Anatomy. — *The Anatomy of Lapemis Hardwickei gray.* I. By R. A. M. BERGMAN. (Department of Anatomy, Batavia.) (Communicated by Prof. J. BOEKE.) [1])

(Communicated at the meeting of June 25, 1949.)

Species. Name.

This short and broad sea-snake has been described by STEJNEGER, TAYLOR and DE ROOY as belonging to a single species, WALL and SMITH distinguish between two species, on account of the number of bands and the form of the ventral shields. The snake is commonly called ular lempe in East Java, ular = snake, lempe seems to be used sometimes in the sense of tired. I spent some time in trying to find the meaning of the scientific name "*Lapemis*" until I found the answer of the riddle in the book of STEJNEGER, who quotes it as an anagram of pelamis, so it is one of the relatively few cases where a biological name has no sense whatever.

At first sight, the most impressive anatomical details are the short and stout build and the dirty yellow colour with the darker brown triangular markings pointing to the belly. I definitely got the impression that all the specimens caught in this area belonged to the one species *Lapemis Hardwickei*, the material however and the lists of scale counts are lost trough the japanese plunder so in this case it is not possible to test this impression by the use of the necessary figures.

Distribution.

Near the coast at Surabaia, it is a very common snake and easily collected. In marked contrast to this experience I have never been able to obtain even a single specimen in Batavia. In this place the native fishermen are well used to bring any strange thing they may catch to the marine aquarium at Pasar Ikan as it will bring them a small reward. Before the war the price offered for a sea-snake was equivalent to a months wages, but no one came. This is not because the people in West Java know the danger of these animals better or are more afraid of poisonous snakes, because they bring plenty of other dangerous snakes, which they know very well, to the laboratory now (1947—1948).

Poison.

In Surabaia, from 1936 to 1941 a malayan fisherman brought practically every week the amount of seasnakes he was asked for. He went out in his prahu at night to catch the snakes as they were easily attracted by the ray of a flashlight. This man could very well distinguish the different species and was not afraid of handling the animals: he knew that, when

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[1]) For the tables and lists see part II.

he picked them by the tail and took them quickly out of his bamboo basket, they would just hang head down, unable to redress themselves nor to direct their bite, should they want to do so.

