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**SPINY LOBSTERS
OF CEYLON**

by

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INTRODUCTION

Spiny lobsters of the family *Palinuridae* are known to exist in parts of Asia such as India, Japan, Indonesia and Malaya. In Ceylon spiny lobsters are caught chiefly by a primitive type of gear designed to catch these species and incidentally by nets set to catch fish. The limitations of these types of gear and the results of experimental fishing in Ceylon with different designs of lobster traps have been discussed earlier. As a result of these experiments a very effective trap for capturing spiny lobsters was developed and it was shown that spiny lobsters were present in large quantities. (De Bruin 1960). This created great interest among skin-divers who found lobster fishing very remunerative.

Lobsters are a highly favoured item of food in the United States of America which presently imports the greater part of the catch of such well developed fisheries as exist in S. America and Australia. The demand for this commodity in America is still unsatisfied and enquiries have been made by interested businessmen for supplies from Ceylon.

In Ceylon a well organized fishery has yet to be developed and little is known of the extent of lobster resources. Moreover, nothing is known of the species that exist in commercial quantities, or of their biology or of the effect of intensive fishing on the populations that are present in any particular area.

Work was therefore undertaken to determine the effect of continuous fishing on the lobster populations present in a restricted area and to determine the distribution of the dominant species in the reefs round Ceylon. Investigations also covered the biology of the dominant species.

For this investigation, skin-diving and the trap proved to be the most effective in the earlier work (De Bruin 1960) were the methods employed to obtain lobsters.

SPECIES OF THE GENUS PANULIRUS IN CEYLON WATERS

Six species of the genus *Panulirus* were found in Ceylon waters. Descriptions of these species and a key to their identification are given below.

Panulirus penicillatus (OLIVIER)

Fig. 1

The antennular somite is armed with a pair of large anterior spines and a pair of small posterior spines. The small spines are fused to the base of the larger spines.

A blue patch, semi-circular in shape, is prominent at the base of the second antenna. This spreads from the lateral border of the antennular somite to the lateral border of the basal joint of the second antenna.

The cephalothorax is divided into a anterior spiny region and a posterior, relatively unarmed region, bearing numerous nodules. The tips of all spines in the anterior region of the carapace and the second antenna are brown in colour, the bases being yellow.

The walking legs are dark olive-green in colour with pale yellow stripes running along their length. The abdominal somites are transversely grooved, the grooves being uninterrupted on all six somites. The abdomen is smooth, its lateral borders produced into long backwardly directed spines, one corresponding to each somite. Furthermore, a small tooth is present between two somites on all but the first and sixth abdominal somites.

The pleopods are dark olive-green in colour with white lines running along their margins.

The third maxillipede has a single-jointed exopod without a flagellum.

The second maxillipede has an exopod with a many-jointed flagellum.

