Zoology. — *"Some results of the investigation of the Cirripeds collected during the cruise of the Dutch man-of-war "Siboga" in the Malay Archipelago."* By Dr. P. P. C. HOEK.

Having explained the position the Cirripeds occupy in the Class Crustacea the author emphasized first of all the great advantage of possessing DARWIN's well-known Monograph [1]) when studying the animals of this group. This book may still be considered as a model for similar monographs, not only in treating the Sub-Class from a general point of view, but also for the description of the different species.

As might be expected the study of the material collected with the "Siboga" has considerably increased our knowledge concerning the biology, the mutual relations and the anatomy of these animals: a few interesting cases have already been communicated to the Academy [2]) and a more detailed treatment is given in the Report on the group published in the Results of the Expeditions edited by Prof. MAX WEBER. The first part of this Report on the Cirripeds was published in September 1907, a great deal of the second part and the determination of nearly the whole material has been achieved by this time.

To have an idea of the importance of the material collected by the "Siboga" it is worth while to compare it with that obtained during the English expedition with the "Challenger". The English man-of-war the "Challenger" made a cruise round the world, which lasted about three years and a half, and brought home collections from nearly all the oceans and seas of the earth's surface; the Cirripeds collected during that cruise were also worked up by the present author, the report on the group was published in 1883. From the accompanying table it may now be seen that the material collected by the "Siboga" in the course of one year, and, comparatively speaking, in an area of limited extension, is not inferior to that of the "Challenger"; the latter, however, collected the greater part of its spoil from the bottom of the great oceans of the world where as a rule the depth was very important. The "Siboga" on the other hand, had better opportunity to investigate coasts, reefs etc. Hence it is easily understood that whereas the "Challenger" from depths to over 5000 m. obtained a richer collection of true deepsea-animals, the "Siboga" succeeded in collecting along with an

[1]) DARWIN, CH., Monograph of the Subclass Cirripedia (in 2 Volumes). Vol. I. The Lepadidae or Pedunculated Cirripedes, 1851; Vol. II. The Balanidae (or Sessile Cirripedes); The Verrucidae etc. 1854. London: Printed for the Ray Society.

[2]) Proceedings of the Academy of Sc. of June 25th, 1904 and January 27th, 1906.

COMPARISON OF THE CIRRIPEDS COLLECTED BY THE "SIBOGA", WITH THOSE OBTAINED BY THE "CHALLENGER".

Genera	Siboga: Malay Archipelago				Challenger: Voyage round the world			
	Number of species collected	Of these were novae species	Of these were collected at depths from 200—499 m.	Idem from 500—2800 m.	Number of species collected	Of these were novae species	Of these were collected at depths from 200—499 m.	Idem from 500—5130 m.
Lepas	2	—	—	—	6	—	—	—
Poecilasma	7	3	3	—	2	2	—	2 [5])
Dichelaspis	5	4	—	1 [1])	1	1	—	1 [6])
Conchoderma	—	—	—	—	2	—	—	—
Megalasma	2	1	1	—	1	1	—	—
Alepas	5	5	1	2 [2])	1	1	—	1 [7])
Microlepas n. gen.	1	1	—	—	—	—	—	—
Ibla	2	1	—	—	—	—	—	—
Scalpellum	38	32	8	22	43	43	7	36
Pollicipes	1	—	—	—	—	—	—	—
Lithotrya	4	1	—	—	—	—	—	—
Balanus	±20 *)	±10 *)	3	1 [3])	10	5	2	1 [8])
Acasta	2	1	—	—	1	—	—	—
Tetraclita	3	—	—	—	2	—	—	—
Pyrgoma	3	2	1	—	—	—	—	—
Creusia	1	—	—	—	—	—	—	—
Coronula	—	—	—	—	1	—	—	—
Chthamalus	2	—	—	—	2	1	—	—
Hexelasma n. gen.	1	1	—	1 [4])	—	—	—	—
Verruca	7	6	—	6	6	6	—	6
Total	106	68	17	33	78	60	9	47
			50 deepsea-spec.				56 deepsea-spec.	