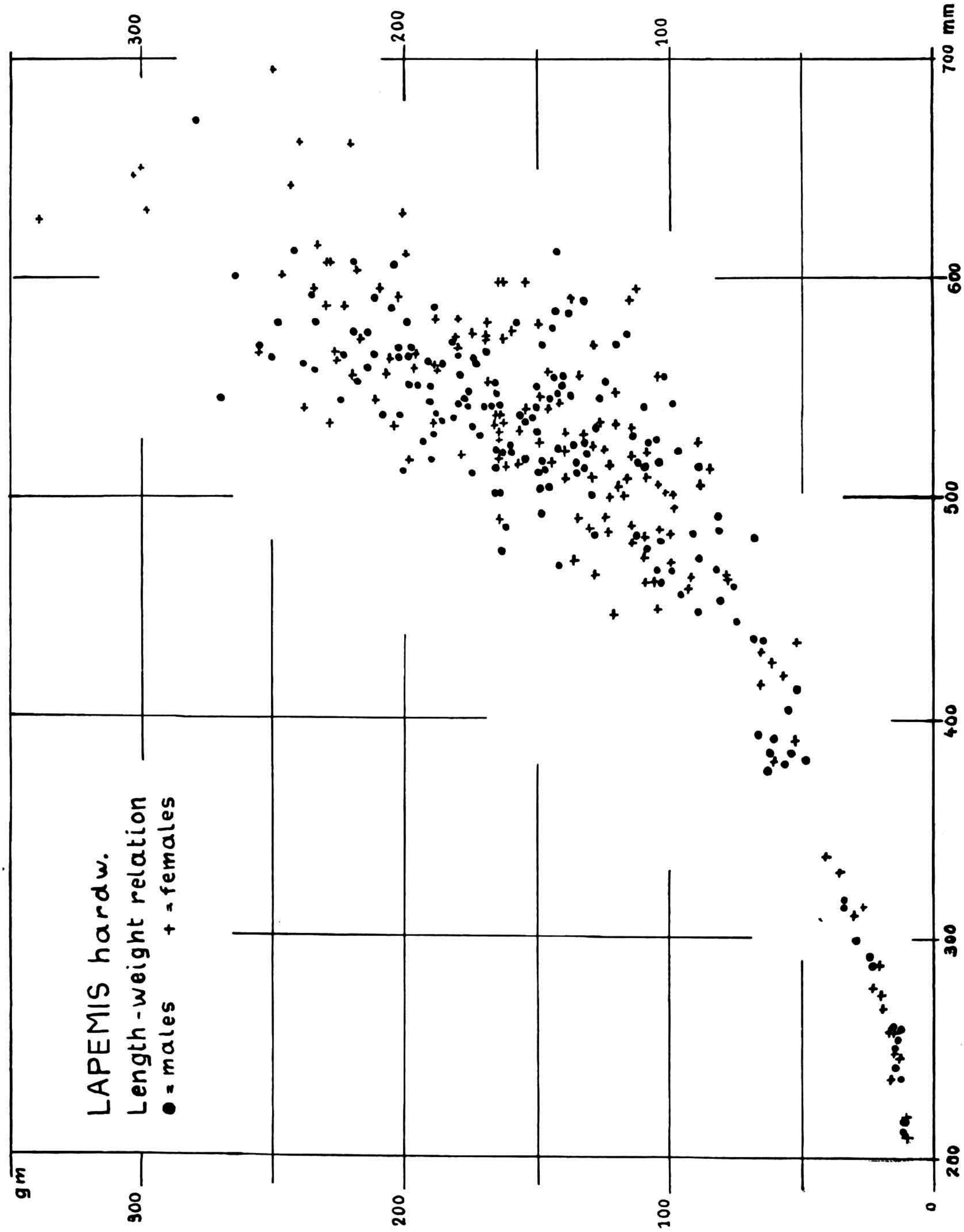

Fig. 1.

Once however he failed to turn up at the usual time and little more than a week later he told us that when he was packing the snakes, one of the lapemis fell besides the basket and bit him on the back of his bare foot. The bite was not very painful, but he had soon felt very tired and a bad headache started. He had slept rather heavily for a few days and recovered gradually without having taken any medicine. He looked rather pale, his foot was slightly swollen and two small puncture points could still be seen.

The snakes are not agressive, I have often tried to make them bite one another, but this was seldom possible and it never gave a fatal result. Once one got accidentally caught with the tail between the side of the aquarium and the lid, it started to screw swiftly round in the water, biting right and left. On another occasion a mouse bitten in the leg did at first not show any symptoms. After I had closed the mouth of the snake over the leg of the mouse and massaged the venom gland, the mouse did not try to run away but only sat down. After a couple of minutes it started to wash its snout with its fore paws and another few minutes later it let itself down and died without any sign of pain, convulsions or being short of breath. The heart was distended and full of dark blood. Lungs and intestines were normal.

Food.

As stated by MALCOLM SMITH, these animals do not thrive in captivity. If kept in salt water they survive easily for a month or six weeks, but finally always die of inanition. They refuse to take food and when fed forcibly, which has to be done gently, they disgorge the fish as soon as they are released. This can be prevented if a moderately large fish is fed and then a piece of string loosely wound around the body cranially from the stomach. But then the snakes regularly strangle themselves by pressing the prey so hard in the string that the ventral aorta becomes completely blocked. During the day they can be stirred up to interrupt this process or the string can be loosened or the prey massaged back into the stomach, but mostly they succeed overnight in their suicidal attempts and are found dead on the following morning. Feeding fish paste through a glass tube brought into the stomach gave no good results either, because this food also was slowly but very regularly regurgitated.

