A STUDY OF *LITHOTRYA NICOBARICA* REINHARDT

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The genus *Lithotrya* comprises a small group of Cirripedes, that live almost exclusively in tropical waters and are of particular interest to the carcinologist, partly by reason of their rarity and partly because the genus, unlike most other Pedunculate Cirripedes, has adopted the cryptozoic habit of forming burrows, in which the animal lives and is protected from its enemies.

Up to the present time eight species have been described, all of which exhibit this peculiarity of habitat, though the medium in which the burrows are made is not always identical. *Lithotrya cauta* Darwin, which is known from a single small specimen having a length of only 0·5 mm., was discovered lodged in a *Conia* shell, and *L. valentiana* (Gray) has only been taken from the valves of an oyster : but with these exceptions, all other members of the genus form burrows in either coral and coral-conglomerate or in solid limestone rock. In this connection it is interesting to note that it is the eastern species, namely *L. nicobarica* Reinhardt, *L. pacifica* Borradaile, *L. conica* Hoek, and *L. truncata* Q. and G. that have their habitat in coral or coral-conglomerate, occurring either in coral masses on the margin of a reef or in dead and sub-fossil coral blocks in a coral-conglomerate : the western species, *L. dorsalis* Sowerby, forms its burrows in solid limestone rock ; but here also the two varieties of this species that have been described from eastern waters by Borradaile, namely var. *maldivensis* and var. *rugata*, were both taken in coral rock over-hanging the reef margin.

In the Table below I give a list of the various species known and have added the regions from which they have up to the present time been obtained :—

SPECIES.	DISTRIBUTION.
1. *Lithotrya nicobarica*	The islands of Timor, Lucipara, and Kur in the Malay Archipelago : Great Nicobar Island and Kachal Island in the Nicobars.
2. *Lithotrya truncata*	The island of Timor in the Malay Archipelago ; the Friendly Archipelago and the Philippine Islands in the western Pacific Ocean.
3. *Lithotrya conica*	The Islands of Kur and Lucipara in the Malay Archipelago.
4. *Lithotrya pacifica*	The Atoll of Funafuti and the Island of Lombok in the Malay Archipelago.
5. *Lithotrya cauta*	New South Wales.
6. *Lithotrya valentiana*	The Red Sea and Zanzibar.
7. *Lithotrya dorsalis*	Barbadoes, Venezuela and Honduras.
„ „ var. *maldivensis*	Tne Maldive Archipelago.
„ „ var. *rugata*	
8. *Lithotrya rhodiopus*	The Atoll of Funafuti.

A study of this Table clearly indicates that the centre of distribution of the genus lies in the region of the Malay Archipelago and the western side of the Pacific Ocean, and the genus appears to have spread from this centre to the Philippines, New Zealand and New South Wales on the east, and to the Red Sea and the east coast of Africa and finally to the western side of the Atlantic Ocean on the west.

The features, which have hitherto been utilised for the purpose of distinguishing these so-called species, are for the most part those of the external characters only, since as a rule so few specimens were obtained that none could be spared for dissection and the examination of the soft parts. The characters, on which the specific determination of the so-called species in the genus *Lithotrya* is based, are as follows :—

1. The general shape of the Capitellum, and the relative heights and shapes of the individual valves and the degree to which they overlap each other.
2. The width and curvature (*i.e.*, concave or convex) of the inner aspect of the Carina, and the degree of development of a crest or ridge on its inner aspect.
3. The height of the Latera and the number of calcareous scales on the peduncle that correspond to them and to the rostrum.
4. The size and distribution of the chitinous teeth along the margins of the laminae of the valves.
5. The shape and size of the calcareous scales on the peduncle.
6. The character of the fixation plate, whether flat or of a cup-like nature.
7. The number of segments in the various cirri.
8. The character of the mouth parts, and particularly the number of denticles between the 1st and 2nd, and 2nd and 3rd teeth of the mandible, and the distances between the 1st and 2nd teeth and between the 2nd tooth and the inferior angle.
9. The length of the caudal appendage in comparison with the pedicel of the 6th cirrus.

Annandale (1911, p. 230) has pointed out that in other Cirripedes, namely in the genus *Ibla*, the determination of the so-called species, based as it is on shell characters, is probably unreliable, and Borradaile (1903, p. 441) in his description of two new varieties of *Lithotrya dorsalis* from the Maldives admits that certain of the characters, on which he bases their distinction from the type form, " may well be due to a difference in the manner in which the specimens have become worn by the sea." It is, therefore, particularly unfortunate that in this genus most of the characters, on which the various species are based, fall within this category. The use of such characters for specific determination is doubtless unavoidable in circumstances such as these, where but one or two specimens exist, but it must be recognised that results based on characters of this nature are always open to doubt, and any such classification can only be provisional, until the acquirement of further material enables one to determine the limits of variation in the external features and permits of the study of the internal anatomy.

A study of a large number of examples of *Lithotrya nicobarica* Reinhardt has shown that most of these external characters are subject to

a very considerable range of variation and, in consequence, indicates that many of the above features are of but little diagnostic value. Darwin (1851, p. 359), in his general remarks on *Lithotrya cauta*, points out that "it is difficult to give obvious characters, (excepting the smallness of the rostrum compared with the scales on the peduncles) by which this species can be externally discriminated from *L. dorsalis*, *L. nicobarica* and *L. rhodiopus*: yet almost all the valves differ slightly in shape. In this species alone (the peduncle of *L. rhodiopus* is not known) the lower microscopically minute, bead-like scales of the peduncle are crenated, though obscurely, all round. In the animal's body, the diagnostic characters are strongly marked,—the long spines on the terminal segment of the first cirrus,—none of the segments in the posterior rami of the second and third cirri being thickened and paved with bristles,—the pectinations being equal in number between the main teeth of the mandibles,—are all characters exclusively confined to this species." It would appear probable, however, that all these diagnostic characters are in reality structural differences due to progressive development and are indications merely of age. In many of the so-called species so little is known of their internal structure that I have been unable to arrive at any definite conclusion, but the impression that I have formed is that, with the exception of *Lithotrya valentiana*, *L. truncata* and probably *L. rhodiopus*, the remaining species are in all probability identical and are merely synonyms of each other.

Lithotrya nicobarica Reinhardt.

Lithotrya nicobarica, Reinhardt, 1850, p. 1, pl. I, figs. 1-3.
Lithotrya nicobarica, Darwin, 1851, p. 359, pl. VIII, fig. 2.
Lithotrya nicobarica, Gruvel, 1905, p. 99.
Lithotrya nicobarica, Hoek, 1907, p. 122, pl. IX, fig. 9.
Lithotrya nicobarica, Hoek, 1913, pp. vii, xv, and xxiv.
Lithotrya nicobarica, Annandale, 1916, p. 131, pl. VII ?, fig. 2.
?Lithotrya cauta, Darwin, 1851, p. 356, pl. VIII, fig. 3.
?Lithotrya conica, Hoek, 1907, p. 124, pl. IX, figs. 10-12.
?Lithotrya pacifica, Borradaile, 1900, p. 798, pl. LI, figs. 3, 3*a*.
?Lithotrya pacifica, Hoek 1907, p. 126, pl. IX, figs. 13, 13*a* and 14.
?Lithotrya dorsalis, var. *maldivensis*, Borradaile, 1903, p. 441.
?Lithotrya dorsalis, var. *rugata*, Borradaile, 1903, p. 441.

Locality.—"Investigator" Station 680; April, 10th, 1925. Shelf of raised coral-conglomerate near high-water mark about ¾ mile to south of Chinese fishing village, S. of Hoini-pot, Kachal Island, Nicobar Islands.

Since 1921 the R. I. M. S. "Investigator" has been engaged for the greater part of each succeeding survey-season in surveying the central group of the Nicobar Islands. The late Dr. N. Annandale, who was keenly interested in and has done much work on the Cirripedes of Indian Seas, was very anxious to obtain examples of this particular species. Described originally by Reinhardt from specimens obtained in the coral-conglomerate rocks in Galatea Bay in Great Nicobar Island, there was every reason to hope that examples of *Lithotrya*, either of the same species or one closely allied to it, would be found in the central group of islands. Around these islands and bounding the shores of Nankauri Harbour are to be found numerous rocks and boulders of varying degrees of hardness and of different geological character; on the east side are numerous reefs and ledges of hard clay, that are bored through and through by

Pholas sp. and Sipunculid worms, but a systematic search revealed no trace of any examples of *Lithotrya*. On the western side the islands consist, for the greater part of their length, of Serpentine rocks; but here also no trace was obtained. It was not until the third year of my search that I was fortunate enough to locate a bed of *Lithotrya*, and even then it was pure accident that led to their discovery. On the east side of the island of Kachal there is clear evidence that within recent geological times the relative levels of sea and land have undergone a change resulting in an apparent elevation of the land. As a result of these changes an extensive reef now dries at low-water spring tides; the reef consists for the most part of dead coral and coral boulders, and on the shore side of the reef is a sandy beach that slopes upwards to the general level of the land. At the upper part of the beach near high-water mark, at a distance of about ¾ of a mile to the south of the Chinese village near Hoini-pot, a bed of coral-conglomerate crops out; this bed is roughly horizontal and in places overhangs the beach, the sand and loose coral debris having been washed away from beneath it by the action of the waves. Embedded in this conglomerate were several large shells and shell-casts, apparently of a species of *Tridacna*, and on excavating one of these from its bed, I found that it was bored through by a specimen of *Lithotrya nicobarica*. A further search in the neighbourhood revealed a large bed of these Cirripedes. Stanley Gardiner (1903, p. 337) has described the manner in which these boring Cirripedes form colonies; "in suitable positions thousands may be present, riddling the whole surface of the rock. The regularity of their holes precludes the idea that they can have been made by any other organism. In life they hang downwards with their appendages just projecting out of their tubes, when their entrances are covered by water." The above description applies equally well to this bed of *L. nicobarica*. They were all living in burrows on the under side of the rock and each individual was completely concealed in its burrow. The occurrence of these Cirripedes in groups may be due to the general suitability of the habitat or, as is more probable, to the formation of a colony owing to daughter-individuals settling down near the parents. In such a colony, as one would expect if it has been produced in this latter way, examples of all sizes, from quite small to full-grown individuals, may be found. The largest colony was discovered in a solid mass of dead coral. Probably, as the tide falls, the animals withdraw into their burrows and so remain completely concealed and protected until the tide again rises. The burrows were situated in all the constituent parts of the conglomerate, some were in the softer sand-stone portion, while others were in blocks of dead coral or even in the thick hard portions of the large *Tridacna* shells. The most common position in which the animal occurs is with the head or capitellum hanging vertically downwards; individuals, however, were found in every position between this and the horizontal, but the frequency of occurrence diminishes as one approaches the horizontal.

I was able to obtain a series of sixty-five examples of the species. This is by far the largest collection that has hitherto been obtained, the next largest series being that collected by the "Siboga" in the Malay Archipelago which comprised some eighteen specimens.

GENERAL SIZE.

These examples from Kachal vary very considerably in their general size, and in order to compare them it was necessary to adopt some particular measurement. The measurement, that is usually given, namely the total length from the tip of the capitellum to the extreme end of the peduncle is of but little value owing to the extremely contractile nature of the stalk ; neither is the height of the capitellum itself a reliable criterion, since this will very largely depend on the number of laminae that still remain attached on the outer and older side of the valves. I, therefore, selected as my standard the maximum measurement across the base of the capitellum between the carina and the rostrum. The specimens, measured in this manner, are found to fall into four more or less distinct groups, which I believe to represent age-groups, each corresponding to a year's growth. The smallest group, which I have termed the 1st year stage, includes only two individuals,

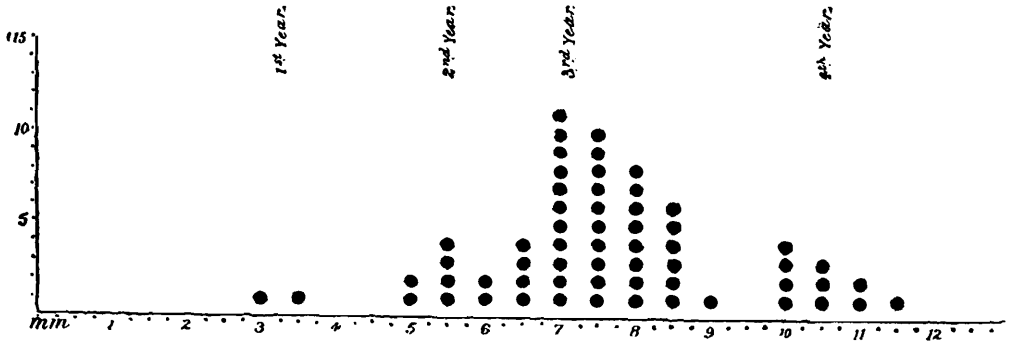


Table 1. Showing the measurements of 60 individuals of Lithotrya nicobarica Reinhardt.

having a breadth of 3·0 mm. and 3·5 mm. respectively. The second group, or that of the 2nd year, contains eight specimens, whose breadth ranges from 5·0 mm. to 6·0 mm., the average being 5·50 mm. The next or third year group is by far the largest and includes thirty-nine examples with a breadth-measurement that varies from 6·5 mm. to 9·0 mm., the average being 7·56 mm. The last group, or those belonging to the fourth year of life, consists of ten individuals, whose size ranges from 10·0 mm. to 11·5 mm., the average being 10·55 mm.

It would appear from this that the average length of life of the members of this species is approximately three years, but that a certain number of individuals may survive for a fourth year.

EXTERNAL CHARACTERS.

As has been pointed out by Darwin (1851, p. 336) these Cirripedes periodically undergo a process of exuviation, by which their outer chitinous and calcareous covering is shed, either wholly or in part ; wholly as regards the outer covering of the peduncle and in part only as regards the valves of the capitellum. A study of the structure of the valves shows that they are each composed of a number of calcareous plates or laminae, superposed in series one on the other. At each process of exuviation a fresh lamina is deposited on the inside of the old one and

the valves are thus gradually built up from within. Similarly, the outer covering of the peduncle is armed with a number of small calcareous studs or nodules and these are also renewed every time the chitinous skin is cast. But whereas at each exuviation the outer covering of the peduncle is completely cast off and renewed, the various layers of the valves remain more or less firmly attached to each other, the number of such laminae in a valve being indicated by raised ridges on the outer surface. The process of exuviation appears to be directly correlated with the burrowing habit. It occurs in *Lithotrya* and also in the other burrowing genus of Cirripedes *Alcippe*, and in both the main burrowing organ is the peduncle, which is covered in chitin and is armed with numerous little star-headed nails or studs, composed of an inner chitinous core and a calcareous outer coat. These calcareous studs periodically become worn down and are renewed by the process of exuviation. Both genera anchor themselves firmly by means of a disc of attachment that in *Lithotrya* is calcareous and in *Alcippe* is horny. The formation and enlargement, as growth increases, of the burrow appear to be carried out by movements of the animal in its cavity, and by the resulting friction against the sides of the burrow of the calcareous scales of the peduncle and the edges of the laminae of the valves. Each newly-formed lamina bears along its free margin a number of minute chitinous teeth that are directed " downwards," *i.e.* towards the fixed base of the peduncle, and these are gradually worn down against the wall of the burrow. The number of superposed laminae in any valve will largely depend on factors, such as the violence of the muscular movements of the peduncle and the degree of adherence between the superposed laminae which are individual in origin, and others, as the degree of hardness of the rock in which the burrow has been constructed, that are purely fortuitous and beyond the control of the animal, except in so far as the initial selection of a habitat is concerned. It is, therefore, not surprising to find that the number of laminae in the various valves exhibits a considerable range of variation; in the table below I have given the degree of variation observed in the examples of *L. nicobarica* collected by me.

Valve.	No. of Laminae.
Tergum	from 3 to 18
Scutum	„ 5 „ 17
Carina	„ 4 „ 16
Rostrum	„ 2 „ 9
Latera	„ 1 „ 10

It is clear, therefore, that the relative height of the valves, depending as it does entirely upon the number of laminae in the valve, can have little or no value as a diagnostic character. It would also appear probable that the shape of the various valves may exhibit a wide range of variation, but I propose to examine this question in greater detail when studying the individual valves. The capitellum as a whole, however, shows a wide range of form that must, of course, depend on intrinsic differences in the valves themselves.

In Plate XIV, figs. 1-11, I have given photographs of several examples of *L. nicobarica*. It is evident that from the present series of over sixty

individuals it is possible to match, as far as the external appearance is concerned, many of the so-called species in the genus. In figs. 1 and 2 I have shown two examples that agree remarkably closely with the form described and figured by Borradaile (1900) under the name *L. pacifica ;* the curved carina and the elongate latera, reaching approximately to the distal border of the tergum, are clearly shown. In figs. 3, 4 and 5 we have examples in which the capitellum exhibits a rounded or conical shape that corresponds clearly to the form described by Hoek (1907) as *L. conica*, but which also show a marked resemblance, especially in the case of fig. 4, to the figure given by Reinhardt in his original description of *L. nicobarica*. Figs. 6 and 7 exhibit an elongate form of the capitellum due specially to the tapering shape of the tergum, and this imparts to the individual an appearance that approximates closely to *L. dorsalis*, as figured by Sowerby (1822). In others again (figs. 8 and 9) the carina is long and straight and the terga are truncated at their extremities. A comparison between figs. 6 and 8 also reveals how great a variation may be found in the degree to which the tergum is exposed between the latus and the scutum ; the extent of the exposed surface is in fig. 6 twice what it is in fig. 8. With the exception of *Lithotrya truncata*, *L. valentiana* and possibly *L. rhodiopus*, of which latter species our knowledge is somewhat meagre, it is possible to match most of the previously described forms from among the examples of *L. nicobarica* that I have been able to examine and it seems clear that the mere shape of the capitellum is of no value as a diagnostic feature.

In all the species of *Lithotrya* the free margins of the laminae of the valves are provided with a linear series of minute teeth, composed of chitin. In the older laminae the teeth are much worn, and may be completely obliterated, owing to the continual friction against the side of the burrow during its excavation. Along the margin of the last-formed lamina they are, as a rule, clearly seen, and they may also persist on the borders of the older laminae in areas where the margins of the ridges are protected by the overlapping of the neighbouring valve. Darwin described these teeth in *Lithotrya dorsalis* as follows ; " Exteriorly the valves are covered with yellow membrane, with rows, corresponding to each zone of growth, of very minute, yellow, horny spines, generally having their tips bent over, and so made hook-shaped." In *L. cauta* he states that the teeth are " broad, blunt and often stand rather distinct from each other." In the examples of *L. nicobarica* that I have examined these teeth are exactly as Darwin has described them in *L. dorsalis ;* they are very small in size and are yellow in colour, being somewhat bent or curved, especially at the angular ends of each ridge, where they are for the most part distinctly claw-shaped ; this is particularly well seen in the smallest specimens, namely those having a capitellar measurement, as noted above of 3·5 mm. In the small examples these teeth are also rather wider apart than in the older specimens, so that in this respect small specimens of *Lithotrya nicobarica* closely resemble *L. cauta*.

During the to-and-fro movement of the Cirripede within its burrow there must be a considerable amount of friction on the sides of the peduncle and around the basal portion of the capitellum, but the more

peripheral parts of the valves are obviously not subjected to such rubbing, since they are in almost every case covered by a deposit of calcium carbonate and in many cases serve as a base for the attachment of algae or of small sessile Cirripedes (*vide* Pl. XIV, figs. 10, 11).

In several species of *Lithotrya* it has been observed that examples of other species of Cirripedes are by no means infrequently associated with them. In only a single instance, namely *Alepas lithotryae* Hoek, is the smaller associated form known only from such a source, and it seems clear that in most cases at least we are not dealing with a condition of either parasitism or even one of commensalism, but that the association of the two Cirripedes is purely accidental and is merely the natural result of the sedentary habit of the group. These animals are all sessile and the young free-swimming larvae, when their development is sufficiently advanced and the time comes for them to adopt the sedentary habit of the adult stage, will attach themselves to any hard body or substance, with which they may come in contact. Owing to their structure the vast majority of the Cirripedes are totally incapable of removing from their external surface any extraneous organism that may have attached itself. *Lithotrya* is better off in this respect than most of the other Cirripedes in that there are two processes by which its external surface is kept free from unwelcome hangers-on ; in the first place the external chitinous covering, with the exception of the valves themselves, is completely and frequently cast off and is renewed by a process of exuviation, and in the second place the continued to-and-fro rubbing of the body of the animal in the burrow, which the members of this genus make for themselves, must act very effectively in freeing their surface from lodgers except in those parts, such as the extreme apical areas of the valves, which never actually come into contact with the walls of the burrow. Even in these latter situations, where sessile animals may effect a temporary footing, the lodger is eventually cast off with the lamina though by the time that this happens it may have attained to a considerable size.