*) Provisional determination.
[1]) *Dichelaspis Weberi* from a depth of 560 m.
[2]) *Alepas morula* from 538 m. and *Alepas ovalis* from 984 m.
[3]) *Balanus alatus* from 564 m.
[4]) *Hexelasma arafurae* from 560 m.
[5]) *Poecilasma carinatum* from 750 m. and *P. gracile* from 740 m.
[6]) *Dichelaspis sessilis* from 1800 m.
[7]) *Alepas pedunculata* from 740 m.
[8]) *Balanus hirsutus* from 900 m.

important deepsea-material, a greater number of shallow-water forms: a richer collection altogether, as many species of Cirripeds belong to the coastal fauna.

However, this table was not compiled especially to show the greater number of species collected by the Dutch expedition. Its main object is to point out that the deepsea-material of all the oceans and seas of the world together, as far as Cirripeds are concerned, has after all no other composition than that which was collected in a relatively small area, the Malay Archipelago. For both collections that composition comes to this, that after all only two genera *Scalpellum* and *Verruca*, in deeper water, are represented by numerous species and that the other genera which do occur in that deeper water are represented there by very few forms only. It is true that the genera *Scalpellum* and *Verruca*, in shallow water, are also represented by several species: we now know 125 species of *Scalpellum*, which are so-called "good" species and which in any case, almost without exception, can easily be distinguished from one another; of these 90 live at depths of over 500 m. to ca. 5000 m. and 35 in shallower water. The number of known species of *Verruca* now amounts to 36; of these 5 were observed in shallow water and 31 at depths from 500 to ca. 3400 m. In deep water, however, only these two genera found circumstances specially favourable for the formation of new species, whereas the same for other genera holds good in more shallow water. As an instance of the latter the genus *Balanus* may be pointed out: of this genus by this time over 60 species are known and, therefore, it can safely be considered as one rich in species. However, only 5 of these have been observed in water of a depth of 200—500 m. and of the latter only 2 at a depth down to 564 m. On the other hand 55 species of this genus are known, which inhabit the coast or relatively shallow water only.

The author thinks that at the present moment our knowledge is by far too incomplete to permit of an explanation of phenomena of this kind; in such cases all we can do is to try to state and to control the facts as accurately as possible and we must then confine ourselves to considering it as a peculiarity of a few genera that their numerous species divide themselves over so strongly divergent depths, whereas it is characteristic of other genera that none, or a single, or a few species only have been able to adapt themselves to somewhat more considerable depths.

It is remarkable at the same time, and this holds good for the genus *Scalpellum* especially, but for most of the known species of *Verruca* also, that such richness in species is accompanied by so great

an isolation of the different forms. Of course, we cannot express our opinion on this matter with absolute certainty, as dredging, especially in deeper water, always remains an insecure method of testing the greater or lesser commonness of a species at the place where it occurs. Yet it is very striking, that in the collections made the species of Cirripeds from deeper water nearly without an exception are represented by one or by a very few specimens only. Especially when taking into consideration that the pelagic Cirripeds and those living near the coast or in shallow water, are nearly all of them characterised by numerous specimens living in the neighbourhood of one another, we are brought to admit, that where the depth is more considerable, relatively large distances separate the places, where the animals of a certain species occur, from one another, or, that specimens of such a species are never numerous and not to be found at all at very many places. This is also proved by the circumstance, that the "Siboga" found again specimens of two species of *Scalpellum* only out of the ten which were collected by the "Challenger" in the Malay Archipelago. That the "Siboga" found again the only species of *Verruco* which the "Challenger" brought home from deeper water in that area, would not be in accordance herewith — in both cases, however, that species was also represented by very few specimens only. Finally, it seems astonishing in this connection that in several cases representatives of two and three species of the genus *Scolpellum*, sometimes moreover accompanied by a single specimen of a species of *Verruca*, were obtained with the same haul of the dredge, from the very same locality in consequence. Such stations seem to be very favourable for the occurrence of these animals: however, for these found there the same holds good, viz., that they were collected in very few specimens only [1]).