When caught, the stomach is nearly always empty. In 4 individuals out of 552 the stomach was distended, the content being twice a small fish, once a granular mass and once a gelatinous substance.

Sex.

In the adult animals the males have generally stronger tubercles on the scales, but this is by no means an absolute characteristic, it is always difficult and very often impossible to tell the sex of an animal without having seen the ovaries or the testicles. Sometimes the place of the hemipenis is marked by a slight lateral groove on the tail.

WALL gives for Lapemis curtus a sex ratio of 21 males and 28 females. In two consecutive series in Surabaia and in a group of young animals I found the figures listed in the following table. The percentages of male animals are given with their standard deviation; the differences are clearly not significant. For the samples of WALL and the adult group from Surabaia chi^2 = 0,36 and P is greater than 0,1 so there is no significant difference between the figures.

	N	Fem	Male	% Male
Wall	49	28	21	43,– ± 7,–
Surabaia	326	165	161	49,4 ± 2,8
Surabaia	139	80	59	42,5 ± 4,5
Sur. young	87	43	44	50,7 ± 5,4

Fertility.

In 12 pregnant snakes WALL found 22 embryos, the young varying in length from 330 to 335 mm, the adults from 686 to 825 mm. In the Surabaia series out of 210 adult females controlled by dissection, 32 were pregnant. Four of these caught in June had just ovulated and for a short while the yolk mass is not clearly divided in a certain number of eggs. In six animals caught in December and January there was a half resorbed egg or an embryo dead before birth. For these 32 snakes the total number of eggs, including all, was 60. Normal embryos were found in 22 animals, 27 in the right uterine tube and 15 in the left one, an average of two young per animal, and an assymetry of 3/2 for right and left.

In the same series, next to the 210 adult females and the 42 embryos, there were 63 young animals belonging to the production of the same year. If we do not count the unknown mortality of the newborn animals, this would mean 105 young in the group, or 53 pregnancies to 210 adult females, which seems a figure rather lower than expected.

Birth, Maturity.

In the series of WALL, young are born between May and August, foetuses being found in June and July, measuring from 215 to 355 mm. In the Surabaia series birth occurs later, between October and December, at the end of the dry season, November being generally considered as the hottest month of the whole year.

In a somewhat large series, maturity is indicated by the length of the shortest pregnant female, which in our series is an animal with a body length of 449 mm. The first bend in the curve of GALTON occurs exactly at the same place and in the case of Lapemis this is the same spot for males and females. This point may be considered as the treshold between immature and mature animals, between youth and adult age.

Growth.