The commonest Cirripede associated with *Lithotrya nicobarica* is *Balanus tintinnabulum*, var. *communis*. This species is usually attached to the outer aspect of the upper part of the tergum or the scutum, or else is situated on the inner aspect of the carina ; in no case that I have seen does the individual attain to any size ; all the examples were quite small. The second commonest species is *Ibla cummingi*. Hoek has recorded that he found a single specimen sessile on an example of *Lithotrya pacifica* Borradaile and I have myself seen three examples attached to *L. nicobaria*. In all these three cases the smaller Cirripede was situated on the inner aspect of the carina in the angle between it and the tergum. All three specimens, as was necessary from the very confined space in which they were living, were quite small, the largest being about three millimetres in length ; in spite of their small size all three were well developed and were hermaphrodite or at any rate agreed in their structure with the normal hermaphrodite individual of the species. Hoek (1907, p. 39) has recorded the discovery of a new species of *Alepas*, namely *A. lithotryae*, on two species of *Lithotrya*, namely on *L. nicobarica* and *L. pacifica*, while a small example of the same genus, that, though too small

to identify, was in all probability of the same species, was found on an example of *L. truncata ;* in the present series, however, no examples of this species were discovered.

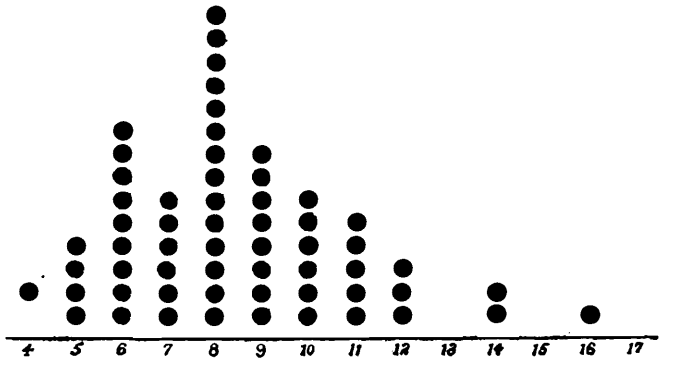
THE INDIVIDUAL VALVES.

The Scutum (Pl. XV, fig. 3).

The scutum in *Lithotrya cauta, L. dorsalis, L. pacifica* and *L. nicobarica* exhibits but little difference. In every case the valve is triangular in outline ; internally it is concave and the tergal margin is straight, as in *L. dorsalis*, or slightly sinuous, as in *L. nicobarica*. The degree to which the valve overlaps the tergum is small, usually not exceeding one-third of the latter valve, except in the case of *L. cauta*, in which species, according to Darwin (1851, p. 357), the degree of overlap is somewhat greater. In Plate XV, fig. 3 I have given photographs of the internal aspect of the scutum in four individuals of *L. nicobarica*. It will be noticed that in the left-hand individual there is no trace of any pit for the attachment of the adductor muscle, although this is well seen in the other three specimens ; *L. cauta* is also said to differ from all other species of *Lithotrya* in this particular respect, namely, the absence of an adductor pit. The degree to which the scutum overlaps the tergum, as indicated by the rough area on the right of the valve-margin in the figures given, exhibits a considerable range of variation, as also does the shape of the valve itself ; and it would, therefore, appear that these features are not reliable as diagnostic characters. The rostral angle of the valve is thickened and in the larger specimens forms a well-marked knob, exactly similar to that described as being present in *L. dorsalis*, so that in respect of these two species there is apparently no distinguishing character in the valve. As regards *L. cauta*, such differences as do exist are for the most part slight, and the fact that those specimens of *L. nicobarica*, which most closely resemble it, are the very smallest, appears to me to indicate that the differences are in all probability due to immaturity in the only known example of this species. Darwin himself considered that this example was mature ; the size of the specimen is, however, very small, being only 5·0 mm. in total length ; it is much smaller than those examples of *L. nicobarica* that I believe to be one year old and I am of opinion that most of its so-called specific characters are not only due to, but are actual evidences of immaturity.

As I have already mentioned, the number of laminae in this valve exhibits a wide range of variation, and may be as low as four or as high as sixteen on the right side of the body, or as low as five and as high as fourteen on the left side ; the average number on the two sides is 8·57 on the right and 9·05 on the left, the total number of specimens examined being sixty. The number of laminae in each valve is shown in Table 2. It will be seen that on both sides of the body there is a distinct tendency for the number of laminae present to exhibit two maxima, on the right side the greater number of specimens have either six or eight, and on the left side seven or nine laminae. This tendency towards a double

maximum may be due merely to an insufficient number of specimens but, as will appear later, the same or a similar tendency can be traced



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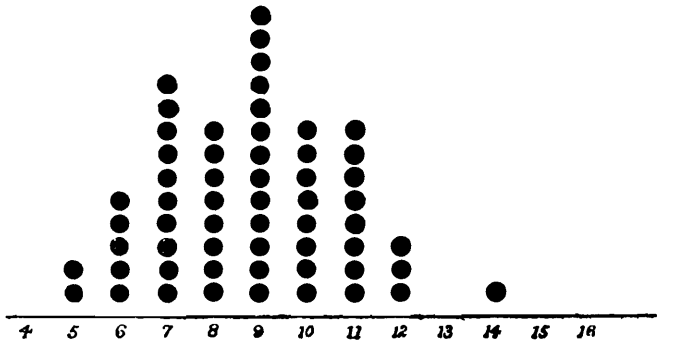


Left side

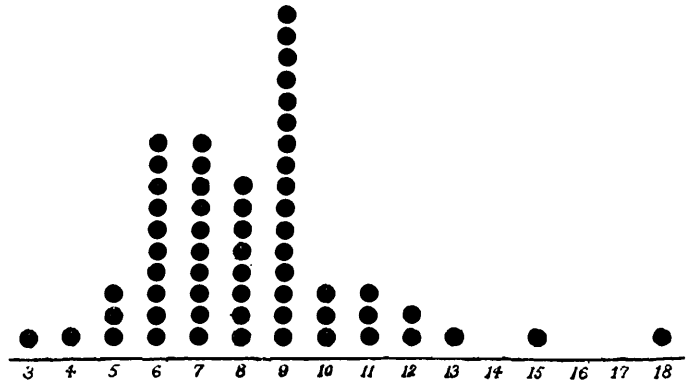
Table 2.— Showing the number of laminae in the Scutum in **Lithotrya nicobarica**.

in the other valves and I am therefore inclined to think that there is a definite cause for it.

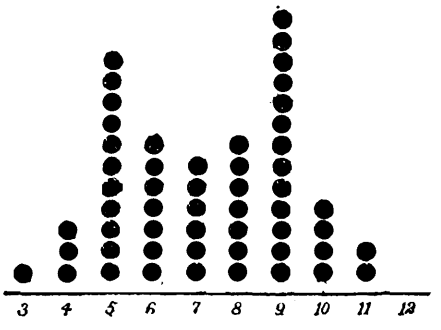
The Tergum (Pl. XV, fig. 1).

The terga in *Lithotrya dorsalis*, *L. cauta*, *L. conica*, *L. pacifica* and *L. nicobarica* exhibit but little specific variation in shape. With the exception of *L. dorsalis*, in which the valve is described by Darwin (1851, p. 352) as being " irregularly oval," the tergum is said to approach to a rhomboidal shape. In both *L. dorsalis* and *L. nicobarica* the scutal and carinal margins meet at an angle of 45 degrees and in all the species the carinal margin is slightly sinuous, the upper part being convex and the lower portion concave. In every case the exposed outer portion of the valve is narrow at the base, *i.e.*, just above the peduncular margin, but widens out somewhat distally ; and across this narrow area runs a series of short ridges, each marking the edge of a lamina. The crest thus formed by the ridges divides the outer surface of the valve into carinal and scutal portions ; in *L. cauta* these are stated to be of nearly equal width, whereas in all other species the scutal area is the smaller, being only about one-third of the total surface. In all my examples of *L. nicobarica*, of whatever size, the scutal area is the smaller; this character does not appear to be merely an age change, though, since the smallest examples of *L. nicobarica* are already much larger than *L. cauta*, it is possible that it is so. In Table 3 I have given the numbers of the laminae

in the terga of sixty specimens of *Lithotrya nicobarica*. As in the case of the scutum we see that the number of laminae exhibits a distinct



Left side



Right side.

Table 3. — *Showing the number of laminae in the Tergum in* Lithotrya nicobarica.

tendency towards two maxima, namely between six and seven (6·5) and nine on the left side, and at five and nine on the right.

The average number of laminae present in the valve is 7·8 but in different examples the number may vary from 3 to 18, so that the height of the valve can have but little value as a diagnostic character. Here again we find a distinct tendency towards asymmetry, for on the left side the average number of laminae is 8·4, whereas on the right side it is only 7·2 : the range of variation in the number of laminae is also greater on the right side, from 3 to 18, than on the left, from 3 to 11 only.

The Carina (Pl. XV, fig. 4).

The carina is usually described as being concave on its inner aspect and having a slight internal crest running down its long axis. The crest is formed by the projecting apices of each succeeding lamina or zone of growth. Here again one finds a high degree of variation. The median crest may consist merely of an inconspicuous line of small papillae, or may be a strong ridge occupying nearly one-third of the breadth of the valve. This latter condition corresponds very closely with the condition described and figured by Borradaile (1900, p. 798, pl. LI, fig. 3*a*.) in *Lithotrya pacifica*, " the carina long, rather narrow, curved somewhat strongly, inside hollow with, in the upper part, a middle row of triangular

knobs corresponding to the external ridges." In the smallest examples of *Lithotrya nicobarica* the carina is concave on its inner aspect and bears a linear row of small bosses, similar to but not so well marked as in the first of the series shown on the left hand in fig. 4. In *Lithotrya cauta* there is, according to Darwin (1851, p. 357), no trace of a central ridge in the upper portion. It would seem probable that the development of this ridge is again merely a question of age, being absent in the very young and gradually becoming more marked as age advances. The height of the carina in proportion to the other valves depends entirely on the number of laminae that remain attached to the valve ; as I have already remarked this may vary from four to sixteen ; in the following Table 4 I have given the various numbers found in sixty specimens :

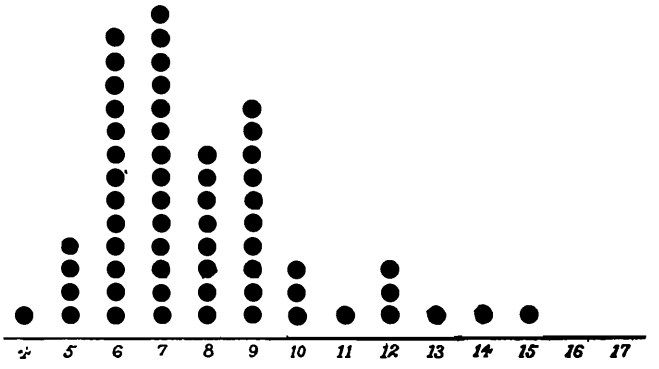


Table 4.—Showing the number of laminae in the Carina of Lithotrya nicobarica.

It will again be noticed that the number of laminae exhibits two maxima, at 6·5 and 9 respectively. In some examples the carina is straight (*vide* Pl. XIV, figs. 6, 8 and 9) whereas in others it may be slightly or even strongly curved (*vide* Pl. XIV, figs. 1 and 5).

The Latus (Pl. XV, fig. 2).

The latera in *Lithotrya nicobarica* according to Darwin (1851, p. 361), " as seen on their interior surfaces, (or in a section parallel to their zones of growth) are triangular, elongated transversely, with the carinal angle a right angle." In *L. dorsalis* these valves (*vide* Darwin, 1851, p. 353) are described as being " narrow, elliptical, pointed at both ends, but the carinal half rather thicker than the scutal half " and in *L. cauta* (*loc. cit.*, p. 357 and pl. VII, fig. 3*c*) as " broadly elliptic, pointed at both ends." In *Lithotrya nicobarica* the latera are described by Gruvel (1905, p. 99) as follows ; " Plaques latérales peu développées en hauteur avec leur surface interne triangulaire et environ aussi large que sept des écailles sous-jacentes." Darwin, however, in his account states that they are " unusually large." Hoek (1907, p. 123), who was able to examine the fairly large series of examples of this species obtained by the " Siboga," remarks that " the latera vary greatly in the different specimens. Their general shape is as described by Darwin, triangular, elongated transversely with the carinal angle a right angle ; but they are much broader in some, narrower in other specimens." He also found

that the length varied enormously and that in sixteen specimens the number of zones of growth was as follows :—

	Zones.
In 6 examples	3
„ 4 „	4
„ 3 „	5
„ 2 „	7
„ 1 example .	8
Average	4·4

In the examples of *L. nicobarica* that I have examined these small valves exhibit a wide range of variation in the shape of the inner surface, being narrow and elongate in some and broadly triangular in others, with all shades of variation between these two extremes. The latera are almost exactly similar as regards their form in *Lithotrya nicobarica*, *L. cauta*, *L. dorsalis*, *L. conica* and *L. pacifica* and it is clear that this valve gives us no assistance in the specific determination of the various species in the genus. The height of this valve, also, varies greatly according to the number of laminae of which it is composed, which in my examples ranges from 1 to 10, the average being 5·2.

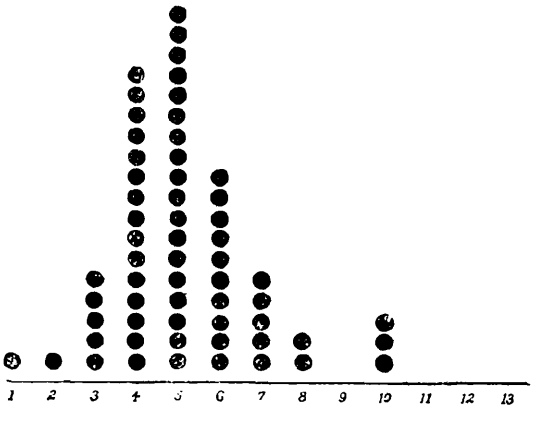


Table 5.—Showing the number of laminae in the Latera in Lithotrya nicobarica.

Another character that is frequently utilised in the diagnosis of the various species is the width of certain of the valves in comparison with the number of underlying scales of the peduncle. In his account of *L. pacifica* Borradaile (1900, p. 798) states that the latera are " very long, more than three-fourths the length of the terga, the base of each of them marching with seven of the underlying scales." In his figure, however, he shows five scales actually in contact with the latera and two in the interspace between it and the scutum. There appears to be a certain amount of confusion in the literature regarding the number of scales in contact with this valve ; in certain cases previous authors, as well as Borradaile, appear to have included in their total not only those scales that are actually in contact with the valve but also those that lie below the narrow gap between the latera and the scutum, in which the tergum appears on the surface. In my examples of *L. nicobarica* the number of scales that lie beneath the latus and tergum, that is beneath the latus and the gap between it and the scutum vary from 6 to 11.

There are 6 scales present in 19 %
" " 7 " " " 39 %
" " 8 " " " 26 %
" " 9 " " " 11 %
" " 10 " " " 4 %
" " 11 " " " 1 %

There are usually five scales underlying, and in actual contact with, the latera, the actual numbers ranging from 3 to 8 and the average being 5·26.

The majority of these examples thus show seven scales, which agrees with the description of *L. pacifica* and *L. nicobarica*. Hoek on the other hand states (1907, p. 127) that in the two examples of what he took to be *L. pacifica* the latera correspond to 4 (indistinctly 5) of the underlying scales. This is shown in his figure to be correct, if one considers only those scales that are actually in contact with the latera but if we include also those that are in contact with the tergum, the number is 7 and Hoek's figure and that given by Borradaile agree exactly in this particular.

The Rostrum.

The rostrum varies enormously in the length to which it may attain, this, of course, depending on the number of scales or laminae that have been worn off. In my examples the number present ranges from 2 to 9, the average of sixty examples being 4·6,and the majority of examples—30 per cent.—having 5. Hoek (1907, p. 123) in eighteen specimens found from 2 to 7 zones of growth, the average being 3·55 and the majority of his examples—55·5 per cent.—had three only.

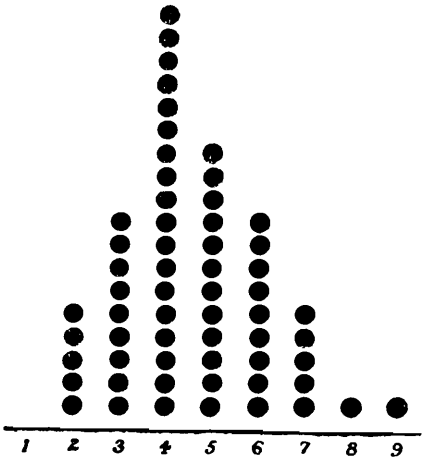


Table 6.—showing the number of laminae in the Rostrum in Lithotrya nicobarica.

Between the different species there is but little difference as regards the general characters of this valve ; in all cases it is small and delicate, though it is, apparently, relatively larger in my examples of *Lithotrya nicobarica* than in *L. cauta*, for its width in this latter species is stated to be " not so wide as the immediately subjacent scale " (Darwin, 1851, p. 357). In the smallest examples of my series of *L. nicobarica* it was equal to two scales ; but, if we examine these sixty specimens carefully,

it is found that there is a distinct tendency for the number of the peduncular scales, that lie beneath the rostrum, to vary according to the size of the specimen. In Table 7 I have given the results of an examination of the different individuals in each of the four groups.

In the 1st year group (breadth 3—3·5 mm.) there are 2·5 scales.

„	2nd	„	„	„	5—6 mm.	„	„	4·1 „
„	3rd	„	„	„	6·5—9 mm.	„	„	5·3 „
„	4th	„	„	„	10—11 mm.	„	„	5·5 „

It is thus probable that the narrow condition of the valve in *L. cauta* is merely a sign of immaturity.

The number of subjacent scales below the rostrum shows a wide range of variation in the different so-called species. In *Lithotrya dorsalis* Darwin gives the number as 2·5, Gruvel as 2 or 3. In *L. conica*, according to Hoek, there were 3 in one example and 4 in another. *L. pacifica* is stated to have 6; and in *L. nicobarica* Darwin states that there are 6; Gruvel gives 6; Hoek, in eighteen examples, found from 3 to 8, the average being 5·4; and in the sixty specimens examined by me the number ranges from 3 to 8, the average being 5 (in 35 per cent.).

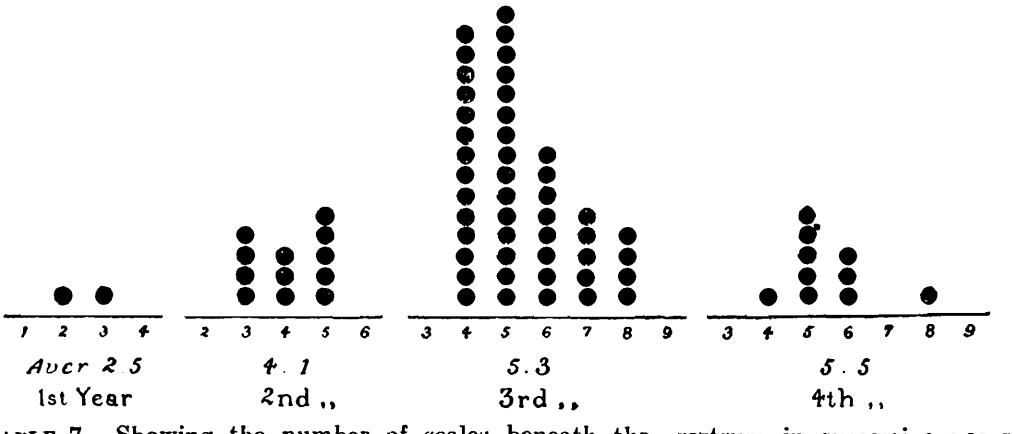


Table 7.—Showing the number of scales beneath the rostrum in successive years of growth in *Lithotrya nicobarica*.