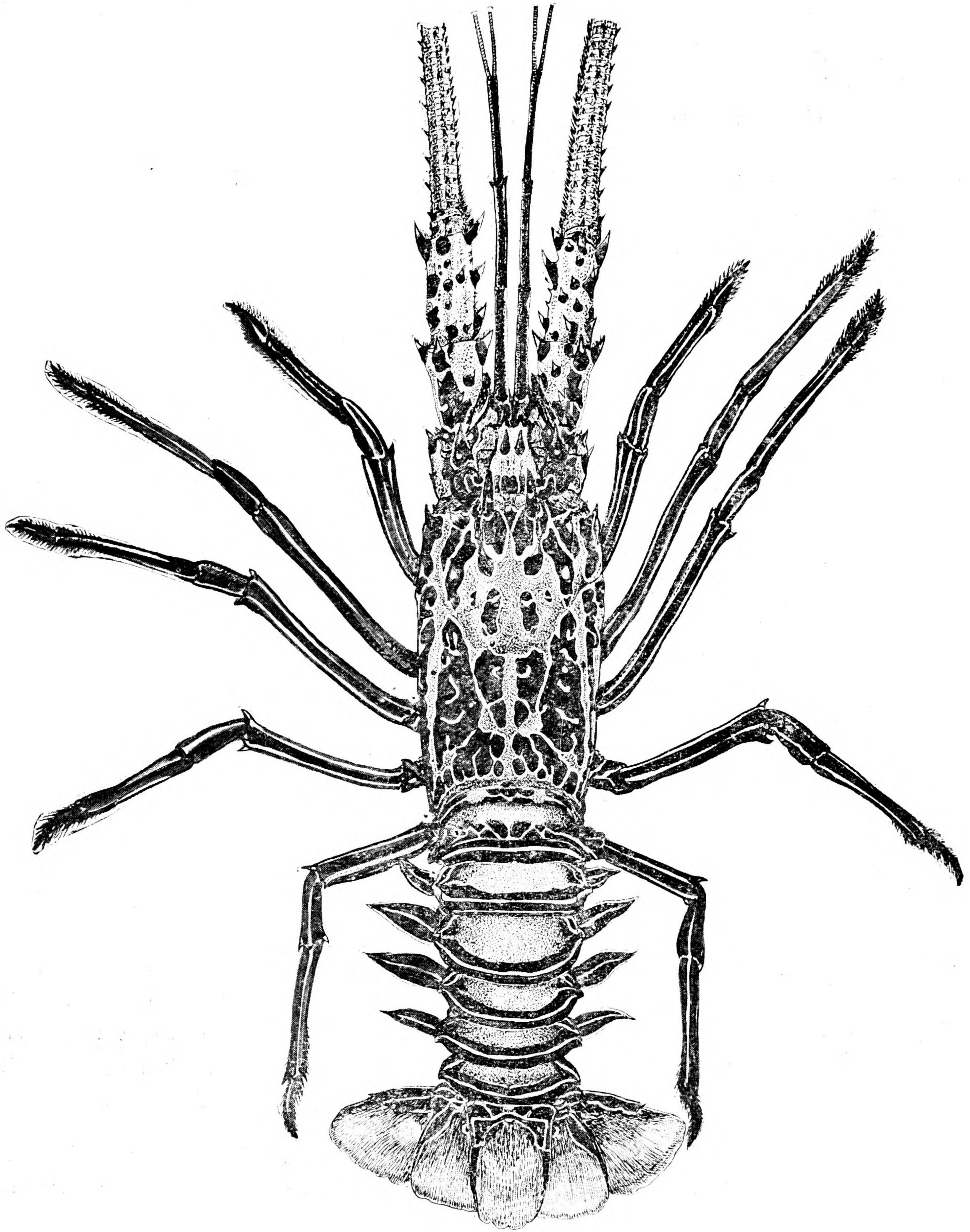


Fig. 2—*Panulirus versicolor* (LATR.)

Panulirus versicolor (LATR.)

Fig. 2

Two pairs of conical spines are present on the antennular somite, the anterior pair being twice the size of the posterior pair. The rest of the somite is unarmed.

The flagella of the first antennae are white in colour.

The post-orbital spines are large and anteriorly curved.

The cephalothorax is divided into an anterior spiny region and a posterior less spiny region.

Wavy white lines are present along the eyes, the post-orbital spines and along the cephalothoracic carapace. The base of the carapace is dark bluish black.

Each walking leg is bright bluish-green in colour with striking white lines running along its length.

The abdomen is not grooved in adults but in small specimens (less than 2") rudimentary grooves are present. These observations agree with those made by Barnard (1950). Each abdominal somite has a dark blue, almost black band running across the somite, with a brilliant white line running along the middle of the black band. A lateral abdominal spine is present on all six segments. In addition, there is a cluster of four spines on the lateral border of the third, fourth and fifth abdominal somites.

The pleopods are bluish-green with distinct white lines running in the middle.

The base of the telson, which is calcareous, has symmetrical wavy white lines forming a white triangle on each side. The third maxillipede has no exopod, the second maxillipede has a single jointed flagellum.