For some deepsea-species of *Scalpellum* it was possible to make out, that they produced only a few but relatively large eggs, and that their metamorphosis was an abbreviated one. There is good reason to suppose that these peculiarities are of importance for the question of their scarcity — we cannot say, however, that the one is explained by the other. Nevertheless, so far as our knowledge

[1]) It is obvious to admit, that the condition of the bottom in such cases is all-important. Without denying it, we must point out, however, that to judge from the information regarding the condition of the bottom as given in the list of the stations, its importance for the distribution of the *Cirripedia* is by no means so apparent as might be expected. So we can well say that many species of *Scalpellum* were found at places where the bottom was muddy, but several other species were obtained from a bottom of hard sand, of coarse sand or of coral sand etc. etc.

now goes, we must consider the deepsea-species of *Scalpellum* and *Verruca* as hermits; as the number of species of these genera especially is very large, most probably they furnish precious evidence for the ideas, about the influence of isolation on the origin of new species, which were brought forward originally by MORITZ WAGNER [1]) and were criticised and adopted in a much modified form only by WEISMANN [2]).

For the geographical distribution of the Cirripeds the study of those collected by the "Siboga" has also been very instructive. With the exception of the pelagic forms, which are found attached to floating objects: pieces of wood, vessels, animals swimming at the surface: Cetaceans and others, etc. etc. and many of which are found in various parts of the world, these Crustaceans live attached to stones, shells of molluscs, corals etc.; the latter have good opportunity for active locomotion only in larval condition. But even in that condition, in consequence of their nearly microscopic size, their activity is only very limited; Nauplius- and Zoëa-larvae have limbs which enable them to move about, but more important is no doubt the distribution they are subjected to in a passive way, i. e. by means of the currents. However, even the latter distribution as a rule seems to be a very limited one: we only know very few non-pelagic Cirripeds which have a world-wide range or which occur in several of the eight provinces which were proposed by the present author in his Report on the "Challenger" Cirripeds for the animals of this group. The East-Indian or Malay Archipelago combined with the Philippines, Malacca, New-Guinea and the East coast of (British) India is one of these provinces; the investigation of the "Siboga"-material has shown again that this province indeed possesses its own Cirripeds, with the exception only of those species, which so to say spread themselves over its boundaries into other provinces, perhaps also of a few species which are at home in an adjacent province and came over its frontiers into the Malay Archipelago. Of the deepsea-Cirripeds we only know one single species, which can be said to occur at widely distant places of the earth's surface: *Scalpellum acutum*. The "Challenger" collected this species in the Atlantic Ocean (near the Azores) and in the Pacific (near the Kermadec-Islands) at a depth of 940-1800 m.; the "Talisman" also in the

[1]) WAGNER, MORITZ, Die Darwin'sche Theorie und das Migrationsgesetz der Organismen. Leipzig, 1868.

[2]) WEISMANN, AUGUST, Ueber den Einfluss der Isolirung auf die Artbildung. Leipzig, 1872.

Atlantic (not very far from the coast of Portugal) at a depth of 1925 m.; the "Siboga", finally, at three different places in the Malay Archipelago and at depths varying from 825 to 1265 m. But this does not change the rule, which still can be accepted as general, viz. that whereas several *genera* of *Cirripedia*, and those of the deepsea in the first place, are spread over the whole surface of the earth, the *species* of Cirripeds and especially the deepsea-species have been found to possess a very local distribution only.