There are no data of actually measured growth. WALL mentions an

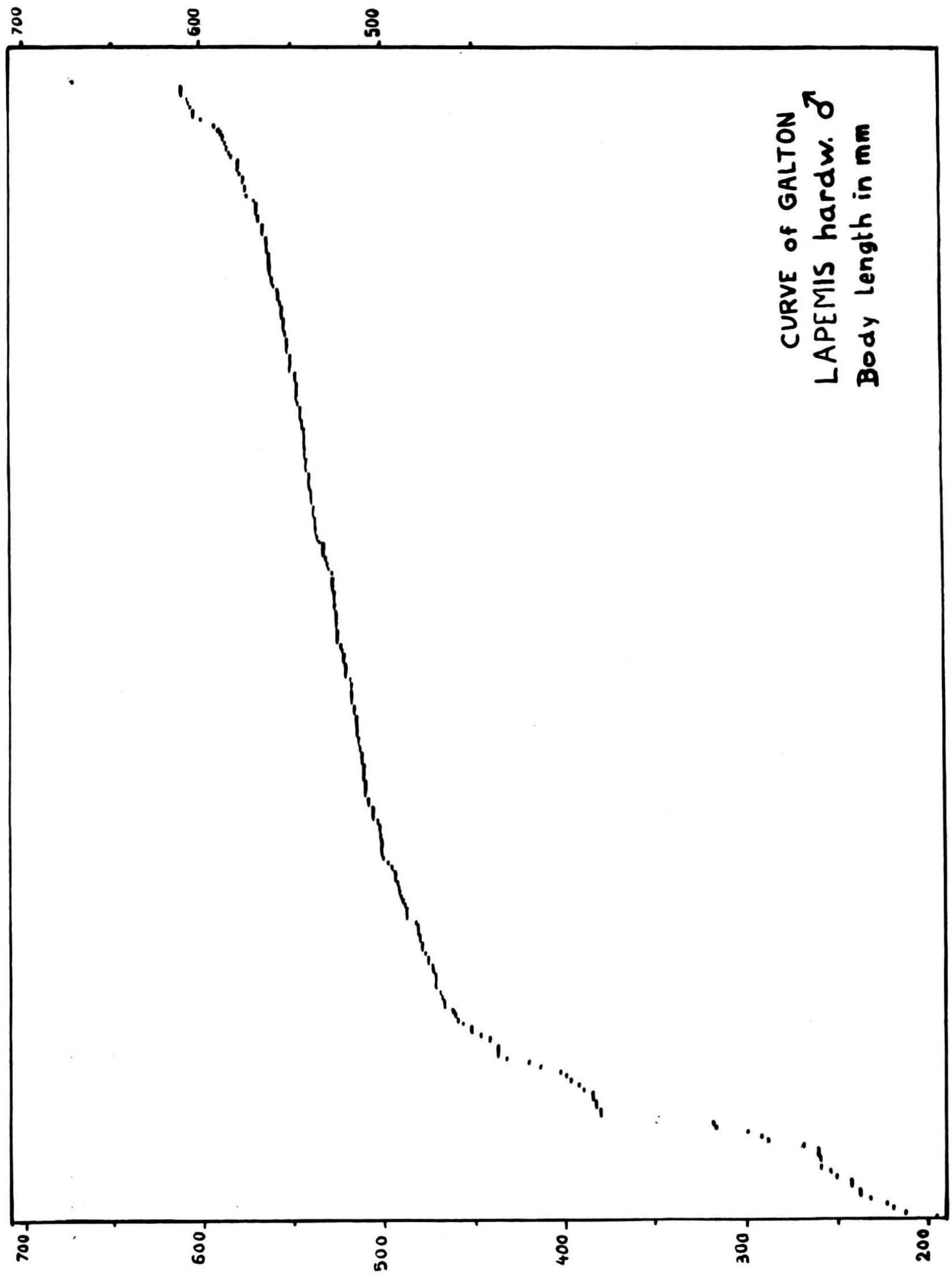
CURVE of GALTON
LAPEMIS hardw. ♂
Body length in mm
700
600
500
400
300
200

Fig. 2.