It is clear from the above table that the scales on the upper part of the peduncle do not increase in size at the same rate as the valves themselves and in consequence the number of scales that lie beneath any of the valves increases as size and age advance. The smallest group, *i.e.*, those having a breadth of 3 to 3·5 mm. and which I take to be the 1st year, agrees closely with *L. dorsalis*. The next group, or those of the second year, agrees with *L. conica*. And it is only the two larger groups, corresponding to the third and fourth years, that agree with the condition said to be characteristic of *L. pacifica* and *L. nicobarica*. Hoek himself (1907, p. 126) remarks that "the specimens of *L. conica* are smaller than most of *L. nicobarica* and it seems probable that they were merely young examples," though he does not definitely adopt this view. If this change with age is due to unequal rates of development of the valves and of the small calcareous scales of the peduncle, we ought to find that the same or a similar change in the numbers of subjacent scales can be traced in the other valves. In the case of the

scales corresponding to the latera, we find that the number at different ages, or at least at different sizes, is as follows :—

In the 1st year group there are 4·5 scales below the latera.
,, 2nd ,, ,, ,, ,, 4·8 ,, ,, ,, ,,
,, 3rd ,, ,, ,, ,, 5·2 ,, ,, ,, ,,
,, 4th ,, ,, ,, ,, 5·9 ,, ,, ,, ,,

or if we take the number corresponding to both latera and terga together we get

In the 1st year	6·0 scales
,, 2nd ,,	7·1 ,,
,, 3rd ,,	7·4 ,,
,, 4th ,,	8·4 ,,

In both cases, then, there is a distinct increase in the number of subjacent peduncular scales, and there can be no doubt that this is due to unequal rates of growth of the different calcareous structures and is not in any sense a specific character.

It is interesting to note that there is in the present series of *Lithotrya nicobarica* a slight though distinct tendency towards " right-handedness," inasmuch as the earlier formed laminae exhibit a tendency to be rubbed off more easily, or at least more quickly, on the right side of the body than on the left. This tendency is not confined to any one valve, as is shown in the following table :—

	Average No. of Zones.		
	Right side.	Left side.	Difference L.—R.
Latus	5·12	5·00	—0·12
Scutum	8·64	9·22	+0·58
Tergum	7·20	8·05	+0·85

The above figures are derived from the examination of sixty specimens and it is clear that there is but little difference in the two sides of the body as regards the latera, but it must be remembered that these valves are small and are easily damaged and, moreover, are situated at the most exposed points, namely at the ends of the transverse diameter. In the other two valves, the scutum and tergum, there is a quite distinct difference, the average number of scales or laminae in the scutum being 0·58 higher on the left side than on the right, and in the tergum the difference is as great as 0·85.

GENERAL COLOURATION.

Darwin (1851, p. 354) remarks that the " valves are coloured dirty white, with the enveloping membrane, when preserved, yellow. The outer maxillae, palpi, pedicels of the cirri, anterior faces of the segments, dorsal tufts, caudal appendages and penis, dark purple. Thoracic segments brown. There is a purple spot between the bases of the first pair of cirri."

In the examples of *Lithotrya nicobarica* that I have examined the peduncle is as a rule of a yellow colour, though in some of the specimens the yellow is interrupted by a patchy staining of dark purple or black colour. The valves are in all cases dirty yellow, but this is often obscured by a superficial deposit of calcareous material, which may form a complete covering to the outer aspect of the oldest lamina and in certain individuals has attained a considerable thickness; similarly a mass of the same material may be deposited in the grooves between the various laminae. Where they still persist the outer chitinous membrane and the microscopic teeth on the margins of the laminae are of a dark brown colour.

In the smaller examples the mouth parts are well pigmented with closely-set, black chromatophores, and there is a well-marked black spot on the ventral surface of the body between the posterior margin of the mouth and the bases of the first pair of cirri. Each ventral sternite is in the full-grown examples heavily pigmented and so is the dorsal aspect of the last two segments of the body. The penis is of a dark purple colour. The cirri themselves are heavily pigmented; in the pedicels the pigmentation is deepest in the distal half of the segments and along two bands down the outer aspect of the first free joint, of which the posterior band corresponds to the outer border of the elongate, scaly area noted below (*vide infra*, p. 291). The degree of pigmentation in the rami gradually decreases distally; the proximal segments of the ramus, and especially of the outer ramus, are heavily pigmented along both anterior and posterior surface and across the distal margin, but the distal segments are comparatively free from pigment except on the anterior aspect. As the age or size of the examples increases the degree of pigmentation appears to diminish, possibly because the total number of chromatophores does not increase *pari passu* with the surface area of the body or of the appendages.

THE PEDUNCLE.

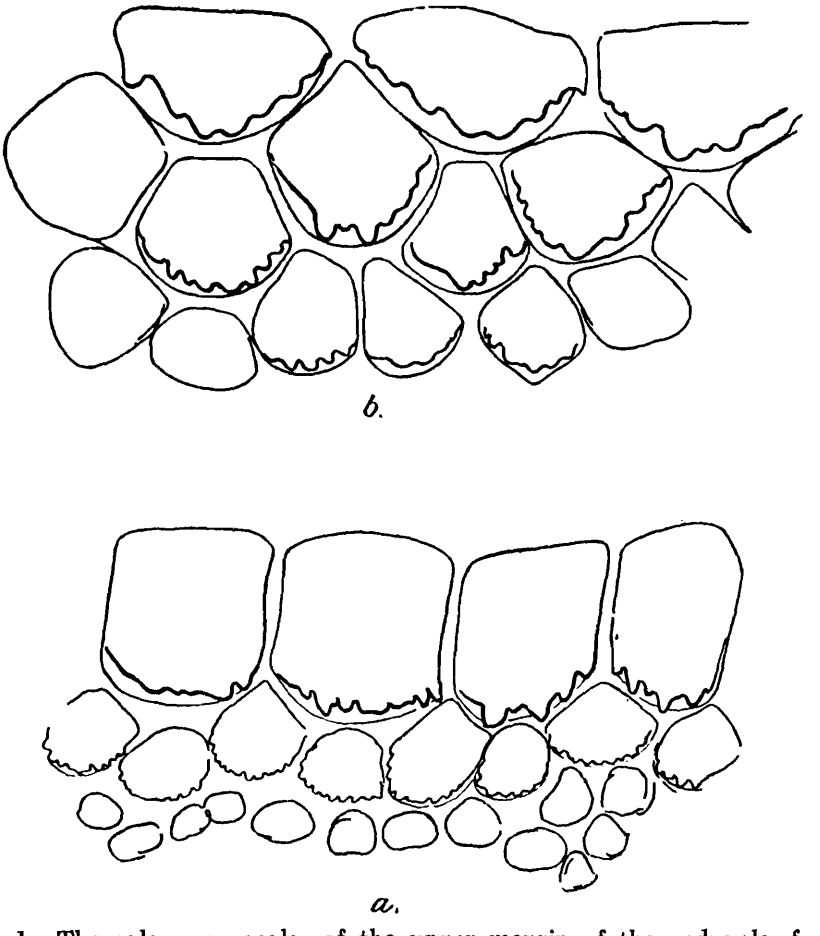
The peduncle, owing to its great power of contraction, varies enormously in shape from a short and almost conical to an elongate and cylindrical type. The whole peduncle is furnished with a chitinous covering, in which are embedded numerous chitinous nail-like bodies, the head of each nail being originally enclosed in a small calcareous bead. The size of these beads rapidly decreases as one passes down the peduncle. Darwin (1851, p. 337 and Pl. VIII, fig. 3*e*) has given an account of and has figured these nail-like structures in the species *Lithotrya cauta*. In the examples of *Lithotrya nicobarica* that I have examined, identical structures can easily be detected in the lower part of the peduncle, especially if the chitinous sheath be stripped off the under-lying muscular layer and be treated with acid alcohol, which will dissolve away the calcareous beads that surround the chitinous nails. Each nail bears a head that is flat and is produced in a number of small points that give to it a star shape. Darwin states that in *L. cauta* and *L. dorsalis* these are usually five-pointed; but he remarks (1851, p. 337) that "in *L. cauta* the lowest scales on the peduncle are a little larger than in *L. dorsalis*, giving a frosted appearance to it, and all of them are serrated

around their entire margin." In the specimens of *L. nicobarica*, that I have examined, they vary from triangular to seven-pointed stars in the lowest part of the peduncle, while further up the stem they become oval or rounded with a crenated margin. In numerous cases the basal or sunken part of the nail can be seen to end in a narrow winding tail of chitin, that undoubtedly corresponds to the duct and in some cases appears at its inner or deep end to be double.

There is a considerable degree of difference in the size and arrangement of the calcareous scales in the upper part of the peduncle and especially in the upper two or three rows, *i.e.*, in the rows around the base of the capitellum. This difference in the characters of the scales of these rows has been utilised as a diagnostic character in the determination of the various species. In *L. dorsalis*, Darwin remarks, " the calcified scales in the uppermost whorl are only slightly larger than those in the second whorl ; the scales in the succeeding three or four whorls are considerably larger than those below." In *L. cauta* the scales of the uppermost row are said to be " quadrilateral and nearly four times as large as those in the second whorl ; these latter are about twice as large as those in the third whorl." In *Lithotrya nicobarica* the scales are said (*vide* Darwin, 1851, p. 361) to vary from circular to quadrilateral and those of the upper row to be three times as large as the second, while in the next three or four rows the scales rapidly decrease in size.

If these differences were constant they would form a reliable basis on which to found specific distinctions and it is necessary therefore to examine these characters in some detail. In a series of *L. nicobarica* I find that there is a wide range of variation both in the character of the scales from the same part of the peduncle in different individuals as well as in different parts of the peduncle in the same individual. An examination of a number of individuals shows that the scales of the upper three or four whorls on the peduncle exhibit marked differences in different areas in the same individual. In the region below the carina the scales of the upper two whorls are almost exactly equal in size, while those of the third whorl are only slightly smaller than those above, but are markedly larger than those in the whorls immediately below. In this area then the character of the scales exactly agrees with the condition that is said to be characteristic of *L. dorsalis*. In the region below the latus and scutum the scales of the uppermost whorl are quadrilateral and are at least three times as large as those in the second whorl, which are in turn twice as large as those in the third row ; in this area therefore the character of the scales corresponds to that of *L. cauta*. In a series of individuals we also find an extreme range of variation in the scales from the same part of the circumference in different individuals. The proportional size of the scales of the first and second whorls varies very considerably, and there is an appreciable degree of variation in individuals of the same size, but a study of a number of examples seems to me to indicate that there is also a change in the relative proportions of the scales in the different whorls with increasing size and, therefore, presumably with increasing age. In examples of the smallest size, *viz.*, those with a diameter of only 3·5 mm., the scales of the second row are very much smaller than those of the first row, the proportions

being approximately 1 to 4, which agrees exactly with the description and figures given by Darwin of *L. cauta ;* the upper scales have attendency to be rhomboidal in shape. In other examples, ranging from 5·5



TEXT-FIG. 1. The calcareous scales of the upper margin of the peduncle, from below the latus and scutum:
(*a*) in a medium sized example, 6·5 mm. in breadth.
(*b*) in a large specimen, 9·5 mm. in breadth.

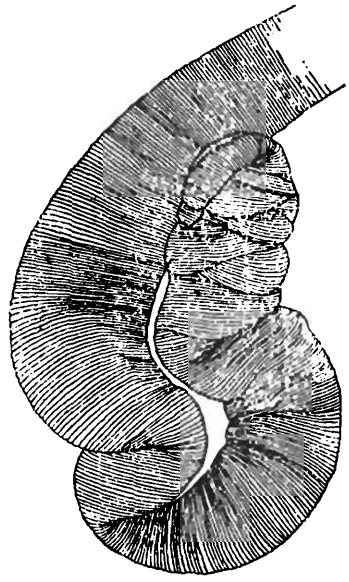
mm. to 8·5 mm. in breadth, the scales of the second row are somewhat larger and the proportional sizes of the scales of the two rows is still 1 to 4, while the upper scales are square or nearly so (*vide* Text-fig. 1 (*a*)). In the largest examples of all, namely, those having a breadth of 8·0 mm. to 9·5 mm., the second row of scales have markedly increased in size and are now almost as large as those of the first whorl, the proportions now being those said to be characteristic of *L. dorsalis*, while the upper scales are rectangular or oval with their long axis transverse (*vide* Text-fig. 1 (*b*)). It appears then that a given individual may so far as this character, at least, is concerned commence as *L. cauta* and develop into *L. dorsalis*, and that the character of the scales of the peduncle in the so-called species of *Lithotrya* may be perfectly well accounted for on the grounds of age alone and has therefore no specific value.

The peduncle bears on the carinal margin and a little above its extreme tip the calcareous basal plate by means of which the animal attaches itself to the inner wall of its burrow. In *L. nicobarica* this calcareous plate of attachment is said to be slightly concave in shape

and of moderate size, whereas in *L. dorsalis* it is cup-shaped and considerably larger. In the specimens of *L. nicobarica* that I have examined the size of this plate varies very considerably and in some it is almost flat, in others deeply concave, though I have not found one that is cup-shaped : the largest example measured a little over 3/10th of an inch. In most cases a row of overlapping calcareous discs or their remains can be traced down the side of the burrow.

The upper portion of the peduncle is hollow (*vide* Pl. XV, fig. 5) and is lined with a delicate layer of chitin that is continuous at the point of attachment of the body with the chitinous covering of the body itself, while laterally it is continued up on the inner side of the mantle, from which, however, it is separated by a space, to become continuous with the margin of the valves. Owing to the formation of this hollow cavity in the upper part of the stalk, brought about by the extreme degree of contractility possessed by the peduncle and the consequent necessity of a space to accommodate the body during retraction, the ovary has become displaced and lies close to the region of attachment of the peduncle, between the two lateral masses of the longitudinal retractor muscles. The peduncular muscles are usually described as consisting in the Lepadidae of three layers, namely, (1) oblique, (2) transverse and (3) longitudinal, from without inwards, and *Lithotrya* appears to be no exception to this. In *Lithotrya nicobarica* the oblique layer is by far the least developed ; it consists of a series of separate bundles, each bundle being composed of two or three fibres, separated by wide intervals. The transverse layer is well developed. The longitudinal muscles are arranged in two series, the fibres of which are also distinguished by a difference in size. Along the carinal arc of the peduncular circumference, and immediately internal to the layer of transverse muscle fibres, is a layer of small, longitudinally arranged muscles-fibres : inside this layer, there is a second series of longitudinal muscles, the fibres of which are larger and are grouped together into distinct bundles or bands. The number of these muscle-bands may differ on the two sides of the body, as was the case in the smaller specimen examined, which had a capitellar diameter of 3·5 mm. They were numerous on the right side but on the left side these bundles were for the most part absent and immediately internal to the layer of small longitudinal fibres were several spaces, in one of which was situated the " tige pedonculaire " or chitinous supporting rod. Koehler, who described this organ in the peduncle of *Pollicipes*, shows it as being present on both sides of the body near the canal that runs along the rostral margin. Gruvel (1905, p. 378) states that " On retrouve cette formation, plus ou moins modifiée, chez *Lepas, Scalpellum, Lithotrya, Ibla.* il est certain que c'est un organe en voie de régression, autrefois trés développé et aujourd'hui seulement représenté chez les formes qui se rapprochent le plus des types ancestraux, comme les *Turrilepas, Loricula*, etc." This cartilaginous support appears to consist of a delicate rod of chitin that passes down the peduncle in one of the spaces, noted above, immediately internal to the layer of small longitudinal fibres and at a point about midway between the anterior and posterior margins ; at its lower extremity this rod is rounded and recurved (*vide* Text-fig. 2) and the free

end is again recurved and is directed downwards; though this coiled portion is covered by numerous muscle-fibres I was unable to detect any direct connection with the muscle system. At the upper end however,



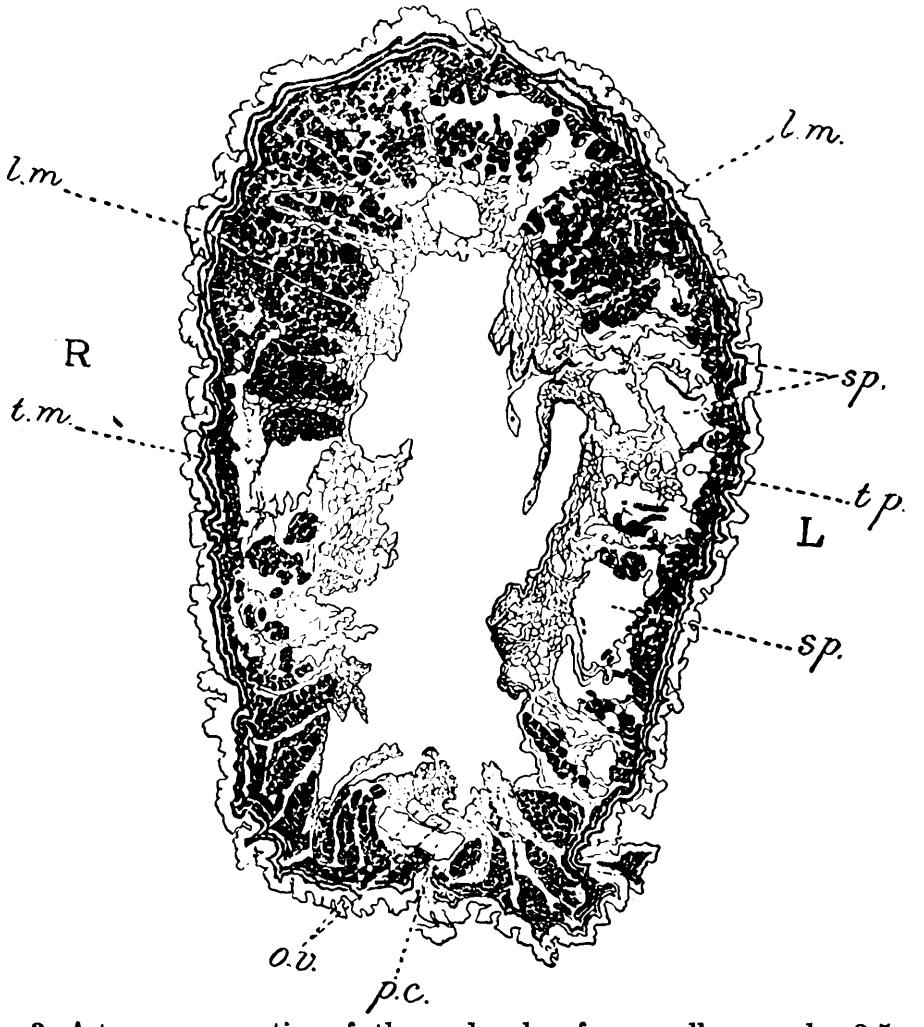
TEXT-FIG. 2. The lower portion of the cartilaginous supporting rod, or "tige pedonculaire," in the peduncle of *Lithotrya nicobarica*.

the rod appears to be connected with the longitudinal muscles. A study of the serial sections cut of the peduncle of the small example of *Lithotrya nicobarica* (*vide* Text-fig. 3) reveals the very interesting fact that, at any rate in this specimen, there was only a single "tige pedonculaire" present, which was on the left side; and a further study of these sections shows that this marked asymmetry of the peduncle, as regards both the chitinous support and the muscle-bands, agrees with the "right-handedness" that I have already pointed out in the capitellum. The much greater development of the longitudinal peduncular muscles on the right side would certainly seem to be associated with the smaller number of laminae in the paired valves, namely the scutum and tergum, since more violent movement of this side of the body would cause a more rapid removal of the older laminae.

As one traces the strands of the longitudinal muscles downwards from the lower border of the capitellum one sees that they converge and eventually unite to form two large muscle-masses that in the lower part of the stalk pass towards the carinal margin and become attached to the inner aspect of the body-wall underneath the calcareous plate. Darwin (1851, p. 338) has called attention in this genus to the presence of two little fan-shaped muscles that are attached, one on each side, to the basal part of the carina near the central line and converge to a point where the lower margins of the carina and terga touch each other.

As in other pedunculate Cirripedes the peduncle is traversed throughout almost its whole length by the longitudinal peduncular canal, which runs down the rostral side: immediately internal to this and in close apposition to it run the two oviducts, which pass upwards to the body from the ovary, situated at the lower end of the peduncle.

The general structural characters of the muscular and connective tissues appear to agree closely with the description given by Koehler (1888).



