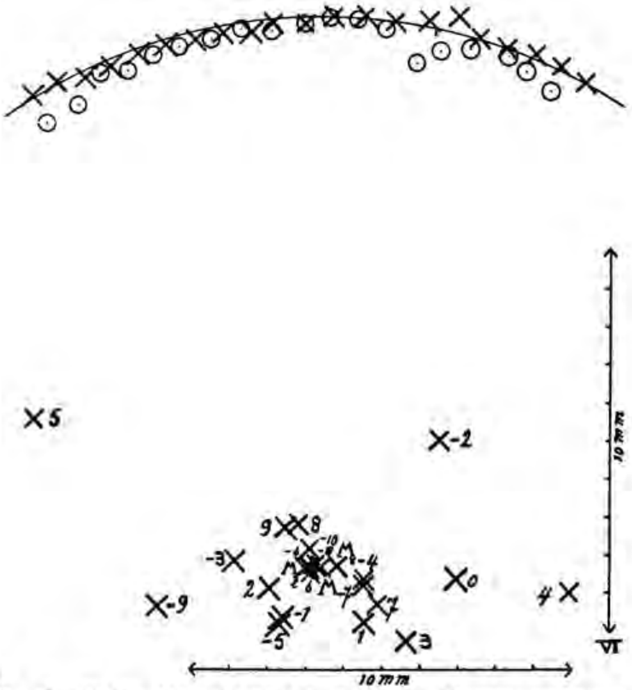

Fig. 8. Tables XXI, XXII, XXIII, XXIV. Crosses: situations of the point P of the cornea in monocular fixation, and corresponding instantaneous centres of rotation. Small circles: situations of P in binocular fixation. The centre of the larger circle is M, its radius ϱ_m. Tables XXI, XXII.

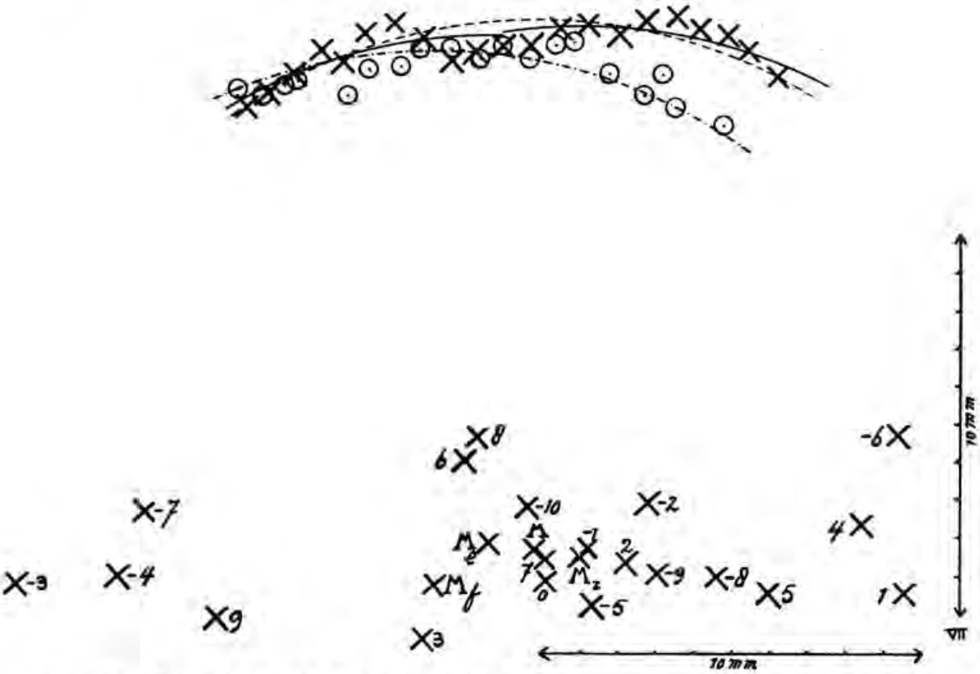

Fig. 9. Tables XXV, XXVI, XXVII, XXVIII. Crosses: situations of the point *P* of the cornea in monocular fixation, and corresponding instantaneous centres of rotation, to which the average centre M_f for right and left in binocular fixation is added; small circles: situations of the point *P* in binocular fixation. The centres of the full-drawn circles are M_r and M_l. From the dotted circles is that with dashes alone drawn around the average *M*, the circle with dashes and points around the centre M_f. The radii of these circles are respectively ϱ_r, ϱ_l, ϱ_m (Tables XXV, XXVI), and ϱ_m (Tables XXVII, XXVIII).