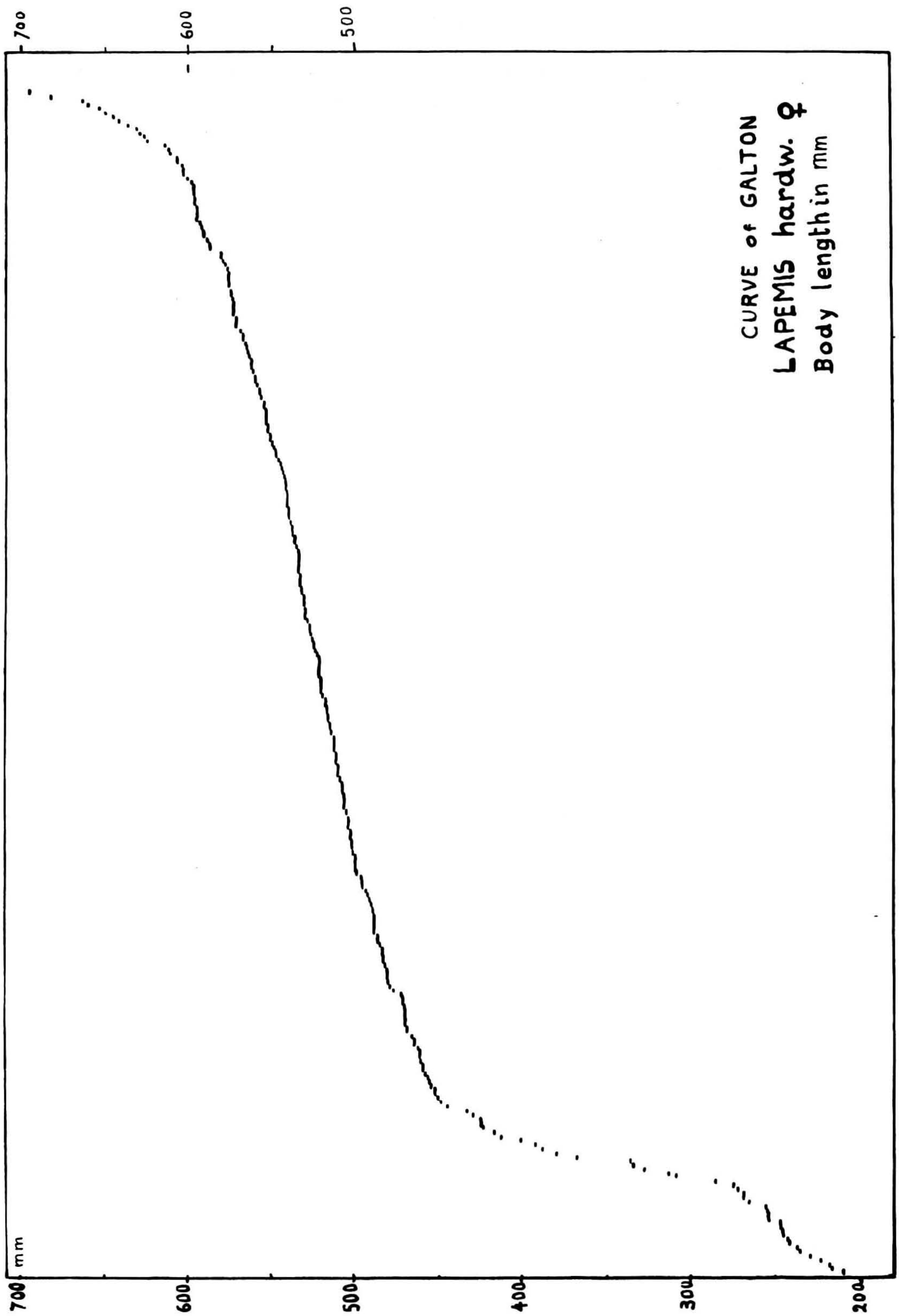
CURVE of GALTON
LAPEMIS hardw. ♀
Body length in mm
mm
700
600
500
400
300
200

Fig. 3.

increase of six to eight inches in the first year. The figures in the Surabaia series may suggest a somewhat slower development. The bodylength of the smallest newborn male is 190 mm and the female 200 mm, the body length of the mature animals is 450 mm. Between those points however, the specimina are not evenly distributed but seem to belong to two different groups showing the same range for both sexes. Males first from 190 to 320 and second from 370 to 400, females first from 200 to 340 and second from 370 to 400 mm.

The first group is distributed over the months October to March, the second from May to November, overlapping each other only during October—November. In these overlapping periods the smallest animals are clearly newborn so it may be concluded that it must have taken the others a year to reach the size they show.

We will see later that in adult Lapemis there is no difference in size in both sexes, so it seems justifiable in the early stages of life to neglect the sex difference and to calculate the average body length in each juvenile group for males and females together. These averages will then be for the first juvenile group including the newborn animals 259 mm and for the second juvenile group 382 mm. In our hypothesis the difference of 123 mm is the growth in the first year. The further growth from the average bodylength of the one year old to the mature size, from 382 mm to 450 mm, is 70 mm and it can reasonably be estimated that these are gained in the second year of life.