TEXT-FIG. 3. A transverse section of the peduncle of a small example, 3·5 mm. in breadth, of *Lithotrya nicobarica*. l.m., longitudinal muscle-bundles ; o. v., oviducts ; p.c., peduncular canal ; sp., lacunae ; t.m., transverse muscle-bundles ; t.p., cartilaginous supporting rod or " tige pedonculaire." R-right side ; L-left side.

THE BODY.

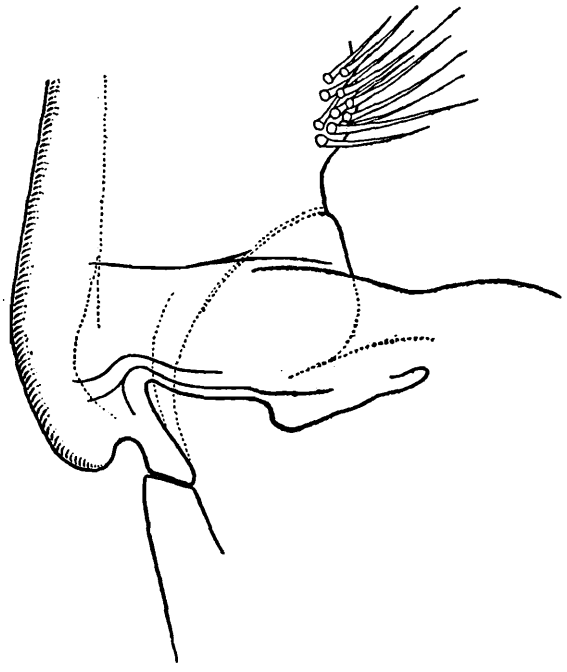
The prosoma is large and appears to vary somewhat in shape. In some examples the (anatomically) dorsal aspect is uniformly rounded, while in others it is more nearly conical, as in Pl. XV, fig. 5. A well-marked adductor muscle runs from side to side between the scuta. The first cirrus is placed at some distance above and in front of the second cirrus. As in other Cirripedes the oviducts open at the lower margin of a rounded swelling, situated at the base of the first segment of the pedicel of the first cirrus. Darwin (1851, p. 53) in his account of the structure of *Lepas* mistook the terminal part of the oviduct and its external opening for an accoustic organ, but the correct interpretation of this structure was pointed out by Gruvel (1905, p. 415). Below and in front of the first cirrus lies a thin-walled sac, the walls of which are in the larger examples of a brown colour, but in the young stages they are almost colourless. This structure I take to be excretory in function. Gruvel (1905, p. 394) has described a pair of sacs, one on each side of the body, in the same situation and he remarks " Ces deux

formations sont les sacs rénaux proprement dits qui peuvent être assimilés aux reins maxillaires des autres Crustacés."

Darwin remarks (1851, p. 355) that in *Lithotrya dorsalis* "on the antero-lateral faces of the pedicels of the second, third and fourth pairs of cirri there is an elongated white swelling or shield. Moreover on the posterior thoracic segments there are similar white-coloured swellings, with the membrane more plainly marked with scales than in other parts." Hansen (1925, p. 50) suggests that these swellings are of the nature of a rudimentary epipod. I can find no mention of such structures in any of the accounts given by previous observers of other species of *Lithotrya* and Darwin appears to have considered that they possessed a diagnostic significance. Exactly similar colourless swellings, however, can clearly be seen in the larger examples of *L. nicobarica*. The swellings on the 2nd, 3rd and 4th pedicels are of an elongate pyriform shape, the narrow end pointing upwards towards the biramous appendages; they increase in size from before backwards and are situated on the antero-lateral aspect of the first free, or second basal, joint of the pedicel. In addition to these three swellings there is an additional small swelling on the basal free segment of the 5th cirrus. This last swelling is much smaller than the other three and I was only able to detect it after the appendage had been cleared with caustic potash. Three similar swellings occur on the lateral aspect of the 2nd, 3rd and 4th segments of the abdomen, and are also oval or pyriform in shape, the anterior being the larger and the posterior quite small. As in *Lithotrya dorsalis* the surface of these swellings is covered with fine scales.

THE CIRRI.

Hansen (1915, p. 48 *et seq.*) has put forward the view that in the Cirripedes the basal part of each cirrus is composed of three segments.



Text-fig. 4. The articulation of the 4th cirrus with the body in *Lithotrya nicobarica* viewed from in front.

He states that in *Balanus porcatus* " all six pairs of legs have the sympod three-jointed ; in the three, and especially in the two, anterior pairs the first joint is considerably longer and broader, the second joint shorter and broader than in the three, especially in the two, posterior pairs." I have carefully studied, in both spirit specimens and in others treated with caustic potash, the structure of the basal parts of the cirri in *Lithotrya nicobarica* and I am quite unable to convince myself that the first or proximal segment has in this species any separate existence, such as Hansen shows in his figure (*loc. cit.*, 1925, Pl. II, figs. 8, *a*). The chitinous covering is thin in certain areas and thicker along certain lines, and in Text-fig. 4 I have given a drawing of the basal part of the anterior aspect of the 4th leg. As is evident, the articulation is complicated and on the anterior surface the chitinous covering of the basal segment of the pedicel is continuous across the front of the sympod with the sternal portion of the body covering. There is a well-marked articulation on the outer aspect between the sympod and the body chitin, but posteriorly the portion that appears to correspond morphologically with the first of the three segments of the sympod is continuous with the sternum, though partially separated from it by an incomplete articulation, and is completely separated from the pedicel by a curved articular line. While admitting the probable correctness of Hansen's view that the sympod consists morphologically of three segments, as a matter of fact the lines of separation of the 1st or proximal part are incomplete both anteriorly and posteriorly.

Both Darwin (1851) and Hoek (1907) have attempted to make use of certain characters of the cirri in the determination of the various species in the genus. One of the characters, on which stress has been laid, is the number of segments in the different cirri and in the caudal appendage ; and a second is the relative length of the latter as compared with the pedicel of the 6th cirrus. In the following Table 8 I have given such details as I have been able to extract from Darwin's and Hoek's papers, and it seems clear that, allowing for a certain degree of individual variation in the different species, there is a steady increase in the number of segments in the cirri as one passes from *Lithotrya cauta* through *L. conica* and *L. dorsalis* to *L. nicobarica*. In exactly the same order we

	1st cirrus.		2nd cirrus.		3rd cirrus.		4th cirrus.		5th cirrus.		6th cirrus.		Caudal appendage.		
	Ant. ramus.	Post ramus.	Ant. ramus.	Post ramus.	Ant. ramus.	Post ramus.	Ant. ramus.	Post ramus.	Ant. ramus.	Post ramus.	Ant ramus.	Post ramus.	No. of segments.	Length of caudal appendage compared with the pedicel of 6th cirrus.	No. of Mandibular teeth.
L. cauta	..	..	8	9	11	12	..	..	..	..	16 o	r 17	7	1⅓ times.	3, 3
L. conica	9	11	15	18	17	20	20	20	21	21	22	22	18	..	12, 7
	11	12	..	..	..	..	..	..	..	..	..	..	..	..	.. 8
L. dorsalis	..	..	15	16	20	20	..	..	..	..	..	..	17	1½	.. ..
	..	..	..	17	..	21	..	..	..	..	..	..	..	times.	15, 7
L. nicobarica	8	12	17	16	22	24	23	23	25	26	23	26	22	..	.. ..
	12	13	..	17	..	..	..	..	..	..	..	..	23	twice.	16, 8
	..	..	..	20	..	..	..	..	..	..	..	..	..	.. ..	20, 10

TABLE 8.—Showing the variation in the number of the segments in the cirri, the No. of segments and the length of the caudal appendage, and the number of denticles between the primary teeth of the mandible, as recorded by previous authors.

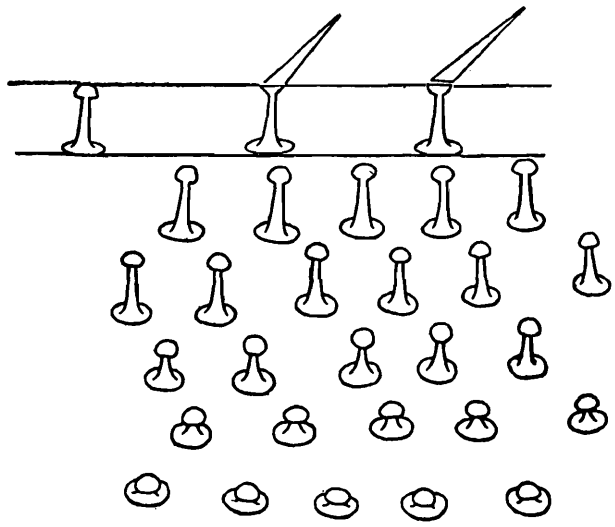
find a steady increase in the number of denticles between the three large teeth in the mandible and in the relative length of the caudal appendage. It is a well-recognised fact that in the Crustacea the number of segments in the appendages steadily increases as age and development advances, and it is therefore open to question how far the differences that have been noted in the above-mentioned characters are truly specific, and not merely due to and evidence of developmental changes in the individual. In this connection it is important to remember that *Lithotrya cauta* is by far the smallest of the so-called species in the genus, having a total length of only 5·0 mm. and a breadth of capitellum of only 1·9 mm., whereas the smallest example of *L. nicobarica* obtained by me already possessed a breadth of 3·0 mm.; and Hoek himself (1907, p. 126) has remarked that "The specimens of *Lithotrya conica* are smaller than most of *L. nicobarica*." It seems more likely that the progressive increase in the number of segments in the cirri and in the size of the specimen are correlated with each other and are evidences of growth than that they are actual specific characters. Darwin himself, however, thought that the single specimen of *Lithotrya cauta*, on which the species is founded, was full grown; he remarks (1851, p. 357) "I do not know whether the specimen had attained full size, but think this is probable, as a larger sized species would not have made its habitation in one of the valves of so small a shell as a *Conia*." This implies the exercise on the part of this example of *Lithotrya* of a degree of conscious selection of habitat that can hardly be justified, and I think that it is much more likely that the specimen was only able to occupy such a restricted habitat because of its small size and that at a later stage it would have outgrown the *Conia* shell and have fallen a prey to its natural enemies. I believe the species to be founded on a small and immature example and that many of its so-called specific characters are due to its immaturity.

In order to determine to what extent these differences in structure can be explained and accounted for by differences of age I have examined a series of eleven individuals of *Lithotrya nicobarica*, that to judge from their size belong to four different years of age, and the results are given below.

1ST CIRRUS.

This cirrus is, as I have noted above, placed, at some distance from the second cirrus. The first segment of the pedicel is elongate and bears on its anterior aspect at the distal end a small group of long spines, which appear to arise in two series, while a few smaller spines are to be found between the paired ones. At the distal part of the outer aspect of this segment is a small group of long and delicate spines; in subsequent stages of development these spines appear to be replaced by shorter and stouter spines. The anterior and inner aspect of the proximal part of the first free joint of the pedicel is perforated by a number of small pores that appear to pass through the thickened chitin, and a similar but smaller series of perforations can be found on the inner aspect of the joint near the distal end and internal to the series of long spines that fringe the segment in its distal region. As I shall have occasion to mention later, when describing the other cirri, similar perforations occur on all the cirri and in every case the perforation appears to be

stud-shaped with a wide inner aperture (*vide* Text-fig. 5); the canal narrows somewhat as the external surface is approached and then again widens out at the exterior end, though the aperture of the exit is smaller than that



TEXT-FIG. 5. A portion of the chitinous exoskeleton of the first free joint of the pedicel of the 1st cirrus, showing the pores, highly magnified.

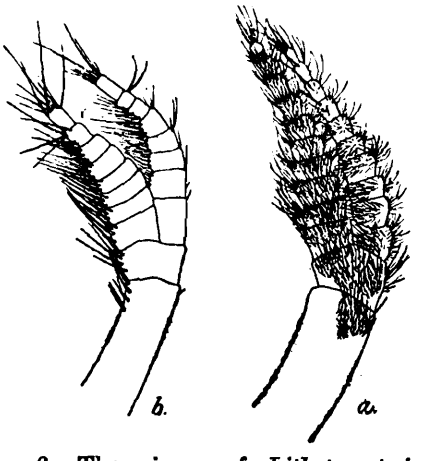
of the inner entrance. In the untreated individual each aperture appears to be covered by a minute sharp spine, but these are usually lost in examples that have been treated with caustic potash. With the exception of these spinules the external surface of the chitinous covering is smooth and is not, as in the posterior cirri, covered with small spiny scales. The second segment of the pedicel is short and broad and bears a thick clump of long spines on its anterior aspect. In all stages of development the rami are short. The distal end of each free segment in the rami is armed posteriorly with a group of spines of two sizes, long and short. The long spines are of varying length on the different segments, those on the 2nd and 3rd segments reaching to the middle of the next segment but one, while those of the distal segments are considerably shorter and only reach to or even fall short of the end of the next segment. The posterior surface of the swollen proximal segments also bears a few scattered spinules.

Breadth of example, 3·5 mm.

(Text-fig. 6 (*b*).)

At this stage of development each ramus consists of eight segments. The outer or anterior ramus is broader and stouter than the inner and posterior, and is slightly shorter; in it the first or proximal segment is equal in length to the succeeding two and is incompletely divided into two. The proximal six segments are thickly clad with long doubly-serrated spines, while the two distal segments bear comparatively few spines, these, however, are considerably longer than those on the basal segments and their length in proportion to the total length of the ramus is 24 : 50. In the inner ramus the proximal five segments are somewhat swollen, though to a less degree than the corresponding segments in the outer ramus. The three distal segments bear comparatively few, long,

needle-like spines, that are also doubly-serrated and have a length, in proportion to the whole ramus, of 16 : 50.



TEXT-FIG. 6. The cirrus of *Lithotrya nicobarica*—
(*a*) from a specimen measuring 8·5 mm. in breadth × 10.
(*b*) from a specimen measuring 3·5 mm. in breadth × 23.

Breadth of example, 5·0 mm.

In this stage the anterior ramus consists of 8 segments and the posterior of 10 segments.

The anterior ramus is broader than the posterior and the terminal three segments are armed with long spines, the proportional length of which in comparison with the length of the whole ramus is, however, only 28 : 73. The proximal five segments are all armed with close-set bristles.

In the posterior ramus the distal four segments are armed with comparatively few spines.

Breadth of example, 8·5 mm.

(Text-fig. 6 (*a*).)

The anterior and posterior rami in this example are each composed of 10 segments.

In the anterior ramus the basal six segments are thickly clad with spines, and the terminal segments bear long spines that have, in proportion to the whole ramus, a length of 39 : 115.

In the posterior ramus the basal five segments are thickly clad with spines, while the distal segments bear only a comparatively few longer spines.

Breadth of example, 10·0 mm.

Both rami now consist of 12 segments.

In the anterior ramus the basal seven segments are thickly clad and the terminal segments bear long spines that have a length in proportion to the whole ramus of 44 : 145.

In the posterior ramus the basal six segments are thickly clad with spines.

It is thus clear that the number of segments that are swollen and are thickly clad with spines remains, on the whole, fairly constant, while the distal, more slender and sparsely-spined segments show a steady

increase as the size and presumably the age of the specimen increases. The results found at each stage of development are given in the following Table 9 :

Size of example.	Anterior ramus.		Posterior ramus.	
	Thickly clad basal segments.	Sparsely clad distal segments.	Thickly clad basal segments.	Sparsely clad distal segments.
3·5 mm.	6	2	5	3
5·0 mm.	5	3	6	4
8·5 mm.	6	4	5	5
10·0 mm.	7	5	6	6

TABLE 9 : showing the number of segments in the two rami of the 1st cirrus at different stages of development.

The proportional length of the terminal spines of the distal segments of the two rami in comparison with the length of the whole ramus shows a steady decrease as age or size advances, as is clearly seen in the Table 10 below :

Size of example.	Length of ramus.	Length of terminal spines.	Proportional lengths.
3·5 mm.	50	24	2·1 : 1
5·0 mm.	73	28	2·6 : 1
8·5 mm.	115	38	3·0 : 1
10·0 mm.	145	44	3·3 : 1

TABLE 10 : showing the proportional lengths of the end spines and the whole ramus in examples of different sizes.

The condition found in the smallest example approximates to the description given by Darwin of the structure of the 1st cirrus in *Lithotrya cauta*, in which the anterior ramus is thicker and shorter and " all the segments thickly paved with bristles, except the two terminal segments, of which the ultimate one bears some serrated spines of most unusual length, namely, equalling within one segment the entire length of the ramus." The smallest examples in the present collection are considerably larger than Darwin's example of *Lithotrya cauta* and the terminal spines are not so long, but this is in clear agreement with the steadily diminishing length of the spines in the successive stages of growth.

2ND CIRRUS.

The basal or first free segment of the pedicel bears on its outer aspect an elongate area in which the chitinous covering is made up of a number of small scales (*vide supra*, p. 291). At all stages of development the two segments of the pedicel are armed along their anterior margins with numerous long spines. The posterior aspect of the distal end of the

basal joint is armed with numerous small pointed scales and the whole posterior surface is perforated with numerous small pores (*vide supra*, p. 294) as also is the case in the 2nd segment. Each perforation in the spirit specimen appears to be crowned with a small spine, but in examples that have been treated with caustic potash most of these have dropped off and are lost. A similar series of perforations occur over an area on the inner aspect of the 1st pedicel, posterior to the area of attachment of the long doubly-serrated spines.

Breadth of example, 3·5 mm.

(Text-fig. 7 (*b*).)

The anterior ramus consists of 11 segments. This appendage is thicker and somewhat shorter than the posterior branch. The basal 5 segments are broad and are provided with numerous spines ; the distal segments are armed with three pairs of long spines and between these arise two or three shorter spines in a linear series. The penultimate segment bears only 2 pairs of spines. The length of the terminal spines in proportion to the length of the last segment is 17 to 8·5. The distal border of each segment is armed posteriorly with a row or group of spines of varying sizes ; in the last two segments some of these are long and reach beyond the distal end of the next segment. The segments also bear a row of small needle-like spinules on the distal margin of the lateral surface and 1 or 2 larger spines at the antero-lateral corner.

The posterior ramus consists of 13 segments. The 1st basal segment is only slightly inflated and bears comparatively few spines. The distal segments are armed anteriorly with 3 pairs of spines, between which 3 or 4 spines arise in a linear series. All the distal segments are crowned with a row of needle-like spinules, arranged as a palisade around their distal margins and have one or two larger spines at the antero-lateral corner. The terminal spines on the distal segments have, in proportion to the distal segment, a length of 20 to 9·0.

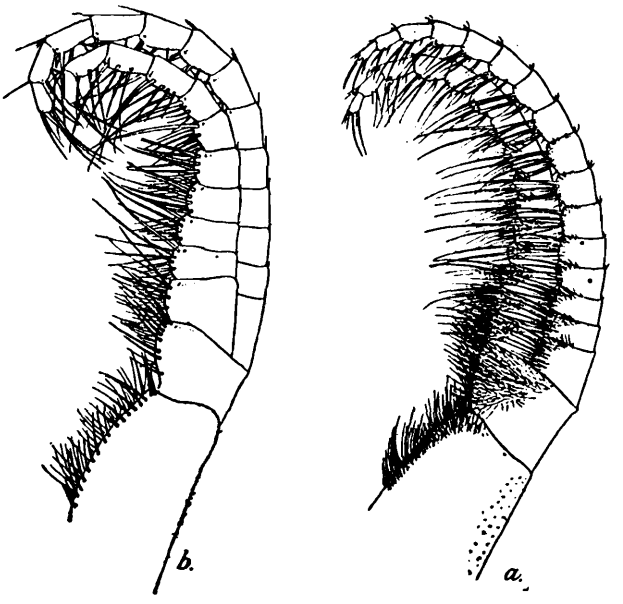
Breadth of example, 5·0 mm.

The anterior ramus consists of 11 segments, of which the proximal 5 are broad and are armed with numerous spines.

The posterior ramus, in the example examined, possessed only 12 segments, which is one less than in the previous stage ; but, as I shall show later, the average number of segments in the rami exhibits a steady rise with increasing size. The four basal segments are armed with numerous spines. The 8th segment in the specimen examined is in reality double, though the line of separation is not complete ; the basal half of the segment is slightly swollen and bears 2 pairs of spines, and the distal portion, which is marked off by a constriction, bears 3 pairs of spines.