Panulirus dasypus (LATR. M. EDW.)

Fig. 3

The antennular somite has four principal spines, the anterior pair being only slightly larger than the posterior pair. In one of 236 specimens examined there were six principal spines arranged "en carre". In the centre of these four principal spines, a group of spinules is present.

The first antenna is olive-green in colour, there being white patches at the articulations of the segments. The flagella of the first antennae are also olive-green in colour, with white bands along their length.

The cephalothorax is divided into an anterior region bearing many forwardly directed spines and a few tubercles and a posterior region with few spines but many tubercles. Tiny yellowish-white spots are found distributed throughout the carapace.

The walking legs are olive-green in colour, with numerous small yellowish-white patches.

The abdomen is olive-green in colour dotted with numerous small yellowish-white spots. These spots are small on segments one, two and three but conspicuously larger on segments four, five and six. A conspicuous white patch is found on the antero-lateral region of each abdominal somite. Each somite is produced laterally into a backwardly directed spine while a cluster of four spines is present laterally on somites two to five as in *P. versicolor*. The abdominal somites are grooved transversely but the interruption of these grooves medially is a very variable feature.

Table I below gives an indication of the extreme variability of this feature.

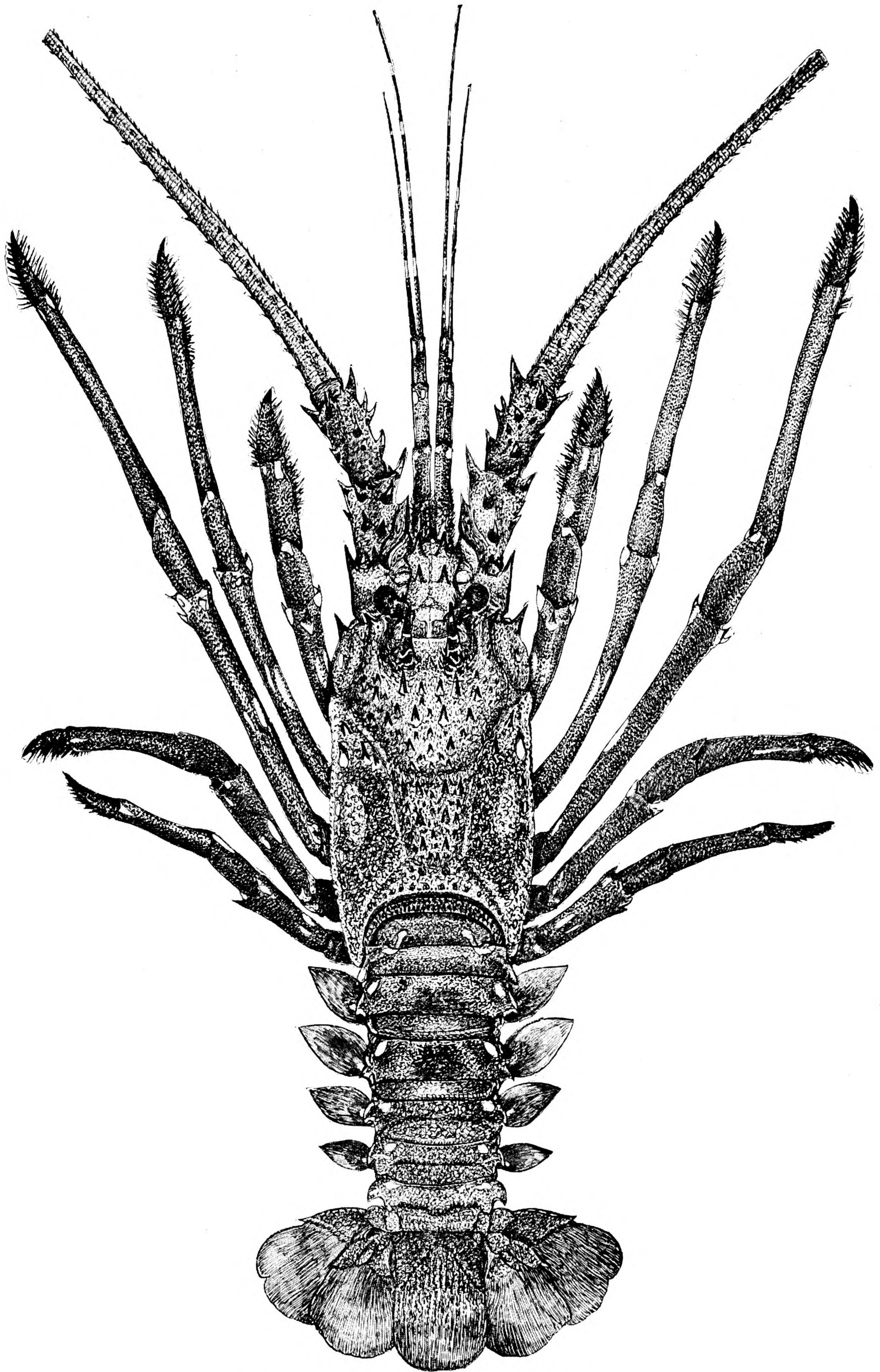


Fig. 3—*Panulirus dasypus* (LATR. M. EDW.)