In this line of thought, the growth rate as given by SIMPSON & ROE in the formula

$$G = 2{,}3026 \frac{\log Yt - \log Yo}{t}$$

will be in weekly % for the first year of life 0,065 and for the second year 0,053. Or if we prefer to consider growth as uniform (in two years) from birth to maturity, 0,038.

Next to using the average sizes of different groups as an indicator of growth, we can check up the records of single female individuals. In this latter method we have not only the body length to go by, but also the aspect of the ovaries, which presents a very definite picture of different stages of activity correlated with seasons and with age.

In our series a newborn female, caught in December had only thin colourless peritoneal folds without any morphological differentiation, but identifiable as ovaries, her body length was 250 mm. Another young female with a bodylength of 328 mm was caught in February, it was the smallest one to show yellow pin-points in the ovaries as the first sign of eggs. In a third animal of 389 mm bodylength, caught in October, the little eggs were clearly visible in a regular straight row, as neat little spheres each with a diameter of nearly 3 mm. Clearly it was still an immature animal, but with the eggs on the verge of ripening and it took at least from December till October to reach this stage, together with a growth from 250 to 390 mm in bodylength. Finally the smallest pregnant female was caught in August with a bodylength of 449 mm. In this small series the differences in size between the animals from December and October was 140 mm and from October to August 60 mm. This is 200 mm in round 20 months or 87 weeks and shows a growth rate of 0,047 % weekly, which is on good accordance with the figures found by the other method.

In the Surabaia series the number of firstyear animals is 63, and of the two year olds 14. If this is to be considered as the constant pattern of the population, it would suggest for the juvenile animals in the course of the first year a death rate of about two thirds.

Blood, Pathology.

In 1937 RADSMA and in 1939 STREEF analysed samples of blood from Lapemis, from the latter series only two records could be saved from the war plunder. The figures are shown in the following table.

Blood salt in mg % of plasma *Lapemis*

Author	Sex	Na	K	Ca	Total Cl
RADSMA 1937	—	421	35,-	—	—
STREEF 1939	Fem	433	35,-	—	469
STREEF 1939	Fem	410	35,5	—	483

There are only a few data on pathology. In the Surabaia series there were two abnormalities with the aspect of a tumor, one in a female on the back and one in a male on the eye, also a few ulcerating wounds of the skin. Infection with parasitic worms is very frequent, mostly under the skin and in the wall of the stomach. Of the organs, the kidneys, the testicles and the uterus showed macroscopical abnormalities. In two females one kidney was missing, once left and once right, in two other females the right kidney was abnormally thin. In three females the uterus was abnormal on the distal end, twice on the left side, once not marked. In males there were no kidney abnormalities, but in 10 cases the right testicle was abnormally thin, the bodylength of these animals ranging from 383 to 673 mm.

Length and Weight.

In the next table the maximum lengths given in litterature and my own data are reproduced. For the data of BOURRET and my own I calculated the mean value. The figures of WALL, SMITH and BOURRET seem to belong to one group, different from the others.

If we ask for the probable maximum length, the answer for the Surabaia series is that not more than three animals in a thousand will exceed 647 mm for males in bodylength or 682 for females. In fact we found one male in 220 longer than 647 mm and two females in 243 longer than 682 mm.

We have already mentioned that there is no easily recognisable sexual

Length in mm *Lapemis*

Author		Sex	Total	Body	Tail
		Maximum			
STEJNEGER	1907	—	750	670	80
DE ROOY	1916	—	750	670	80
WALL	1921	—	846	—	—
TAYLOR	1922	—	762	689	73
SMITH	1926	—	860	785	75
BOURRET	1935	—	860	770	80
BERGMAN		M	753	673	80
		F	777	697	80
		Averages			
BOURRET		—	605	542	63
BERGMAN adults		M	599	533	66
,,		F	607	535	64

dimorphism in Lapemis, nor is there a difference in bodylength or in weight. The average bodylength is in males 533, and 535 mm in females, the weight in adult males 161 grams and 163 grams in female adults.