In both rami the distal segments bear 3 pairs of spines and three or four spines in a linear series ; a palisade of small needle-like spines runs along the distal margin of the lateral aspect of each segment with one or

two larger spines at the anterior end, and a tuft of larger spines is situated on the distal margin of the posterior aspect of the joint.



Text-fig. 7. The second cirrus of *Lithotrya nicobarica*—
(*a*) from a specimen measuring 8·5 mm. in breadth × 10.
(*b*) from a specimen measuring 3·5 mm. in breadth × 23.

The spines on the terminal segments of the posterior ramus have a length in proportion to the distal segment of 18 to 8 and in the anterior ramus of 21 to 10.

Breadth of example, 8·5 mm.

(Text-fig. 7 (*a*).)

The anterior ramus now possesses 15 segments, of which the proximal 6 are somewhat swollen and are armed with numerous spines. In the distal segments the number of paired spines decreases from 4 pairs in the middle of the ramus to 2 pairs at the distal end, as follows :—

Segment	7	8	9	10	11	12	13	14	15
No. of pairs of spines	4	4	4	4	4	3	3	2	2

Each segment has the usual palisade of needle-like spines on its distal margin with two, or sometimes only one, larger spines at the anterior end of the series. The tufts of spines on the distal end of the posterior aspect of the segments consists of both long and short spines. The terminal spines are, in proportion to the distal segment, as 31 : 14.

The posterior ramus consists of 16 segments, of which the proximal ones are only slightly swollen. The proximal 4 segments are armed with numerous spines but the remaining distal ones are normal ; the number of paired spines on the distal segments are as follows :—

Segment	7	8	9	10	11	12	13	14	15	16
No. of pairs of spines	4	4	4	4	4	3	3	3	2	2

The proportional length of the terminal spines in comparison to the length of the distal segment is as 28 to 12.

Breadth of example, 10·0 mm.

The anterior ramus now possesses 17 segments, of which the proximal 7 are swollen and bear numerous spines ; the distal 10 segments bear comparatively few paired spines, as follows :—

Segment	8	9	10	11	12	13	14	15	16	17
No. of pairs of spines	3	3	3	3	3	3	3	2	2	2

The terminal spines, in proportion to the legnth of the distal segment, have a length of 33 to 14.

The posterior ramus consists of 18 segments, of which the proximal 5 are somewhat swollen and bear numerous spines, though fewer than the corresponding segments of the anterior ramus. The distal segments bear the following number of spines :—

Segment	7	8	9	10	11	12	13	14	15	16	17	18
No. of pairs of spines	4	4	4	4	3	3	3	3	3	3	2	2

The length of the terminal spines is, in proportion to the length of the segment, as 31 to 13.

The palisade of needle-like spines on the lateral surfaces and the distal groups of spines on the posterior aspect of the various segments are similar to those in the previous stages of development.

As one traces the series from small to large examples one sees that the number of basal segments which are swollen and enlarged and are thickly clad with spines steadily increases with increase in size and, therefore, presumably with age, as is shown in Table 11.

Size of example.	No. of segments swollen and thickly spined.	
	Anterior ramus.	Posterior ramus.
3·5 mm.	5 (6)*	1 (12)
5·0 mm.	5 (6)	4 (8)
8·5 mm.	6 (9)	4 (12)
10·0 mm.	7 (10)	5 (13)

Table 11 : showing the number of segments in the rami at different stages of development.

* The numbers in brackets are the numbers of unswollen and thinly spined segments at the distal end of the ramus.

According to Darwin there are in *Lithotrya cauta* in the anterior ramus of the second cirrus six basal segments that are thickly paved with spines and two terminal segments that are provided with only a few spines, while in the posterior ramus all nine segments are armed with only a few spines. In the smallest examples of *L. nicobarica* the condition of the anterior ramus is somewhat different from that of *L. cauta* as the number of distal segments is much greater but this is probably due to age, the number of such segments steadily increasing as age progresses ; the posterior ramus shows a close agreement for only a single segment shows any signs of increased breadth and is thickly clad with spines. In *L. dorsalis* there are said to be " seven basal segments of the

anterior ramus very broad and paved with bristles ; the eight terminal segments having the usual structure ; in the posterior ramus the three or four basal segments are similarly paved, but to a very much less degree and the remaining thirteen have the usual structure." On the other hand in *L. nicobarica*, according to Darwin (1851, p. 362), " the anterior ramus has the eight basal segments highly protuberant and thickly clad with spines, the upper nine having the usual structure ; the posterior ramus has the four or five basal segments thickly clothed with spines and the twelve upper ones with the usual structure." It is clear that Darwin's account of *L. nicobarica* applies only to the larger specimens, namely to those having a length of 10·0 mm., while there is so little difference between the condition found in *L. dorsalis* and the examples of *L. nicobarica* of a length of 8·5 to 10·0 mm. that no reliance can be placed on the number of swollen and heavily spined segments in the rami in attempting to discriminate between the two species, if they really are distinct.

As I have shown in the case of the 1st cirrus, the proportional length of the terminal spines on the distal segments of the rami shows a steady diminution in proportion to the length of the whole ramus with increasing size, and the same phenomenon can be seen to occur in the second cirrus also. In the following Table 12 I have given the lengths of the spines and the terminal segment of the cirrus :—

Size of example.	Anterior ramus.			Posterior ramus.		
	Length of spines.	Length of of segment.	Proportional length.	Length of spines.	Length of segment.	Proportional length.
3·5 mm.	17	8·5	2·0 : 1	20	9	2·2 : 1
5·0 mm.	21	10	2·1 : 1	18	8	2·3 : 1
8·5 mm.	31	14	2·2 : 1	28	12	2·3 : 1
10·0 mm.	33	14	2·4 : 1	31	13	2·4 : 1

Table 12 : showing the proportional lengths of the end-spines and the distal segments of the rami of the 2nd cirrus in *Lithotrya nicobarica.*

From this data it is evident that though the length of the spines decreases in proportion to the ramus as a whole, it shows a progressive increase in proportion to the length of the segment that bears them.

3RD CIRRUS.

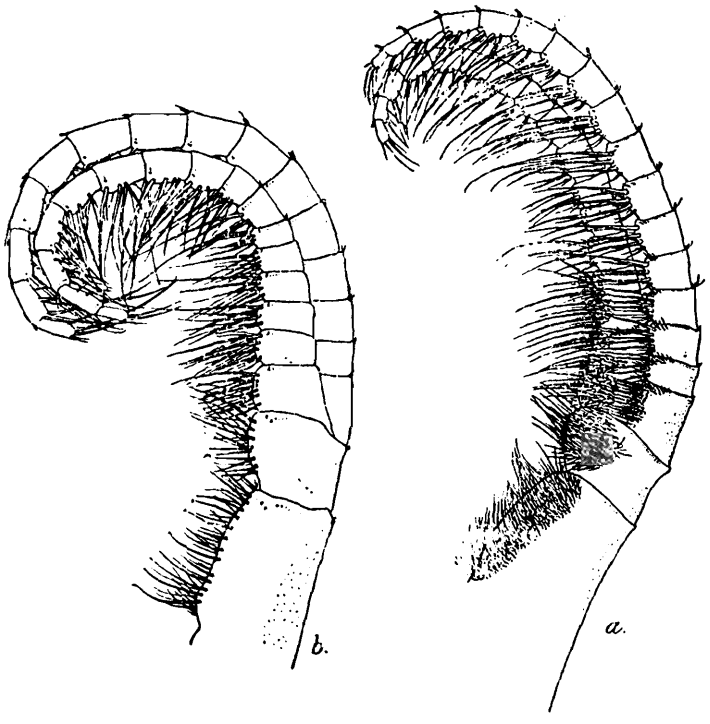
In its general structure this appendage is at all stages of development very similar to the 2nd cirrus ; both segments of the pedicel are thickly clad with small pointed scales and there are the same perforated areas on the posterior aspect and on the inner surface posterior to the long serrated spines. I have already (*vide supra*, p. 291) called attention to the presence of an elongate white swelling, covered with small scales, on the 1st free segment of the pedicel.

Breadth of example, 3·5 mm.

(Text-fig. 8 (*b*).)

In the anterior ramus the first four segments are slightly swollen and are armed with numerous spines. The distal segments bear three pairs of long spines and three or four somewhat shorter spines in a linear series between the paired rows. Each segment is crowned distally with a palisade of needle-like spines, and there is usually one (occasionally two) larger blunt spine at the antero-lateral angle of the joint. The terminal segment bears long spines that have, in proportion to the distal segment, a length of 74 to 38.

In the posterior ramus none of the segments are appreciably swollen nor are they thickly clad with spines. The first basal segment is armed with scattered spinules on its posterior aspect, and a few also occur on the distal portion of the second and third segments. The distal segments



Text-fig. 8. The third cirrus of *Lithotrya nicobarica*—
(*a*) from a specimen measuring 8·5 mm. in breadth × 10.
(*b*) from a specimen measuring 3·5 mm. in breadth × 23

of the ramus bear three pairs of spines and a linear series of three or four spines along the anterior margin between the paired rows : the penultimate segment bears only two pairs of spines and three in the linear row. The length of the terminal spines is to the end segment as 102 to 48.

Breadth of example, 5·0 mm.

In this stage the four basal segments of the anterior ramus are rather more swollen than the others and are armed with numerous spines. The next few segments bear three pairs of spines and three or four in a linear series, while the 2nd and 3rd last segments bear only two pairs of spines.

The length of the terminal spines is to the length of the last segment as 22 to 9.

In the posterior ramus the basal three segments are armed with numerous spines but are somewhat less thickly clad than the corresponding segments in the anterior ramus. The fourth segment bears five pairs of spines on the anterior border and a linear series of 5 or 6 spines along the distal margin. Segments 5 to 8 bear four pairs of spines and the linear row on the distal margin is reduced to 2 situated at the antero-lateral angle. The 9th to 13th segments bear three pairs of spines and the 14th bears only two pairs. The terminal spines are, to the length of the segment, as 25 to 9.

In both rami the spines on the distal part of the posterior aspect of each segment increase in length as one passes towards the tip of the ramus and each group consists of two different kinds of spines ; some are short and are doubly serrated, while others are long and are considerably thinner. There is a small group of needle-like spinules at the base of these spines.

Breadth of example, 8·5 mm.

(Text-fig. 8 (*a*).)

In the anterior ramus the basal five segments are slightly swollen and are armed with numerous spines ; the next 2 or 3 segments bear 4 pairs of spines, the 9th and 10th bear 3 pairs and 5 in a linear series along the anterior margin, while the 20th to the 22nd bear only 2 pairs of spines. The terminal spines are to the terminal segment as 22 to 11.

In the posterior ramus the three basal segments are slightly swollen ; following these the next several segments bear 4 pairs of spines and a linear row of 6 or 7 ; the 13th to 18th bear 3 pairs and the 19th to 20th segments bear 2 pairs of spines. The length of the terminal spines is to the end segment as 21 to 11.

Breadth of example, 10·0 mm.

In the anterior ramus the basal six segments are somewhat swollen and are armed with numerous spines. Segments 7 to 9 bear 4 pairs of long spines, segments 10 to 15 bear 3 pairs and segments 16 and 17 bear only 2 pairs ; throughout the whole series the segments bear a linear series of 6 or 7 spines. The terminal spines have, in proportion to the length of the segment, a length of 36 to 13.

In the posterior ramus the basal three segments are slightly swollen but less so than the segments of the anterior ramus, and are armed with numerous spines. The 5th segment bears 5 pairs of spines, the 6th to the 11th bear 4 pairs, the 12th to the 18th bear 3 pairs and the 19th only 2 pairs. The middle segments of the ramus bear 6 to 7 spines in a linear row between the paired spines. The terminal spines are to the terminal segment as 35 is to 15.

In this cirrus also the degree of inflation of the basal segments steadily increases with increasing size of the example, as also does the number of

segments that are thus affected. This is clearly shown in the following Table 13.

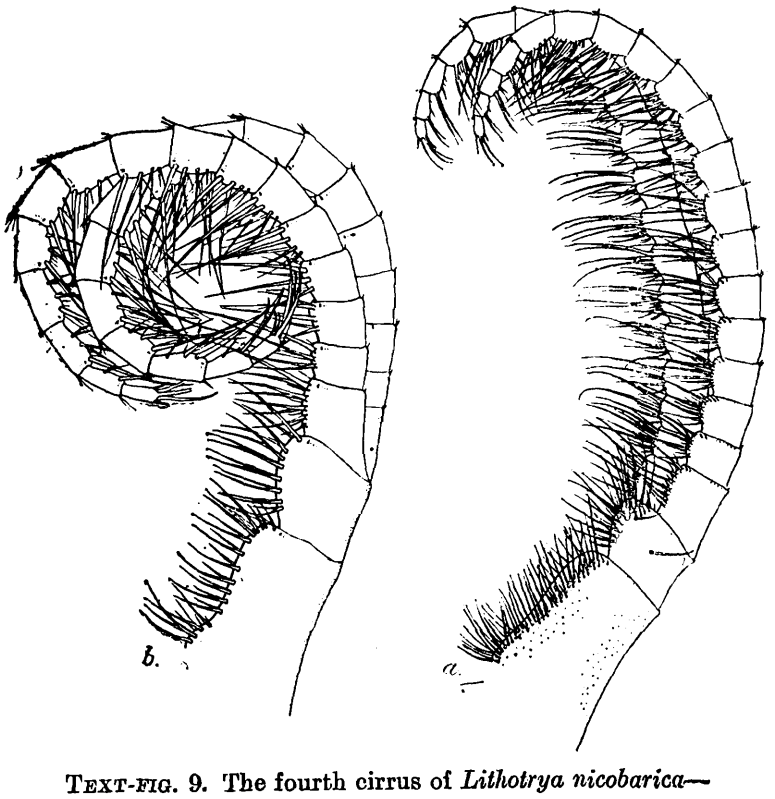
Size of example.	No. of segments inflated in anterior ramus.	No. of segments with numerous spines in posterior ramus.
3·5 mm.	4 (12)*	0 (15)
5·0 mm.	4 (12)	3 (12)
8·5 mm.	5 (18)	3 (18)
10·0 mm.	6 (12)	4 (16)

Table 13 ; showing the variation in the character of the segments of both rami with increasing size.

* The numbers in brackets indicate the number of normal unswollen segments in the two rami.

4TH-6th CIRRI.

As in the 3rd cirrus, there are in all the three posterior cirri numerous small perforations scattered over the posterior aspect of both segments of the pedicel and over an area behind the row of long spines on the anterior part of the inner surface. In all three cirri the posterior surface of both free segments of the pedicel is armed with numerous minute



TEXT-FIG. 9. The fourth cirrus of *Lithotrya nicobarica*—
(*a*) from a specimen measuring 8·5 mm. in breadth ×10.
(*b*) from a specimen measuring 3·5 mm. in breadth ×23.

pointed scales, and similar scales can be seen on the posterior aspect of the proximal five or six segments of the rami of the sixth cirrus.

The long spines on the anterior aspect of the pedicels occur in two series, between which are several smaller spines in a linear row. Except as regards the number of segments in the rami there are few or no changes in the cirri with increasing size or age. The posterior aspect of the 1st free segment of the pedicel in the 4th and 5th cirri bears an elongate white swelling covered with scales (*vide supra*, p. 291).

Breadth of example, 3·5 mm.

(Text-figs. 9 (*b*), 10 (*b*) and 11 (*b*).)

In the anterior ramus the 1st and 2nd segments bear scattered spinules on the posterior aspect. The number of paired spines on the anterior aspect of the segments of the ramus are as follows :—

Segment	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
No. of paired spines	4	3	3	4	4	4	4	4	4	4	4	3	3	3	3	2

Between the pairs of spines there is in most of the segments a linear row of four smaller spines. The terminal spines have in proportion to the terminal segment a length of 16 to 9.

In the posterior ramus the segments bear a similar number of paired spines and the length of the terminal spines is to the last segment as 22 to 8.

Breadth of example, 5·0 mm.

The pedicels are similar to those in the preceding stage, but the basal third of the 1st pedicel is slightly prominent and bears a cluster of long spines.

In the anterior ramus the segments bear the following number of spines :—

Segment	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of paired spines	4	3	4	4	4	4	4	4	4	3	3	3	3	3	3	2

The linear row of spines in the middle segments of the ramus usually consists of 6.

The length of the terminal spines is to the end segment as 14 to 10.

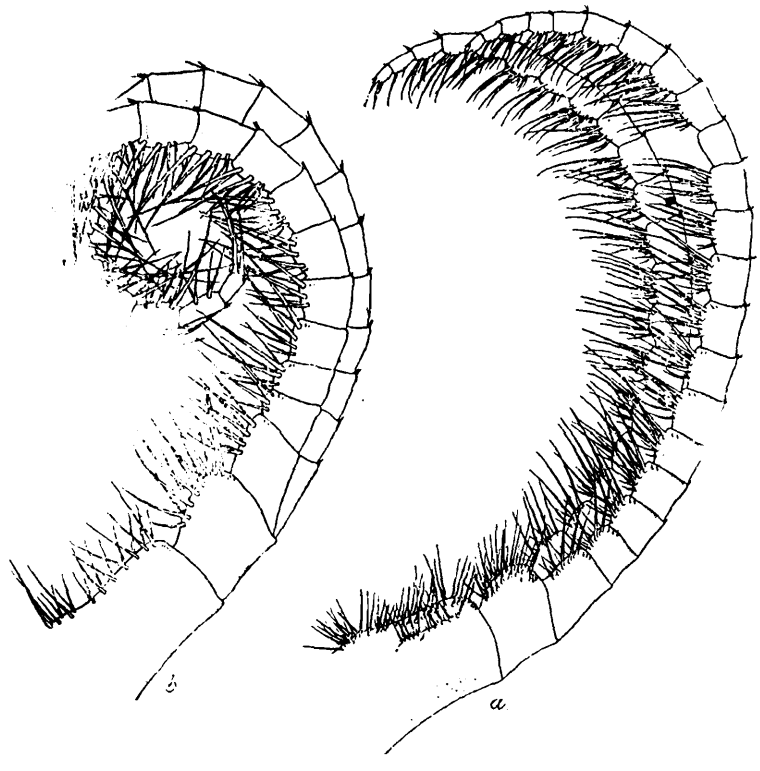
In the posterior ramus the numbers of paired spines on the various segments are exactly the same as in the anterior ramus with this exception that, owing to there being one less segment, the corresponding numbers of the segments are 4 to 19, the nineteenth or terminal segment bearing only two pairs.

Breadth of example, 8·5 mm.

(Text-figs. 9 (*a*), 10 (*a*) and 11 (*a*).)

In this stage of development in the 1st pedicel the proximal third of the segment is prominent and bears a cluster of spines and the distal

two-thirds bears a double row of long spines with intermediate smaller ones on the anterior margin. The prominence of the proximal part of segment is rather more marked at this stage than in the previous stage of development. The 2nd pedicel is as in the previous stage.



Text-fig. 10. The fifth cirrus of *Lithotrya nicobarica*.

(*a*) from a specimen measuring 8·5 mm. in breadth ×10.

(*b*) from a specimen measuring 3·5 mm. in breadth ×23.