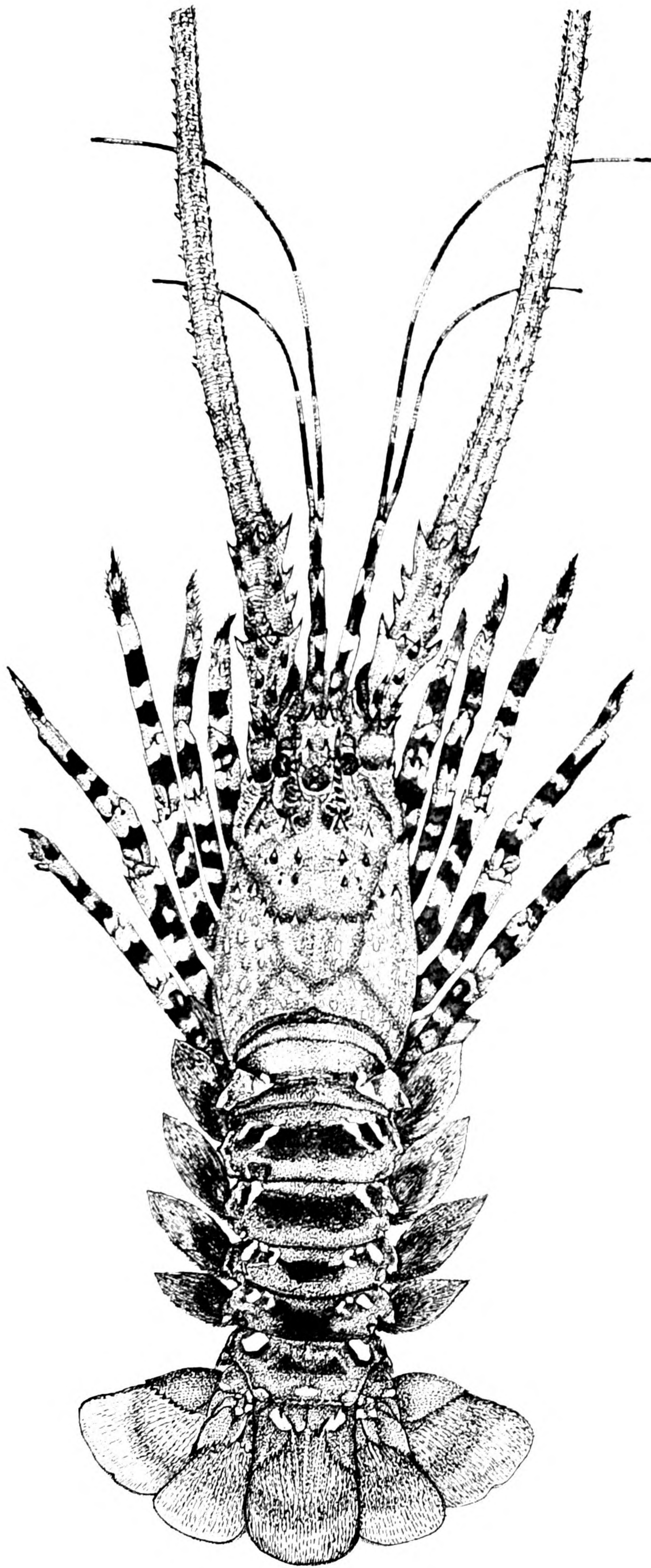


Fig. 4—*Panulirus ornatus* (FABR.)

Segmental groove interrupted medially	No. of lobsters
First only	Nil
Second only	Nil
Third only	1
Fourth only	4
Fifth only	13
Sixth only	Nil
Second and Third	1
Second and Fourth	Nil
Second and Fifth	1
Third and Fourth	7
Third and Fifth	7
Fourth and Fifth	12
Second, Third and Fourth	Nil
Second, Third and Fifth	2
Second, Third, Fourth and Fifth	99
Third, Fourth and Fifth	83
Second, Fourth and Fifth	3
All grooves 1, 2, 3, 4, 5 and 6 uninterrupted	3

Table I.—NUMBER OF LOBSTERS WITH RESPECTIVE ABDOMINAL GROOVES INTERRUPTED MEDIALY

It is clear that only in 3 of the 235 lobsters examined, the abdominal grooves are uninterrupted on all six segments. It must be noted that this feature separates *P. burgeri* (de Haan) from *P. dasypus* (Latr. M. Edw.). Considering the extreme variability in this feature in the specimens examined, there is considerable doubt as to the identity of the species *P. burgeri* (de Haan). *P. burgeri* (de Haan) and *P. dasypus* (Latr. M. Edw.) may be one and the same species.

There is no exopodite on the third maxillipede.

The second maxillipede may or may not have a flagellum. There is considerable variation in the number of joints constituting the flagellum when present as seen in Table II below.

No. of joints on flagellum of 2nd maxillipede	No. of lobsters
0	101
1	98
2	19
3	6
4	6
5	3
6	3

Table II.—NUMBER OF JOINTS ON FLAGELLUM OF SECOND MAXILLIPEDE OF *P. dasypus*

Panulirus ornatus (FABR.)

Fig. 4