In the length of the tail however there seems to be a definite difference, the male adults have longer tails than the adult females 66,2 mm against 63,4 with $D/\sigma D = 4{,}6$ which is significant.

The coefficient of correlation *r* for body length and tail length is in adult males 0,676 and in adult females 0,757; the same coefficient for bodylength and weight is in adult males 0,646 and in adult females 0,756.

Sexual Dimorphism — *Lapemis* adult.

	Sex	N	R	M	σ	D/σD
Weight	M	137	68—279	161 ± 3,2	45 ± 2,7	2/5,7 = 0,35
	F	122	78—340	163 ± 4,7	52,5 ± 3,4	
Body length	M	220	450—673	533 ± 2,6	37,9 ± 1,8	1,9/4,7 = 0,46
	F	245	450—697	534,9 ± 3,2	47,5 ± 2,2	
Tail length	M	220	54—80	66,2 ± 0,4	5,2 ± 0,3	2,8/0,6 = 4,6
	F	245	52—80	63,4 ± 0,4	5,6 ± 0,3	

Length of internal organs.

The lengths of the heart, liver, gallbladder, kidneys, are in Lapemis of both sexes of the same order. The testicles measure less than half the length of the ovaries. The length of spleen and pancreas seem to be greater in males, the $D/\sigma D$ being for the spleen 4 and for the pancreas 4,5. It is however not at all sure that this statistically significant difference has any special biological importance, precisely these organs are during pregnancy markedly pushed cranially; often then the pancreas can be seen turned to the left, so that its long axis is no longer in line with the long axis of the body. When the most cranial and caudal points of the pancreas are measured then, they do not give the longest diameter of the oval as they should do and the organ seems shorter than it really is.

Topography.

The analysis of the data given in the table shows a difference between the topography of the organs in adult males and females. The heart, liver,

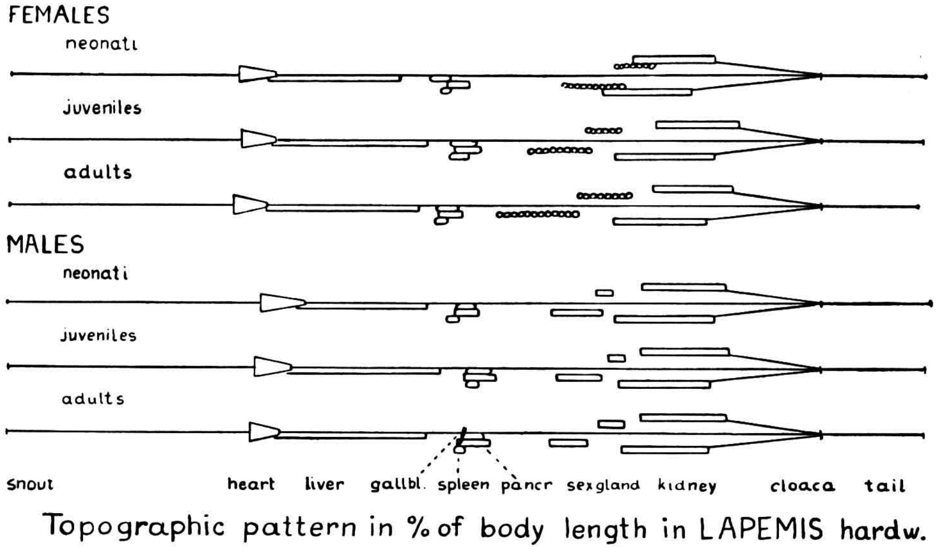

Fig. 4.

gallbladder, spleen and pancreas, in short all the organs of the cranial half of the body are more cranially placed in females. The position of the kidneys on the contrary is in both sexes the same and so it is with the caudal end of the sex glands on the right and left side to. Seeing the difference in length of the sex glands in males and females it is evident that the cranial end of the ovaries must extend much further forwards than that of the testicles. The differences and their sigma are listed in the following table. No measures of the lung have been listed, as in these animals, the lung stretches over the whole length of the body.