In the anterior ramus the number of paired spines on the different segments are as follows :—

Segment	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
No. of paired spines	5	3	3	3	4	4	4	4	4	4	4	4	3	3	3	3	2	2

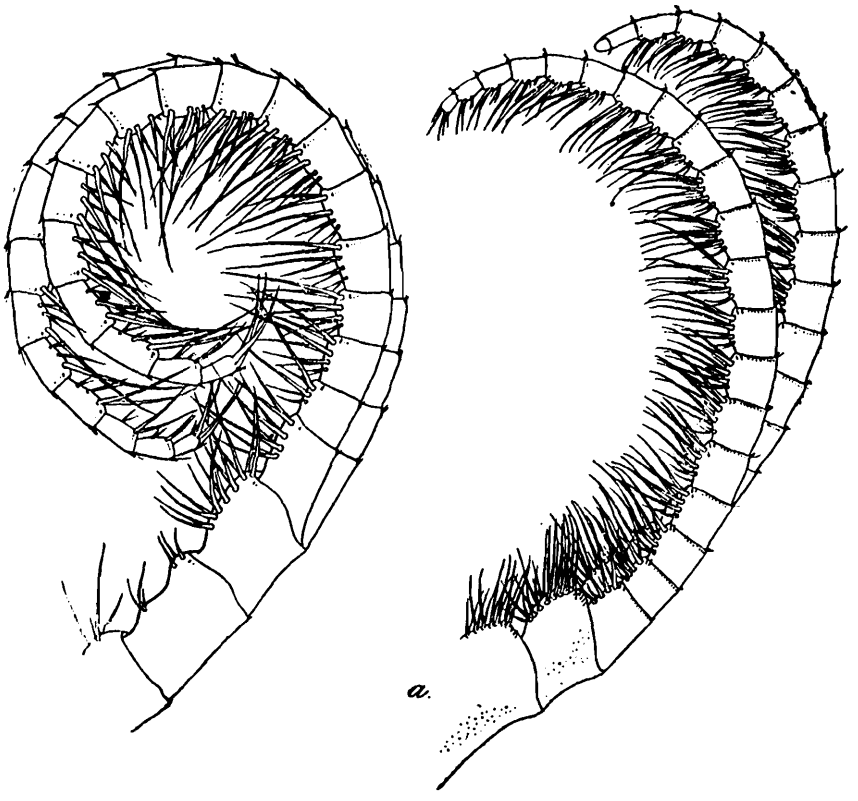
There are usually 5 or 6 spines in the linear row on the anterior margin.

In the posterior ramus, in the example examined, the number of segments in the ramus was considerably greater, being as many as 24, and the number of paired spines also exhibits a corresponding reduction in some of the segments ; the actual numbers were as follows :—

Segment	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
No. of paired spines	5	3	3	3	3	4	3	3	4	3	3	3	3	3	3	3	3	3	3	2	2

In both rami the number of spines in the linear row situated at the antero-lateral angle of the segment near the distal margin is 3 or 4 in the basal segments, 2 in the segments in the middle of the ramus and 1 in the distal segments. The length of the terminal spines is to the end

segment as 33 to 14 in the anterior ramus and 29 to 12 in the posterior branch.



TEXT-FIG. 11. The sixth cirrus of *Lithotrya nicobarica*.
(*a*) from a specimen measuring 8·5 mm. in breadth ×10.
(*b*) from a specimen measuring 3·5 mm. in breadth ×23.

Breadth of example, 10·0 mm.

The number of paired spines in this stage of development on the two rami are as follows :—

In the anterior ramus :

Segment	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of paired spines	5	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	2

and in the posterior ramus :

Segment	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
No. of paired spines	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	2	2	2

The segments in the middle of the rami bear 6 or 7 spines in a linear series. The length of the terminal spines is to the end-segment of the ramus as 35 to 14 in the anterior branch, and as 36 to 12 in the posterior.

In a still larger example, measuring 11·0 mm. in breadth, the number of paired spines on the proximal segment of the rami had increased to 6, and in the next two segments to 5 pairs with 6 or 8 spines in the median linear series in the middle segments.

I have already shown that in the first two pairs of cirri the length of the terminal spines on each ramus steadily increases in each successive

stage of growth in proportion to the length of the segment that bears them ; the same holds good in general in the posterior four pairs.

Size of specimen.	Proportional lengths of spines and terminal segment.	
	Anterior ramus.	Posterior ramus.
3·5 mm.	1·77 : 1	2·75 : 1
5·0 mm.	1·40 : 1	1·56 : 1
8·5 mm.	2·35 : 1	2·42 : 1
10·0 mm.	2·50 : 1	3·0 : 1

Table 13 ; giving the proportional lengths of the terminal spines and the end segment in the 4th to 6th cirri in specimens of different sizes.

In both the anterior and posterior ramus of the example of 5·0 mm. measurement, the length of the terminal spines is considerably less than in the other specimens. This is, I think, probably due to individual variation. In the other cases there is a well-marked and progressive increase in the length, in proportion to the end segment, of the terminal spines, that is particularly well seen in the anterior ramus, though much less clearly marked in the posterior ramus.

Cardo-rostral diameter of capitellum.	1st cirrus.		2nd cirrus.		3rd cirrus.		4th cirrus.		5th cirrus.		6th cirrus.		No. of segments of the abdominal appendage.	No. of denticles between cusps 1 and 2, and cusps 2 and 3 of the mandible.	
mm.	A.	P.	A.	P.	A.	P.	A.	P.	A.	P.	A.	P.			
3·5	8	8	11	13	16	15	16	17	17	19	17	21	20	6	4
														8	4
5·0	10	9	13	13	13	13	17	19	..	..	..	..	..	12	4
5·0	8	10	11	12	15	15	17	18	18	18	17	20	14	..	..
5·5	11	9	11	12	15	14	17	19	18	18	17	18	14	13	5
5·5	8	7	11	13	13	15	17	18	19	21	16	18	13	15	5
6·0	9	9	13	13	16	16	17	18	18	21	20	20	14	9	7
6·5	10	9	15	15	16	16	18	19	19	20	20	21	18	12	9
														13	8
8·0	10	10	15	13	18	16	21	20	21	20	..	23	16	12	6
8·0	10	8	16	12	15	15	17	18	18	18	17	20	14	14	8
8·5	11	10	15	16	23	21	21	24	23	26	23	22	19	27	9
9·5	10	9	14	15	19	18	21	20	21	20	21	20	17	17	7
														13	9
10·0	12	12	17	17	19	18	20	23	22	23	21	21	17	18	9
10·5	11	12	17	19	20	22	23	22	26	24	26	24	..	..	..
11·0	10	10	18	16	18	18	..	..	21	23	20	24	15	..	..
..	10	10	15	16	18	17	19	19	20	21	18	20	..	..	..

Table 14 ; showing the number of segments in the cirri, and in the caudal appendage ; and the number of denticulations between the main teeth of the mandible in examples of *Lithotrya nicobarica* of different sizes.

A study of the data given in Table 14 shows clearly that there is a very considerable range of variation in the number of segments in the cirri ; but an analysis of the figures equally shows that there is a steady increase in the average number of segments in each cirrus as the size of the example increases in accordance with what I believe to be periods or years of growth. In Table 15 I have given the average No. of segments in each cirrus in the specimens examined by me in each of the four groups ; the actual number of specimens examined is not large but at least the figures can be taken as a rough guide.

	1ST CIRRUS.		2ND CIRRUS.		3RD CIRRUS.		4TH CIRRUS.		5TH CIRRUS.		6TH CIRRUS.	
	Ant.	Post.	Ant.	Post.	Ant.	Post.	Ant.	Post.	Ant.	Post.	Ant.	Post.
Group I	8	8	11	13	16	15	16	17	17	19	17	21
Group II	9	9	14	13	14	14	17	18	18	19	17	19
Group III	10	10	15	15	19	18	20	21	21	22	21	22
Group IV	11	11	16	17	19	19	20	22	22	23	22	21

Table 15 ; showing the *average* number of segments in the cirri at different stages of growth in *Lithotrya nicobarica.*

In view of the fact that Hoek has founded his species *L. conica* largely on differences, between this species and *L. nicobarica*, in the number of segments in the cirri, it is important to realise that quite as great differences may be found in different growth-stages of the same species : it is in consequence more than likely that he was dealing merely with slightly immature examples, a possibility that he himself foresaw, for he (1907, p. 126) remarks in his description of the species " The specimens of *L. conica* are smaller than most of *L. nicobarica ;* some of the latter, however, are as small as most of the *L. conica*, yet show the differences in the shape of the capitellum and of the valves, which I think are very striking. There is therefore no reason for me to admit that the one form represents younger, the other older specimens of the same species. On the other hand I would be by no means surprised if future investigations show that the two forms really belong together in some way or other." In *L. dorsalis* the number of segments in the rami, allowing for individual variation, corresponds to those present in the third year of development of *L. nicobarica.*

Again, according to the descriptions of the various so-called species, there would appear to be certain small differences in the number of spines on the anterior aspect of the segments of the cirri. The only author who has given any attention to this feature is Darwin. In his descriptions of the species he states that in *Lithotrya truncata* (*vide* Darwin, 1851, p. 370) the segments of the three posterior cirri bear three or four pairs of main spines and the usual row of smaller intermediate spines ; in *L. cauta* the segments of the three posterior pairs are said to bear four pairs of spines with the usual intermediate fine spines (Darwin, 1851, p. 358) ; *L. nicobarica* bears, in the three posterior pairs of cirri, three or four pairs of long spines, with a single row of moderately long intermediate spines (Darwin, *loc. cit.* p. 362) and *L.*

rhodiopus and *L. dorsalis* are both said to have five pairs of very long spines with an intermediate row of smaller spines, which in the case of *L. dorsalis* are said to be four in number (*loc. cit.* pp. 355 and 366). A study of the condition present in examples of different sizes of *L. nicobarica* shows, once again, that these characters afford no assistance in the specific diagnosis of the various forms. In the smallest examples, measuring 3·5 mm., the three posterior cirri bear three or four pairs of long spines and a median linear row of four smaller spines; in the next size, measuring 5·0 mm., there are still three or four pairs of long spines, but the number of the intermediate spines has increased to six; in the example of 8·5 mm. size the paired spines were three to five in number and the median unpaired row contained five or six; examples of 10·0 mm. possessed four or five pairs of long spines and a median row of six or seven; while, finally, the example of 11·0 mm. has five or six pairs of long spines and a median row of six to eight. There is thus a very clear increase in the number of both the paired and unpaired spines on the segments of the posterior cirri in examples of different size in a single species, and any difference noted in the so-called species may be, and probably is, due entirely to difference in the size or age of the specimen.

In some examples the ends of several of the cirri have been cut-off and in one case a cirrus bifurcated at the end into two short secondary branches. It appears probable that this amputation of the cirri has been done by some predatory animal, who has seized the cirri as they were protruded through the slit between the valves of the two sides, during their to-and-fro movement that is so characteristic of the barnacles. The bifurcated cirrus is probably an attempt on the part of the individual to regenerate the injured limb.

THE CAUDAL APPENDAGE.

Text-fig. 12.

The caudal appendage exhibits a considerable degree of variation in different specimens, especially as regards its length and the number of segments of which it is composed. In the examples that I have examined the number of segments ranges from 14 to 22. In a single example, having a measurement of 3·5 mm., the number is as high as 20; in three examples, whose measurements ranged from 5·0 to 6·0 mm., there were in each case 14 segments present; while in examples whose measurements range from 9·0 to 11·0 mm. the number of segments vary from 15 to 22, the average being 18. I have already shown that the number of segments in the various cirri exhibit a steady increase with a corresponding increase in the size of the specimen, and one would certainly expect to find that the same process is exhibited in the caudal appendage, and, with the exception of the smallest example, this appears to be the case, though, owing to the great variation present, a large example may actually possess fewer segments in this appendage than a smaller one. The proportional length of the appendage, in spite of

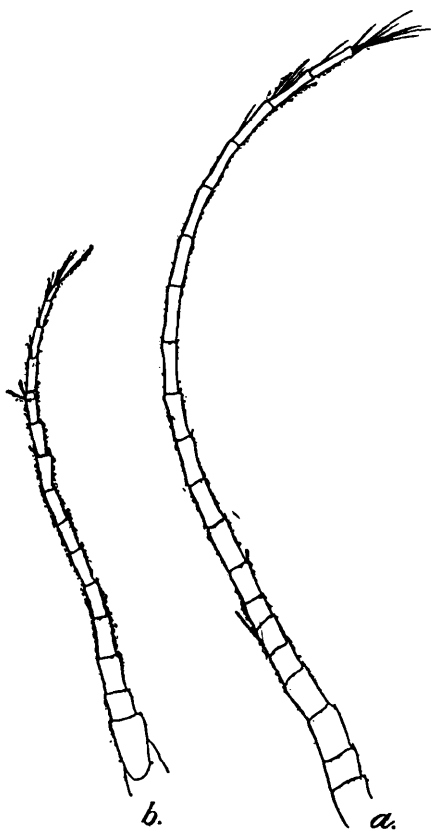
the tendency to an increase in the number of its segments, appears to show a steady diminution with increasing size, thus—

in an example of 3·5 mm. length, the appendage reaches the distal end of the 9th segment of 6th cirrus;

in an example of 8·5 mm. length, the appendage reaches the distal end of the 7th segment of 6th cirrus;

in an example of 10·0 mm. length, the appendage reaches the distal end of the 5th segment of 6th cirrus;

in an example of 11·0 mm. length, the appendage reaches the distal end of the 4th segment of 6th cirrus.



TEXT-FIG. 12. The caudal appendage in *Lithotrya nicobarica*.
(*a*) from a specimen measuring 3·5 mm. in breadth × 23.
(*b*) from a specimen measuring 8·5 mm. in breadth × 10.

This apparent decrease in the proportional length of the appendage appears in the main, however, to be due to a steady increase in the length of the pedicel of the 6th cirrus, as is shown in the following Table :—

Group.	Measurement of specimen.	Length of pedicel of 6th cirrus.	Length of caudal appendage.
1	3·5 mm.	0·917 mm.	3·867 mm.
2	5·0 ,,	1·717 ,,	3·333 ,,
3	8·5 ,,	2·267 ,,	3·433 ,,
4 (*a*)	10·0 ,,	2·867 ,,	4·167 ,,
(*b*)	11·0 ,,	2·917 ,,	4·417 ,,

Table 16; giving the length of the pedicel of the 6th cirrus and of the caudal appendage in specimens of *L. nicobarica* of different sizes.

In *Lithotrya dorsalis* the caudal appendage is stated by Darwin (1851, p. 356) to possess 17 segments and to equal $1\frac{1}{2}$ times the length of the pedicel of the 6th cirrus, a condition that agrees remarkably clearly with specimens of *L. nicobarica* having a breadth-measurement of 8·5 to 10·0 mm. Hoek makes no mention of the proportional length of the appendage of *L. conica*, but states that it possessed, in the specimen examined, 18 segments so that it also agrees with the larger examples of *L. nicobarica*. In *L. cauta*, however, Darwin (1851, p. 359) describes the appendage as being only $1\frac{1}{3}$ times the length of the pedicel of the 6th cirrus and having as few as 7 segments, so that the condition is very different from that present in the smallest example of *L. nicobarica* examined by me. The specimen of mine would, however, appear to be somewhat abnormal, since it possessed far more segments than one would expect, if, as I have suggested above, the number of these exhibits a steady increase as growth progresses; the segments present were 20, instead of some number below 14, the stage reached by specimens having a breadth-measurement of 5·0 to 6·0 mm. (*vide* Table 14): and, furthermore, owing to the unusual number of these segments the total length of the appendage in this small example is actually more than in specimens of a greater size, namely 3·867 mm., whereas in a specimen as large as 8·5 mm., more than twice its size, the length of the appendage was only 3·433 mm.

THE MOUTH PARTS.

THE LABRUM.

In all members of the genus the labrum appears to have the same general structure. The mouth is separated, as Darwin pointed out, from the adductor muscle by a considerable interval. The labrum is therefore somewhat extended. It forms the anterior margin of the mouth and is usually described as having a pair of palps. It is more probable, however, that Hansen is right in thinking that these belong, properly speaking, to the mandibles. According to Darwin (1851, p. 354) the labrum in *Lithotrya dorsalis* is "considerably bullate, equalling about half the longitudinal diameter of the mouth; inferior part produced so as to separate the mouth some way from the adductor muscle; crest with a row of blunt teeth and hairs; central part depressed and flattened." The same description would apply equally well to *L. nicobarica*. In this latter species the labrum possesses a rounded, somewhat swollen lateral region on each side and a central somewhat depressed part; and the whole of the free margin of both parts is armed with a row of small teeth and is fringed with numerous short hairs. In a small specimen of *L. nicobarica*, that I examined, the labrum was furnished with thirteen teeth on each of the lateral parts and fourteen on the depressed central portion. In another, and one of the largest specimens, the number of teeth on the whole margin was forty-two, so that there appears to be little or no change in this feature with advancing age. *Lithotrya conica*, according to Hoek (1907, p. 125), "has about twelve small blunt teeth on its central and about

fifteen on each of the lateral parts." It would appear, therefore, that in the case of these two so-called species the structure of the labrum is very similar to that in the examples of *L. nicobarica*. As regards other species of *Lithotrya*, I can find no records of the number of teeth present. Darwin (1851, p. 358) remarks that in *L. cauta* "the teeth or beads on the crest of the labrum are blunt; few, not very small and equidistant." In all other species he either only notes that the labrum bears a row of teeth and hairs, or omits, as in his account of *L. nicobarica*, any mention of this character.

THE MANDIBLE.

Text-fig. 13.

In all the so-called species the mandible is of the same general type. In his general account of the genus Darwin (1851, p. 348) states that this appendage is provided "with three nearly equal large teeth, and the inferior angle produced, broad, and strongly pectinated: in the interspaces between these teeth there are, in all the species, some very fine teeth or pectinations, which are seated a little on one side of the medial line. The mandibles are somewhat singular from the size of the transparent flexible apodemes to which the muscles are attached; these are oval and constricted at their origins: in *L. dorsalis* they are roughened with little points; in *L. cauta* and *L. truncata* they are large, of the same shape, but smooth." The description applies equally well to the mandible of any of the so-called species, almost the only distinguishing features being (1) the distance separating the upper pair of teeth and that between the second tooth and the inferior angle of the mandibular margin, and (2) the number of the small pectinations between the large primary teeth. In all cases the primary teeth are of approximately

TEXT-FIG. 13. The mandible of *Lithotrya nicobarica*.
(*a*) from a specimen measuring 3·5 mm. in breadth ×35.
(*b*) from a specimen measuring 8·5 mm. in breadth ×35.

the same size, but the distance between the first tooth and the second, and between the second and the inferior angle are said to be different.

In *Lithotrya cauta* Darwin (1851, p. 358) states that "the distance between the tips of the first and second main teeth, equals that between the second tooth and the inferior angle." In both *Lithotrya dorsalis* and *L. nicobarica* the same author remarks (1851, pp. 354 and 358) that the distance between the tips of the first and second teeth is considerably less than that between the tip of the second tooth and the inferior angle; and Hoek (1907, p. 123) gives the measurements in the latter species as 7 : 9. In the examples of *L. nicobarica* examined by me there are considerable differences in this respect in individuals of different sizes; in specimens of a small size, having a breadth-measurement of 3·5 to 5·0 mm., the distance between the first and second teeth and that between the second tooth and the inferior angle is almost exactly equal, namely 48 to 46 and 48 to 48 in the two mandibles; in larger examples, however, such as those with a breadth-measurement of 8·5 mm., the two measurements are 15 to 16 in one example and 18 to 22·5 in another, so that it seems clear that the distance between the second tooth and the inferior angle increases proportionally with increase in age. The smaller examples agree with the condition found in *L. cauta*, while the larger specimens on the other hand correspond to both *L. dorsalis* and the previous accounts of *L. nicobarica*. An exactly similar condition of affairs is found to be present as regards the number of small spines or pectinations between the large teeth. In *Lithotrya cauta*, according to Darwin (1851, p. 358), "the pectinations are equal in number, namely only three between the first and second and the second and third main teeth"; in *L. dorsalis*, according to the same author, there are (*loc. cit.* p. 354) "twice as many pectinations, namely 15, between the first and second main teeth, as between the second and third, namely about 7," and in *L. nicobarica* there are (*loc. cit.* p. 362) "fully twice as many pectinations (*viz.*, from 16 to 20) between the first and second main teeth, as between (*viz.*, 8 to 10) the second and third main teeth." In the smaller examples of *L. nicobarica*, namely those of 3·5 mm. in breadth or one year's growth, the number of teeth in the two situations is from 6 to 8 between the first and second teeth and 4 between the third and second, the proportion between the two sets being 1·75 to 1. In the larger examples the two sets of teeth consist, in three examples of the 2nd group or year, of 9 to 12 between the first and second teeth and 4 to 7 between the second and third teeth, so that in this stage of growth the proportion between the two sets is 2·2 to 1, and in this feature and in the total number of teeth the specimens approximate to *L. dorsalis*. In the examples of the third year, having a breadth of 6·5 to 8·5 mm., the number of denticles in the two situations ranges from 12 to 27 between the first and second teeth and 6 to 9 between the second and third. Out of five mandibles examined four show from 12 to 14 between the first two teeth; the fifth example appears to be somewhat abnormal, not only is the number of teeth high but the number of segments in the cirri is much above the average, as a reference to Table 14 clearly shows; it seems probable that this particular specimen is really of greater age than its size would lead one to think and that it is a member of the fourth year group and not of the third. The inclusion of this abnormal

example raises the average for the 3rd year group to 16 denticles between the first and second teeth and 8 between the second and third. If we exclude this abnormal specimen, the average is 13 denticles between the first and second teeth and 8 between the second and third. In the fourth year group the number of denticles between the second and third teeth is still, on the average, 8, but the number between the first and second has increased to 18.