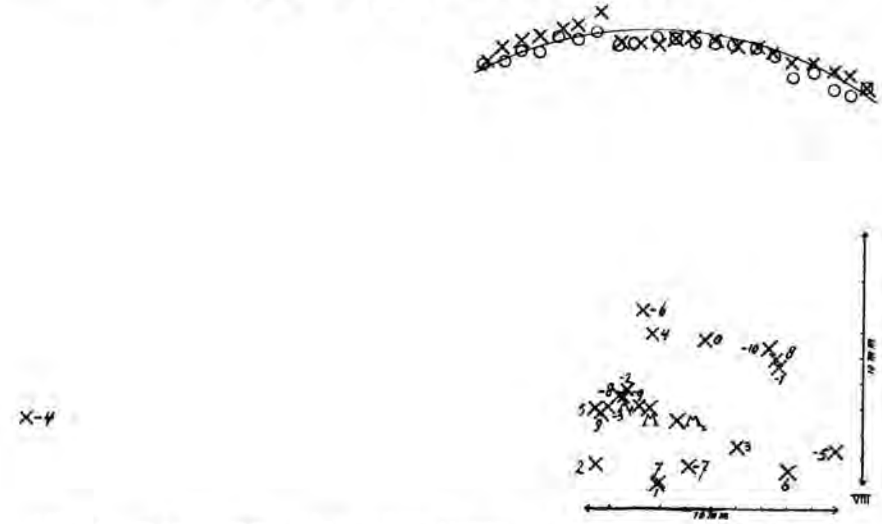

Fig. 10. Tables XXIX, XXX, XXXI, XXXII. Crosses: situations of the point *P* of the cornea in monocular fixation, and corresponding instantaneous centres of rotation. Small circles: situations of *P* with extra accommodation. The centre of the larger circle is *M*, its radius ϱ_m. Tables XXIX, XXX.

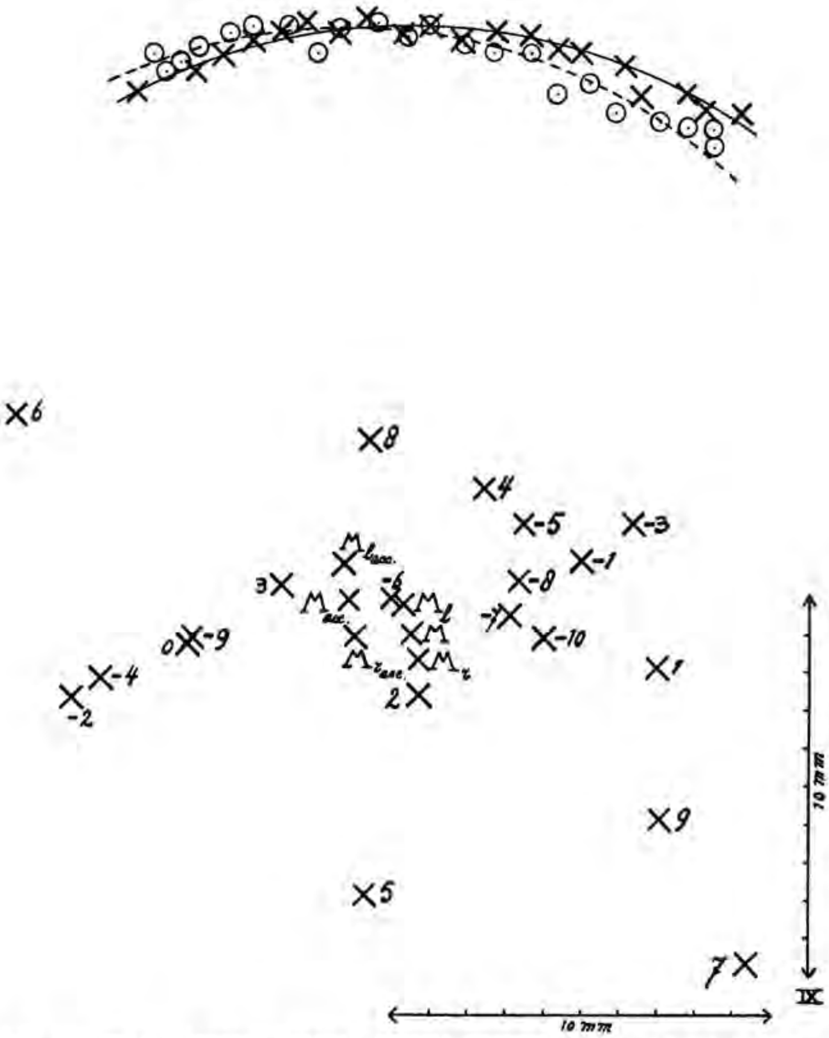

Fig. 11. Tables XXXIII, XXXIV, XXXV, XXXVI. Crosses: situations of the point P of the cornea in monocular fixation and corresponding instantaneous centres of rotation, to which the average centres with extra-accommodation are added. Small circles: situations of P with extra-accommodation. The centre of the larger full-drawn circle is M, its radius ϱ_m, Tables XXXIII, XXXIV, the centre of the dotted circle is $M_{acc.}$, its radius ϱ_m, Tables XXXV, XXXVI.