Sexual Dimorphism in topography D/σD *Lapemis* adult

	Top	End
Heart	9,2/1,2 = 7,7	8,6/1,3 = 6,6
Liver	8,0/1,4 = 5,7	6,3/2,2 = 2,9
Gall bladder	17,4/2,3 = 7,5	16,4/2,5 = 6,6
Spleen	14,9/2,4 = 6,0	15,6/2,4 = 6,5
Pancreas	15,0/2,4 = 6,2	16,8/2,6 = 6,5
Sex gland R	25,6/2,8 = 9,2	
id L	14,6/3,1 = 4,8	
Sex gland R		4,3/3,1 = 1,4
id L		6,8/3,5 = 1,9
Kidney R	5,2/3,2 = 1,6	2,7/1,2 = 2,2
Kidney L	6,4/3,5 = 1,8	2,8/1,2 = 2,3

Intervals between the organs.

In Lapemis heart and liver are so near to one another that there is hardly an interval at all and there is no noticeable difference between both sexes. Gallbladder, spleen and pancreas are also practically fused into one block. The two remaining intervals in the cranial half of the body, the distance from snout to heart and from liver to gallbladder are shortened in female animals.

For the caudal half of the body one has to distinguish between right and left side. On the left side the intervals do not show any sexual difference, on the right side on the contrary there is a difference between males and females. The most important seems to be the distance between pancreas and kidney which is longer in female animals. This is quite understandable as this is the space where in female animals one of the most important functions, the development of the young, has to be carried out.

Sexual Dimorphism in organ intervals. *Lapemis adult*

	Sex	M		D/σD
Snout-heart	M	158,0	0,8	
	F	148,8	0,9	10,8/1,21 = 8,9
Liver-gallbl.	M	22,0	0,7	
	F	10,9	0,7	11,1/1,— = 11,—
Pancreas-sex gl	M	39,1	0,7	
	F	20,3	0,7	18,8/1,— = 18,—

Variability.

The variability of the bodyconstituents thus far analysed, shows very different values. The length of body and tail, the topographical data of the pattern of the internal organs, the sum of all intervals on both sides of the body are not very variable, the coefficient ranging from 7 to 12 for both sexes.

The lengths of different organs however show two distinct types of variability. V from 11 to 15 for heart, liver and kidney, but from 18 to 26 for gallbladder, pancreas and spleen. The sexglands are even more variable, for males right and left V = 24 and 29, for females 26 and 35. If these glands of both sides are taken together as a unity, as they functionally undoubtedly are, the variability diminishes, but then the testicles belong to the first group of organs with V = 12, and the ovaries with V = 24 rather to the second.

The intervals or free spaces show a different variability for those on the ends of the body and those in between. The cranial interval, snout-heart, and the caudal ones, kidney-cloaca, right and left, have a coefficient from 8 to 14. For all other intervals the variability is uncommonly high, with the single exception of the interval between pancreas and left sexgland.

This seems to point first to a very strong tendency to keep the topographical pattern constant, secondly to a marked tendency also to keep the length of the organs constant although the organs at the middle of the body seem to have more freedom in this respect than the others, and thirdly, to the fact the arrangement of the free spaces or intervals between the organs seems in every single case very uncertain, although as a whole they show very little freedom.

Summary.

An analysis of various data on the seasnake Lapemis hardwickei has been given. About 550 specimina were collected from 1936 to 1942 at Surabaia, East Java. The growth of the young individuals, the point where maturity is reached, the fertility and the date of birth, the pathology and the chemical analysis of the blood, the sexual dimorphism as shown by the data have been discussed and a detailed account of the topographical anatomy of this snake has been given.

The tables are printed on p. 894—898 of this number.

Batavia, January 1949.