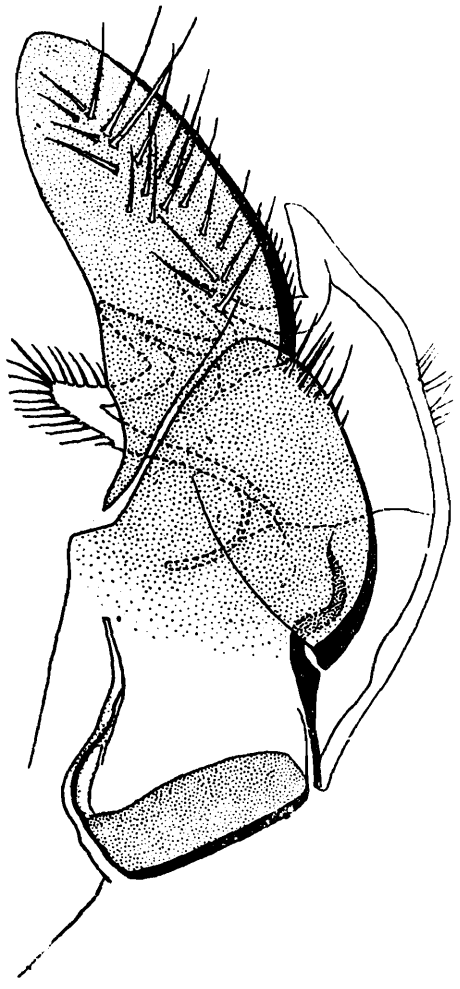
It is thus clear that as age advances the total number of these pectinations increases and the proportional number situated in the intervals between the three main teeth changes, the number between the first and second teeth becoming much greater than the number between the second and third in old examples. The small examples of *L. nicobarica* approximate to the condition in *L. cauta*, but as they were already considerably larger the number of teeth is greater and the proportion instead of being equal is already 1·75 to 1 ; on the other hand specimens of the 3rd year agree with *L. conica* and the largest specimens agree almost exactly with *L. dorsalis*.

The number of denticles on the inferior angle of the mandible also appears to increase with age. In the smallest examples the number is 12, of which the spine at the extreme tip is the largest, as is the case in *L. cauta*. In the larger examples the number has increased to 26 or 27 and the extreme tip is now crowned with four or five teeth.

Darwin (1851, p. 354) remarks that the sides of the mandible in *Lithotrya dorsalis* are hirsute. He makes no further mention of this character in his descriptions of the other species, but in all the examples of *L. nicobarica* that I have examined the mandible shows this feature quite distinctly, and it is probably of universal occurrence throughout the genus.

Hansen (1925, p. 52 *et seq.*) has in a recent paper stated that in his opinion the mandible in the Cirripedes is not homologous with that appendage in the higher Crustacea. He shows that this appendage consists of three separate joints or segments. At the base there is a sheet of chitin which is continuous with the exoskeleton of the head ; articulated to this is a short, more or less quadrangular segment and then comes the actual biting part of the limb ; thus the actual cutting edge is the terminal portion of a ramus and is not, as it usually is in the mandible of other groups, a part of the basal segment. The mandible in *Lithotrya nicobarica* agrees exactly with Hansen's account and, further more, a study of this appendage in an example that has been cleared in caustic potash shows that the so-called labial palp is in reality a part of the mandible and consists of two regions, the proximal of which articulates with the basal segments of the mandible on the anterior side of the articulation for the masticatory part and bears a few setae on its outer border at the distal end. The whole appendage, therefore, in reality consists of a basal part and a pair of rami, of which the outer ramus, the palp, possesses two segments and the inner ramus but one. The palps in this genus are stated by Darwin (1851, p. 348) to be " blunt and even squarely truncated at their ends ; they are of large size, so that if they had been half as large again or even less, their tips would have met." There appears to be but little difference in the

shape and character of this organ in the various species; in *Lithotrya dorsalis* and *L. cauta* it is stated by Darwin (1851, pp. 354 and 358) to



TEXT-FIG. 14. The mandible and palp of *Lithotrya nicobarica*.

be bluntly pointed, and Hoek (1907, p. 125) describes it in *L. conica* as being short, conical, with the tip rounded. There are some differences in the various accounts of this structure in *L. nicobarica*, for Darwin (1851, p. 362) states "palpi with their ends square and truncated; thickly clothed with long spines." Hoek (1907, p. 123), however, says that the "palpi have their ends rather more rounded than truncated." In my experience Hoek's description is much more nearly correct, though there is some degree of variation. In not a single example have I found the palps to be truncated; in some they are more bluntly pointed than in others but I have been unable to correlate this difference with any definite change in the size of the individual. In its general structure this appendage exhibits some resemblance to the maxillula of other Crustacea, but, as Borradaile points out, Hansen's suggestion that it is not a mandible and is really the maxillula, the true mandible being absent, involves one in difficulties with regard to the homologies of the other mouth-parts, since we must then assume that the opening of the excretory organ has migrated from the maxilla to the paragnathum. It is, I think, more probable that Borradaile is right and that the masti-

catory part of the appendage is derived from the endite and not from the gnathobase, as is more usual.

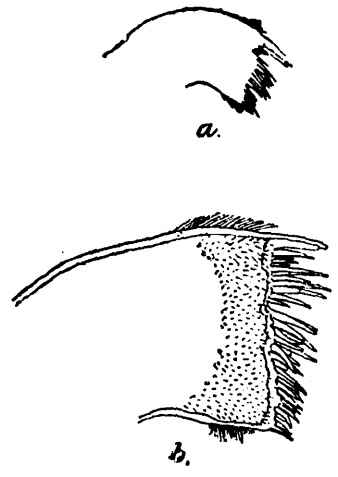
The Maxilla.

(Text-fig. 15.)

The maxillae in all the various species of *Lithotrya* exhibit a close degree of resemblance, both in their general shape and structure. In all cases the appendage consists of two parts, a large and strong distal part, which bears at its end the masticatory lobe with the spine-like teeth, and an elongate narrow " apodeme " to which the muscles are attached. The biting margin and the attached spines are stated to exhibit in the various so-called species certain small differences, that have hitherto been regarded as constituting specific characters, and I give below the arrangement recorded in each case.

Commencing with *Lithotrya cauta*, Darwin (1851, p. 358) states that the maxilla is " with the two upper spines very large; beneath them there are two small spines, and a considerable notch; the inferior part of the edge is nearly straight, bearing about thirteen pairs of spines, obscurely divided into two groups, the lower spines being smaller than the upper ones. The upper convex margin is hirsute with long hairs." In *L. conica* according to Hoek (1907, p. 125) " the maxillae have a notch, two spines are inserted above it, half a dozen delicate ones in the notch and numerous pairs of spines beneath it. The inferior angle can hardly be said to be prominent." In *L. dorsalis* the maxilla (*vide* Darwin, 1851, p. 354) is " with the edge not quite straight, with the whole inferior part slightly projecting; spines very numerous, thirty or forty pairs; those close beneath the two upper great unequal spines, form a tuft and are rather thinner than the others, as are also those near the inferior angle; sides hirsute." The accounts by different authors of this appendage in *L. nicobarica* differ somewhat; Darwin (1851, p. 362) states that it is " with the edge very slightly irregular, beneath the two great upper spines is a slight notch, with some small spines; inferior angle slightly prominent, with a brush of moderately fine spines; besides these, there are about seventeen pairs of large spines; sides very hairy." Hoek (1907, p. 123), however, remarks that " the maxillae sometimes have the notch beneath the large upper and two smaller spines distinct, sometimes it is hardly visible. In no case have I observed two large upper spines. In the notch, or if it is absent in the place it occupies in other maxillae, three or four very short and delicate hairs are planted. Next follows a slightly protuberant part with 5 or 6 pairs of spines and then a second smaller notch. Then about 8 pairs of spines and finally the slightly prominent inferior angle with a brush of rather short spines." A study of this appendage in examples of different sizes shows that there are certain definite changes that are associated with an increase in size and it is impossible to conclude that they are other than age changes. In examples of the smallest size, having a breadth-measurement of only 3·5 mm. (Text-fig. 15 (*a*)), the biting margin of the maxilla is armed above with two large equal spines, below which is a distinct notch in which are planted three pairs of short

and comparatively delicate spines; below the notch the margin is nearly straight. Following the notch are six pairs of long spines and these are succeeded by eight pairs of thinner spines on the inferior part of the margin and round the inferior angle. The sides of the appendage are hirsute and the convex upper margin is fringed with long hairs. The condition at this stage clearly agrees closely with the description of



TEXT-FIG. 15. The maxilla of *Lithotrya nicobarica*.
(*a*) from a specimen having a breadth-measurement of 3·5 mm. ×35.
(*b*) from a specimen having a breadth-measurement of 8·5 mm. ×35.

the appendage in *Lithotrya cauta*. In the succeeding stage, in which the breadth-measurement is 5·0 mm., there are at the upper angle two large spines and one of medium size; these are followed by a small notch in which are planted three pairs of small spines. These again are succeeded by five pairs of medium-sized spines and then follows a second small notch. Finally there are at the inferior part of the border seven pairs of smaller spines. The inferior angle is not markedly produced and the sides of the appendage are hirsute. There is a tuft of long hairs on the upper margin near the angle. In a second specimen of approximately the same size, having a breadth-measurement of 5·5 mm., there is only a single large spine at the upper angle and a second smaller one beneath it. In the notch are four pairs of small spines and the succeeding two groups of spines consist of nine and twelve pairs respectively. In the stage of development in which the breadth is 8·5 mm. (Text-fig. 15 (*b*)) there are again two large spines followed by a distinct notch in which are four pairs of small spines. The next group of spines, of medium size, is divided into two by an additional small notch, the two sub-groups are composed of four and five pairs of spines respectively. The lower part of the edge bears sixteen pairs of small spines. The lower angle is somewhat prominent and the sides of the appendage are hairy. The usual tuft of long hairs occurs on the convex upper margin. In the largest size of all, having a breadth of 11·0 mm., there is again only a single large spine followed by one somewhat smaller. In the notch are four pairs of small spines; then follow five pairs of medium-sized spines, a second small notch and five more pairs of somewhat smaller spines; along the inferior part of the margin are about sixteen pairs of samll spines and the inferior angle is somewhat prominent

and is crowned with a small group of about four small flame-shaped spines. The sides are hirsute and the convex upper border bears the usual group of long hairs.

It is thus quite clear that the number of spines on the margin of the maxilla exhibits a steady increase with increasing size. The smallest example examined agrees closely with the condition stated to be characteristic of *Lithotrya cauta*. In the next stage the condition seems to be much akin to that of *L. conica*. The 8·5 mm. stage corresponds to the condition in *L. dorsalis*, with the exception of the two large spines at the upper angle. *L. dorsalis* is stated to have only two unequal spines as is also the case in the example of *L. nicobarica* that only measures 5·5 mm. in breadth. Finally the largest examples examined by me show a close agreement with the description given by Hoek of this species.

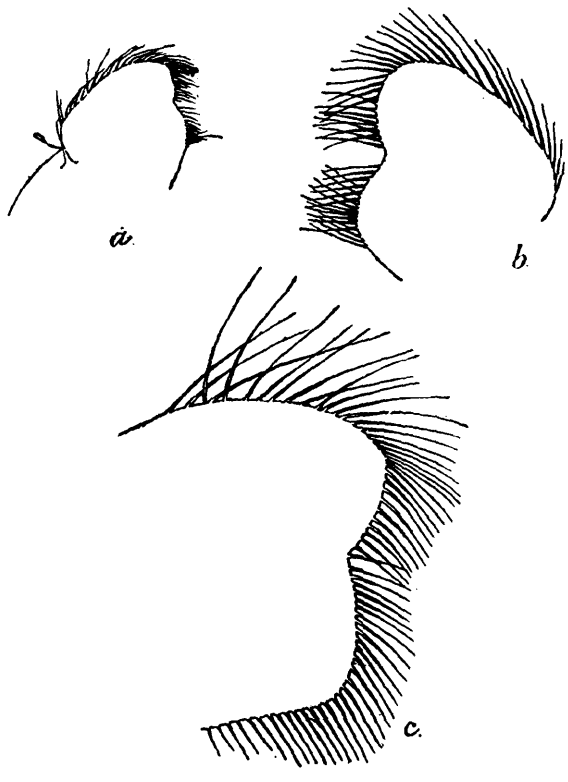
THE 2ND MAXILLA.

(Text-fig. 16.)

The third pair of oral appendages were regarded by Darwin as being a second pair of maxillae. Hansen (1925, p. 51) has put forward the view that this appendage is of a totally different character and in reality corresponds to the labium of other Crustacea or, as he terms it, the hypopharynx. As he points out, there is no trace of any fusion of two lateral organs in the middle line, such as one would expect if this structure were the remains of paired appendages; and he does not consider that the presence of the two openings of the excretory organs, which were mistaken by Darwin for olfactory organs, on the outer side of the appendage is sufficient ground for not accepting this view.

The appendage in all species is very similar as regards its shape but, according to the accounts given by the various authors, there would appear to be minor differences, which might be considered to have a diagnostic value, if they could be shown to be constant. In all the so-called species the outer or posterior margin is curved and is thickly provided with long, doubly-serrated spines or setae. The anterior inner border is stated to be slightly concave and is thickly clad with short spines, and in most species it is stated that the row of spines is continuous; this is the condition as described in *Lithotrya dorsalis*, *L. cauta* and *L. conica*; in *L. dorsalis* the appendage is stated to be blunt, while in *L. cauta* it is said to be rather pointed. In the case of *L. nicobarica* the accounts given by various authors differ; Darwin (1851, p. 362) states that the " inner margin (is) slightly concave, and with the spines continuous." Hoek (1907, p. 124), on the other hand, states that there is a " small but distinct notch between the upper and lower groups of spines;" this condition approximates to that found in *L. truncata*, in which, according to Darwin (1851, p. 370), the outer maxilla is " considerably concave in front, with the spines almost discontinuous in the middle part." In the examples of *Lithotrya nicobarica* that I have examined there is a considerable range of variation. In small examples (Text-fig. 16 (*a*) and (*b*)) the inner margin of the appendage is markedly concave, the two lobes of the margin meeting each other almost at an angle and there is also a very clear gap between the two

sets of spines on the two lobes. At this stage, therefore, the specimens resemble Hoek's account of *L. nicobarica* and Darwin's description of



TEXT-FIG. 16. The 2nd maxilla of *Lithotrya nicobarica* in specimens of different sizes × 35.

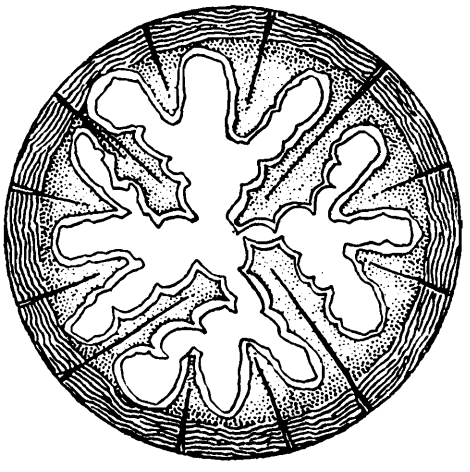
L. truncata. In larger examples (Text-fig. 16 (*c*)) the inner border is only slightly concave and there is little or no tendency to a division or gap between the two sets of spines; the extent to which the inner margin is indented also varies considerably in different specimens. It seems quite clear that in attempting to discriminate between the various species one can place no reliance on slight differences either in the shape of the appendage or in the arrangement of the spines.

The basal plate, to which the two appendages are attached, appears to consist of two parts. This seems to have been noticed by Darwin, for in his description of the Lepadidae (1851, p. 42) he remarks that the two orifices occur "on the exterior face of the outer maxillae, above a trace of an upper articulation." In *Lithotrya nicobarica* this condition can clearly be seen; the plate to which the appendages are articulated is separated by a clear articulation from a second, somewhat crescentic plate, which has the appearance of being perforated by a number of small holes.

THE ALIMENTARY CANAL.

The alimentary canal of *Lithotrya nicobarica*, as one would expect, agrees in its main features very closely with the condition characteristic of the Lepadidae. The canal consists of three regions, the oesophagus, stomach, and intestine. So far as I am aware, no investigations have been carried out on the embryonic development of these regions but it

seems justifiable to conclude that they correspond to the three embryonic areas of the stomodeum, the mid-gut and the proctodeum respectively, since, as Darwin has shown in the Lepadidae, and as I have been able to confirm in the genus *Lithotrya*, the oesophagus and the intestine are both lined throughout their length with a stout chitinous investment, whereas the stomach or mid-gut is devoid of any such covering though the contents of the gastric cavity appear to be enclosed in a sac-like structure that is composed of a very delicate wall of either chitin or some chitin-like substance. The oesophagus, as in the Lepadidae, is of considerable length. Owing to the unequal length of the anterior and posterior lips the opening of the mouth looks somewhat backwards towards the abdominal cirri. The inner aspect of the mouth, on the anterior side and above the row of small teeth on the inner aspect of the labrum, is lined with a tongue-shaped area of thickened chitin, on either side of which there is smaller oval or rounded area, in which the chitin is also thickened, though to a less extent ; and these areas bear a number of delicate, backwardly-directed setae or hairs. The oesophagus passes at first forwards and downwards and then bends round, following with the stomach, the general curvature of the body. The oesophageal canal is surrounded by a thick layer of circular muscle-fibres and its inner wall is thrown into a number of folds, which appear to be of two kinds, primary and secondary (Text-fig. 17) ; the larger or primary folds are four in number and extend inwards till they almost meet each other in the centre ; between each pair of primary folds are two smaller secondary folds. There are thus twelve folds in all, running down the length of the oesophageal canal. A narrow, but well marked, radial band of muscle-fibres arises from the outer surface and, passing through the



Text-fig. 17. A transverse section of the oesophagus of *Lithotrya nicobarica*.

circular layer of muscle, is continued inwards into each radial fold. The inner wall of the oesophagus is lined with a thick layer of chitin, which is continuous through the aperture of the mouth with the chitinous investment of the body. The oesophagus opens somewhat abruptly into the cavity of the stomach and the actual orifice appears to be situated on a papilla that projects into the stomach cavity ; the chitinous lining of the oesophagus is reflected over this papilla and then rapidly thins out and ceases. The proximal region of the stomach, where the oesophagus enters, is surrounded by a dense glandular mass, which is

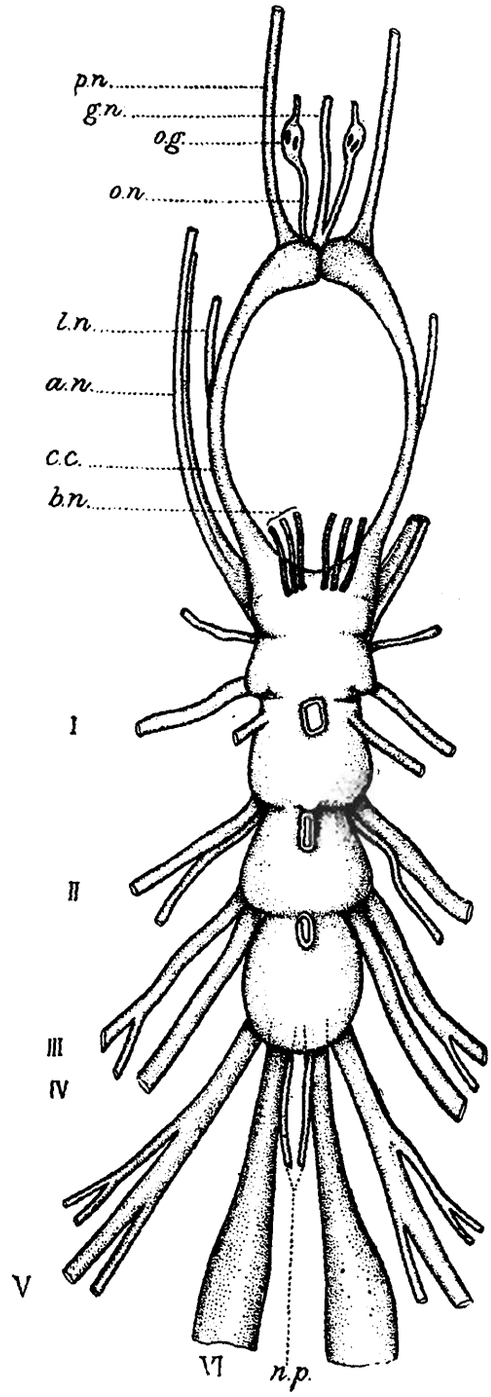
as a rule heavily pigmented and which probably has an hepatic function. The rest of the stomach is coated externally with a pulpy layer of glandular tissue, in which the glands are arranged in longitudinal lines and can occasionally be seen to branch. Darwin (1851, p. 45) states that the whole stomach is thus coated ; in *Lithotrya nicobarica*, however, there is an oval area on the dorsal aspect of the stomach, where it comes into close contact with the chitinous covering of the body, over which this glandular layer is very largely reduced or is even altogether absent. The contents of the stomach in this genus seem to be identical with those other Cirripedes : Darwin (1851, p. 45) states that " the prey, consisting generally of crustacea, infusoria, minute spiral univalves, and often of the larvae of Cirripedes, is not triturated." An examination of the stomach-contents of *Lithotrya nicobarica* shows that the food consists largely of small gastropod molluscs, small copepoda and the ' cypris ' larvae of either other Cirripedes or possibly those of *Lithotrya* itself, as well as of finer debris or detritus. In several examples it was found that the curved cirri held in their concavity a number of small sand grains, and in one or two cases copepods were seen transfixed by the doubly-serrated spines of the segments of the rami. Although I have in no case found actual sand grains in the stomach-contents of *Lithotrya nicobarica*, it seems probable that these may find their way into the mouth, since in more than one instance several or even most of the smaller denticles between the large primary teeth had been broken off, but probably when this occurs the stony particle is rejected and not swallowed. The gastric contents appear to be enclosed in a capsule of thin chitin, which is, however, quite separate from the inner wall of the stomach itself. The intestine is narrower than the stomach and passes back near the carinal or dorsal margin of the body to the anus ; this region of the alimentary canal is, like the oesophagus, lined with a thin layer of chitin. The anus is situated at the extreme end of the body and immediately posterior to the commencement of the long penis, having the basal portion of the 6th cirrus and the caudal appendage on each side.