To close this article a few words on the relation of the deepsea-*forms* to the extinct Cirripeds of which fossil remains have been preserved. The material collected with the "Siboga" in this regard also fully confirmed the conclusions arrived at by the working up of the material from the "Challenger". The species of the genus *Scalpellum*, which in the deepsea are so largely represented, have their representatives already in relatively old layers of the earth-crust, in secondary as well as in tertiary formations. We can even say, that a great majority of the species of the deepsea, with regard to an important anatomical characteristic (shape and structure of the so-called carina), show the greatest affinity to the oldest fossil forms (all those found in secondary formations); for this genus, therefore, we can safely admit that the deepsea-species, at least to a certain extent, show an archaic character. Side by side with the fossil *Scalpellum*'s, in the same formations and even in the same rocks or stones, numerous species of the genus *Pollicipes* were found. To this genus of which DARWIN alone enumerated 22 different fossil species belong the oldest known fossil Cirripeds and under the living it is still represented by half a dozen species. The "Challenger", however, did not succeed in collecting one single species of this genus even from slightly deeper water, which, when the author worked up the material of the "Challenger", gave rise to the remark, that the possibility of future investigations of the deepsea bringing to light species of the genus *Pollicipes*, could not be denied. Well then, the "Siboga" investigating the deepsea very carefully in one of the areas, where one of the living species of *Pollicipes* (*P. mitella*) is very generally distributed, did not obtain from deeper water one single specimen of a species of this genus either. So the exactness of the opinion pronounced in 1883, that, as far as the genus *Pollicipes* is concerned, the littoral or shallow water forms have preserved a more archaic character, has been completely confirmed by the results obtained with the "Siboga"-expedition. Of the genus *Verruca* a few species have also been found in older formations: one of these (*V. strömia*) is still

living and a well-known shallow water form and was also observed in glacial deposits and in Red and Coralline Crag in England as well; a second species is found according to DARWIN in tertiary formations in Patagonia; a third (*Verruca prisca*) in the chalk of England and Belgium. As far as we know the last-named species, a certain affinity of this extinct species with several of the deepsea-species of *Verruca* cannot be denied. But for *V. strömia*, the genus *Verruca*, therefore, in this regard also would show a greater analogy with *Scalpellum* than with *Pollicipes*.

Physics. — "*Calculation of the pressure of a mixture of two gases by means of* GIBBS's *statistical mechanics.*" By Dr. L. S. ORNSTEIN. (Communicated by Prof. H. A. LORENTZ).

By the method of statistical mechanics I have calculated in my dissertation [1]) the pressure of a mixture of two gases, neglecting terms of an order higher than the first with respect to σ_1^3, σ_2^3 and σ^3. The quantities σ_1 and σ_2 are the diameters of the molecules of the gases composing the mixture, and σ has been put for $\frac{\sigma_1+\sigma_2}{2}$.

In a recent paper [2]) H. HAPPEL has determined the pressure of a mixture by means of a method due to L. BOLTZMANN, retaining terms of higher order with respect to the above quantities.

As the method of statistical mechanics seems to me more exact than the one used by HAPPEL, I have been led to apply it to the problem which he has treated.

J. W. GIBBS has shown [3]) that the pressure of a gas is given by the equation

$$p = -\frac{d\Psi}{dV} \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \quad (1)$$

where V is the volume, and Ψ what may be called the statistical free energy. We have therefore to determine this quantity Ψ.

Let us suppose that the volume V contains n_1 molecules of the first kind with the diameter σ_1 and the mass m_1, and n_2 molecules of the second kind with the diameter σ_2 and the mass m_2.

[1]) Toepassing der statistische mechanica van GIBBS op molekulair-theoretische vraagstukken. Leiden 1908.

[2]) H. HAPPEL. Zur Kinetik und Thermodynamik der Gemische. Ann. der Phys. 1908 Bd. 26 p. 95.

[3]) J. W. GIBBS. Elementary principles in statistical Mechanics. New-York 1902.