THE NERVOUS SYSTEM.

(Text-fig. 18).

The nervous system of *Lithotrya nicobarica* differs in several important features from that of examples of both the genera *Lepas* and *Pollicipes*. Darwin in his account of the nervous system in the Lepadidae states (1851, p. 46 *et seq*) that " in most of the genera there are six main ganglia, namely, the supra-oesophageal, and five thoracic ganglia ; but in *Pollicipes mitella* there are only four thoracic ganglia. Of these, the first or infra-oesophageal ganglion is considerably the largest and most massive." As Koehler (1889, p. 202) has pointed out, the fourth and fifth ganglia are in close relationship to each other and the nerves uniting them are, in consequence, very short, so short indeed that in the genus *Pollicipes* the two ganglia are actually in contact. It is this union of the two ganglia in this genus that has caused Darwin to state that there

are only four thoracic ganglia. In the genus *Lithotrya*, if *L. nicobarica* can be taken as an example, the supra-oesophageal ganglia are pear-shaped and are small in comparison with the other and more posterior ganglia ; the two ganglia are united together at their broad ends without any intervening commissure and the narrow posterior ends are continued backwards as the two circum-oesophageal commissures. From the anterior aspect of the ganglia arises, on each side, a stout nerve,



TEXT-FIG. 18. The central nervous system of *Lithotrya nicobarica* ; a.n., adductor nerve , b.n., buccal nerves ; c.c., circum-oesophageal commissure ; g.n., gastric nerve ; l.n., lateral nerve ; n.p., nerves to the penis ; o.g., optic ganglion ; o.n., optic nerve ; p.n., peduncular nerve ; I—VI, nerves to the 1st—6th cirri.

the peduncular nerve, and near the middle line three nerves arise, of which the outer pair are the larger ; this outer nerve appears to

correspond to the nerve to the optic ganglion, described by Darwin in *Lepas fascicularis* and other species of the family Lepadidae, but up to the present I have been unable to trace the ultimate distribution of the branches. After a short course the nerve enters a small but definite optic ganglion and from the anterior end of this a nerve passes to the eye. Gruvel (1905, p. 408) states that the eyes in *Lithotrya* are fused to form a single mass, as in the genus *Lepas*. I have, unfortunately, up to the present time completely failed to detect the eye itself in any of the examples of *L. nicobarica* that I have dissected, though I have been able to trace the nerve as far as the ganglion and to see the commencement of its continuation from there towards the eye. The long circum-oesophageal commissures pass backwards on either side of the oesophagus, giving off the lateral nerves about half way along their length, and unite posteriorly with the two fused sub-oesophageal ganglia. As in the genus *Lepas* the sub-oesophageal ganglion is of a square shape, but in this genus is not markedly larger than the following ganglia and it presents no trace of being formed of two lateral ganglia. From below and behind the point of origin of the circum-oesophageal commissure there arises on each side of the ganglionic mass a large nerve that appears to consist of two parts ; this passes downwards and forwards around the oesophagus to supply the large adductor muscle of the two scuta. Immediately behind the origin of this nerve and the commencement of the circum-oesophageal commissure there is a constriction in the lateral wall of the ganglion that gives to it an appearance as if the ganglion were originally composed of two parts, an anterior, from which arise the commissures, the adductor nerves and the three nerves to the buccal mass, which have their origin on the dorsal aspect of the ganglion near its anterior border, and behind this constriction the ganglion exhibits on each side a small swelling in the postero-lateral region from which arise the two large nerves to the first pair of cirri ; from the anterior part of this region a smaller nerve arises and passes to the viscera, while from the posterior region yet another nerve arises and runs to the muscles below the cirrus. It thus seems clear that this ganglion is in reality two that have become fused, namely the sub-oesophageal ganglion proper and the 1st thoracic ganglion. Behind the sub-oesophageal ganglion are three more visceral ganglia ; each of these is connected to the ganglion in front by a pair of stout short nerve-cords between which there is, in each case, a circular or oval passage. Neither of the posterior ganglia exhibits any trace of division into lateral regions. From the 1st visceral (or 2nd thoracic) ganglion arise a pair of nerves, the stouter of which passes to the 2nd cirrus. The 2nd visceral ganglion sends off from each postero-lateral aspect a pair of large nerves that run respectively to the 3rd and 4th cirri ; it would seem clear, therefore, that this ganglion is in reality the result of the fusion of the third and fourth thoracic ganglia. The 3rd visceral ganglion from its posterior aspect sends off two pairs of large nerves to the 5th and 6th cirri respectively and from its extreme posterior part there arise a pair of small nerves that supply the penis. Here again it seems clear that this ganglion is in reality formed from the fusion of two originally separate ganglia, namely those of the 5th and 6th thoracic segments. The nerve to the 5th cirrus breaks up into a number

of smaller branches, while that to the 6th cirrus is at first rounded but later swells out into a broad ribbon-like structure.

The arrangement of the various ganglia in the line of the ventral nerve cord seems to provide a very clear diagnostic feature between the various genera in the Family Lepadidae ; in the genus *Lepas*, of which *Lepas fascicularis* may be taken as an example, the first four thoracic ganglia are separate and supply nerves to the first four pairs of cirri, while the fifth and sixth ganglia, supplying the 5th and 6th cirri, are fused ; in the genus *Pollicipes*, of which *P. mitella* may be taken as the type, as Darwin points out (1851, p. 48) " there are only four instead of five thoracic ganglia, it is evident from the outline and position of the nerves going to the fourth pair of cirri, that the fourth ganglion is fused into the fifth, itself, as we have just seen, normally composed of two consecutive ganglia." In this genus, therefore, the posterior ganglion of the series is in reality formed by the fusion of three ganglia, namely the fourth, fifth and sixth. Gruvel (1905, p. 408), in his description of the nervous system of *Pollicipes cornucopia* and *P. polymerus*, endorses the account given by Darwin of this system in *P. mitella*. In all three species the last two ganglia in the chain are in close apposition and the terminal ganglion is in reality the fused ganglia of the fifth and sixth segments of the thorax. Gruvel remarks " Celle qui donne naissance aux nerfs de la cinquième paire est placée au-dessus de celle qui fournit ceux de la sixième. C'est ce que l'on observe également dans le genre *Lithotrya* où le système nerveux est à peu près semblable à celui du genre *Pollicipes*, mais les yeux forment une masse unique." In the genus *Lithotrya*, if *L. nicobarica* may be taken as a guide, the posterior ganglion of the series is, as in the genus *Lepas*, composed of the fused fifth and sixth ganglia, but the immediately preceding ganglion is in this species formed by the fusion of the third and fourth ganglia and so supplies the third and fourth pairs of cirri. *Lithotrya nicobarica* certainly resembles *Pollicipes* in the possession of only four instead of five ganglia in the ventral chain but differs in the manner in which these have become fused together.

REPRODUCTIVE SYSTEM.

As in other Cirripedes, all the species of *Lithotrya* appear to be hermaphrodite, though up to the present time no complemental or parasitic males have been discovered in this genus. The general anatomy of the two sets of organs—male and female—agrees closely with that of *Lepas*. The testes form a scattered racemose gland that spreads throughout the body. The vesiculae seminales, lying on each side of the body, are large and the broad blunt end lies anteriorly on each side of the prosoma ; in certain specimens there is a blunt broad diverticulum from the ventral aspect. The ducts from the testes converge and fuse together before entering the vesicula by a single aperture. The vesicula seminalis is surrounded by circular muscle-fibres and owing to more or less localised contractions of this layer the organ occasionally appears to consist of two regions, an anterior wide part and much narrower posterior portion. From the posterior end of the vesicula the vas deferens arises and passes backwards to the extreme posterior end of the body ; at the base of the

penis the two ducts unite together to form a single channel, that passes up the penis and opens at its extreme tip by a small round aperture, the entrance to which is guarded by several small spines or hairs. The penis is heavily pigmented and is corrugated or ringed ; the basal part is ringed on its posterior aspect only and this is followed by a short and somewhat constricted portion in which there is no trace of any corrugation. The terminal region, which is much the longest, is again ringed throughout its whole length with the exception of the extreme tip. Throughout the greater part of the long flexible portion of the penis these rings are complete, but near the base the anterior and posterior surfaces are grooved alternately by a series of half rings which overlap and alternate with each other at the sides. There are in all some 58 to 60 rings. The extreme tip is nipple-shaped with a terminal aperture.

As Darwin (1851, p. 349) has shown the ovary fills the basal portion of the peduncle. The main part of the organ lies at the extreme end of the cavity, between the two lateral retractor muscles, and extends for a short distance up the sides of the cavity though never reaching as far as the bases of the scuta and terga. The remote position of the ovary is probably correlated with the high degree of contractility of the peduncle. In full-grown examples the organ is pigmented with scattered black granules, so that in its general appearance it has a grey colour. The ovary appears to develop at a somewhat later stage than the testes. In the smallest examples, 3·5 mm. in breadth, the testes and vesiculae seminales are already well-developed and appear to be functional, whereas the ovary is extremely small and the oviducts appear to be solid masses of epithelial cells without any distinct lumen. It would appear probable, therefore, that *Lithotrya*, though hermaphrodite in the fully adult stage, is protandrous.

The oviducts open on a small rounded elevation at the base of the first free segment of the pedicel of the 1st cirrus. The terminal portion of the duct is expanded into a globular or oval cavity. This cavity was observed by Darwin, who, however, considered it to be an accoustic organ. It appears probable that this sac secretes the chitinous envelope of the ova.

Out of eleven examples examined by me three were ovigerous. The eggs are deposited in two circular, flattened or slightly concave discs, that lie free in the cavity of the capitellum and upper part of the peduncle on either side of the body. In one example a number of eggs were, in addition, loose in the cavity of the peduncle. I could find no trace in any example of *Lithotrya nicobarica*, that I examined, of ovigerous fraena. Darwin (1851, p. 300) records that in *L. truncata* the fraena are large with an almost bilobed outline ; the margin and whole lateral surface being covered with elongated cylinders, finely pointed but not enlarged at their extremities, as are the glands observed in most of the other genera. The eggs in *Lithotrya nicobarica* are oval in shape but are more sharply pointed at one end ; they appear to be covered with a delicate chitinous covering or shell. In length they vary slightly in different individuals, ranging from 0·235 mm. to 0·276 mm. ; their breadth is about 0·098 mm. Darwin (1851, p. 349) only saw the eggs in *Lithotrya truncata ;* in this species he notes that the eggs were

oval and large, being nearly 4/900ths of an inch (0·570 mm.) in length. We appear to have here two definite points of difference between *Lithotrya nicobarica* and *L. truncata.* Darwin does not state that the fraena are absent in the other species that he examined; as, however, he examined numerous specimens of *L. dorsalis,* it seems justifiable to conclude from his silence on the point that they are not present in that species and that in this respect *L. dorsalis* and *L. nicobarica* resemble each other.

A general consideration of the above-mentioned facts and of the various changes that occur in individuals of the species *Lithotrya nicobarica,* as size and age increase, induces me to believe that several so-called species, which have up to the present time been regarded as distinct, are in reality merely different varieties or life-phases of one single species.

Our knowledge of *Lithotrya rhodiopus* is confined to the imperfect account given by Darwin, and, in consequence, its relationships to other forms must remain doubtful. To judge from the general characters of the valves, *Lithotrya truncata* and *L. valentiana* are closely related and may even be identical. *Lithotrya truncata* would certainly appear to be a different species from *L. nicobarica,* but the same cannot be said of *L. cauta, L. dorsalis, L. pacifica* or *L. conica.* As Darwin himself (1851, p. 350) remarks "it is not easy to imagine a better marked series of transitional forms, than those presented by the terga, in passing from *L. dorsalis* through *L. nicobarica, L. rhodiopus* and *L. truncata* to *L. valentiana*" and it may thus be possible that all these forms are, in reality, merely different varieties or phases of a single species. I hesitate, however, to include the last two forms, but the remainder, namely :—

Lithotrya cauta Darwin
Lithotrya nicobarica Reinhardt
Lithotrya conica Hoek
Lithotrya pacifica Borradaile
Lithotrya dorsalis Sowerby
Lithotrya dorsalis var. *maldivensis* Borradaile
Lithotrya dorsalis var. *rugosa* Borradaile

are, I believe, all representatives of a single widely distributed and somewhat variable species; and such differences as have been noted are due probably to age or to individual variation. If this be correct, the name *L. dorsalis* will have priority.

APPENDIX.

Serial number.	No. of zones of *Scutum*.		No. of zones of *Tergum*.		No. of zones of *Latera*.		No. of zones of *Rostrum*.	No. of zones of *Carina*.	No. of scales subjacent to *Latera*.		No. of scales subjacent to *Tergum*.		No. of scales subjacent to *Rostrum*.	Diam. of Capitellum at base.
	Right.	Left.	Right.	Left.	Right.	Left.			Right.	Left.	Right.	Left.		
														mm.
1	10	7	9	7	8	6	2	6	5	5	1	1	4	3·0
2	9	9	9	9	6	8	3	7	4	4	2	2	2	3·5
3	9	11	..	9	..	4	4	7	5	5	2	1	5	5·0
4	8	9	8	8	4	6	6	7	5	4	2	1	4	5·0
5	10	11	11	12	6	7	3	6	5	5	2		3	5·5
6	11	10	..	5	5	8	6	10	5	4	4	4	4	5·5
7	8	10	7	6	3	4	3	6	5	4	2	3	5	5·5
8	..	11	..	9	..	6	2	8	..	3	..	3	3	5·5
9	11	9	10	12	7	7	3	9	5	5	1	2	3	6·0
10	8	7	5	6	7	5	4	7	6	6	2	3	5	6·0
11	16	17	8	9	5	5	5	8	6	5	3	2	6	6·5
12	14	12	9	10	6	1	7	6	6	5	2	2	4	6·5
13	..	8	..	4	..	4	3	6	..	5	..	2	5	6·5
14	6	6	7	6	5	6	5	7	6	6	2	2	4	6·5
15	6	8	5	5	5	4	4	7	5	5	2	..	4	7·0
16	12	12	9	13	7	10	8	13	6	5	1	5	4	7·0
17	7	7	7	11	4	5	5	7	5	5	2	2	4	7·0
18	8	10	10	9	6	3	6	8	5	4	3	3	5	7·0
19	9	11	..	18	4	5	4	10	6	6	2	2	7	7·0
20	6	6	6	7	3	3	3	6	5	4	1½	2	4	7·0
21	9	10	7	8	4	4	3	5	6	6	1	1	4	7·0
22	8	9	9	9	3	4	2	7	5	5	1	1	4	7·0
23	6	10	5	7	5	4	4	9	5	4	4	3	5	7·0
24	8	9	6	10	5	5	9	6	5	5	3	2	7	7·0
25	11	10	..	9	5	4	4	8	4	5	2	2	6	7·0
26	11	7	5	7	5	5	5	9	5	5	..	2	4	7·5
27	10	11	8	8	5	5	7	7	5	5	3	3	5	7·5
28	6	9	5	9	5	4	5	5	5	5	2	2	7	7·5
29	9	5	6	3	4	3	6	6	4	5	2	2	5	7·5
30	10	7	4	6	4	4	4	4	7	6	1	1	6	7·5
31	6	8	6	6	5	3	4	9	5	6	3	3	6	7·5
32	8	9	9	9	7	6	6	9	5	5	3	2	5	7·5
33	8	11	9	9	4	6	6	7	5	5	4	2	8	7·5
34	14	14	8	9	6	7	7	9	5	4	2	2	5	7·5
35	7	11	8	7	4	6	4	6	6	5	2	2·5	4	7·5

Serial number.	No. of zones of *Scutum.*		No. of zones of *Tergum.*		No. of zones of *Latera.*		No. of zones of *Rostrum.*	No. of zones of *Carina.*	No. of scales subjacent to *Latera.*		No. of scales subjacent to *Tergum.*		No. of scales subjacent to *Rostrum.*	Diam. of capitellum at base.
	Right.	Left.	Right.	Left.	Right.	Left.			Right.	Left.	Right.	Left.		
														mm.
36	10	7	10	6	11	8	4	12	6	7	3		8	8·0
37	6	6	6	7	4	4	6	6	4	5	2		5	8·0
38	7	8	6	8	7	7	6	10	5	5	1		6	8·0
39	12	17	6	10	5	5	4	12	5	5	2		7	8·0
40	6	7	7	8	5	5	7	9	5		2		4	8·0
41	7	6	5	5	7	5	4	7	6	4	2		5	8·0
42	9	17	9	9	5	5	6	9	7	6	3	3	6	8·0
43	8	9	5	6	4	5	5	8	5	5	2	2	5	8·0
44	8	9	5	7	4	5	4	6	5	5	3		6	8·5
45	5	7	9	7	6	4	5	8	5	5	2		4	8·5
46	9	8	8	7	7	6	5	9	6	6	2	2	5	8·5
47	10	9	5	8	4	5	4	9	7	5	2	2	8	8·5
48	7	6	4	11	4	4	2	5	4	5	2	3	5	8·5
49	8	8	9	9	5	3	5	7	5	4	2	2	4	8·5
50	8	10	9	9	6	5	5	16	5	6	3	1	5	9·0
51	9	11	9	9	8	10	3	14	5	5	3		5	10·0
52	5	8	7	6	5	5	5	7	5	5	2		5	10·0
53	12	10	9	8	4	5	4	8	6	7	3		4	10·0
54	5	9	4	15	3	4	3	6	6	6	2		5	10·0
55	8	8	8	8	9	7	7	8	6	7	2		8	10·5
56	11	12	11	7	6	10	5	12	6	6	3		5	10·5
57	5	5	5	9	1	2	2	5	5	4	2		6	10·5
58	7	7	3	6	2	5	4	11	6	6	2	...	5	11·0
59	6	9	10	11	3	4	4	7	8		2		6	11·0
60	8	9	5	6	5	6	4	6	6	7	4		6	11·5

In the above appendix I have given the size, measurement, No. of zones in the valves, and the number of calcareous scales subjacent to the Latera, Terga and Rostrum in 60 examples of *Lithotrya nicobarica.*

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