The antennular somite has four principal spines but the posterior pair is very much smaller than the anterior pair. Small scattered spinules are present on the antennular somite.

Both the anterior and posterior regions of the cephalothorax have numerous spines in young specimens. In older specimens the number of spines on the posterior region of the carapace is considerably reduced. The spines are orange at the base and light green at the tip. Numerous nodules are also present on the posterior region of the carapace there being only a few on the anterior region.

The base of the second antenna and the anterior region of the carapace is vermiculate. Bright orange spots are present on the posterior region of the carapace. The walking legs of this species are decorated with alternate bands of cream and maroon. The peduncles and flagella are also similarly banded.

The antero-lateral border of each abdominal segment has a distinct dark patch while a second less conspicuous mark is present medial to the first patch. Each abdominal segment is produced laterally into a backwardly directed spine and in addition a cluster of spines close to the above spines are present on segments two to five.

The calcareous base of the telson has two white patches on either side of the medial line just behind the posterior border of the last abdominal segment.

The exopod of the second maxillipede has no flagellum but only a tuft of setae.

Panulirus japonicus (VON SIEBOLD)

Fig. 5

In Ceylon specimens the antennular somite has two principal spines, posterior to which are 4-6 irregularly arranged spinules. Sheard (1949) separated the two closely allied species—

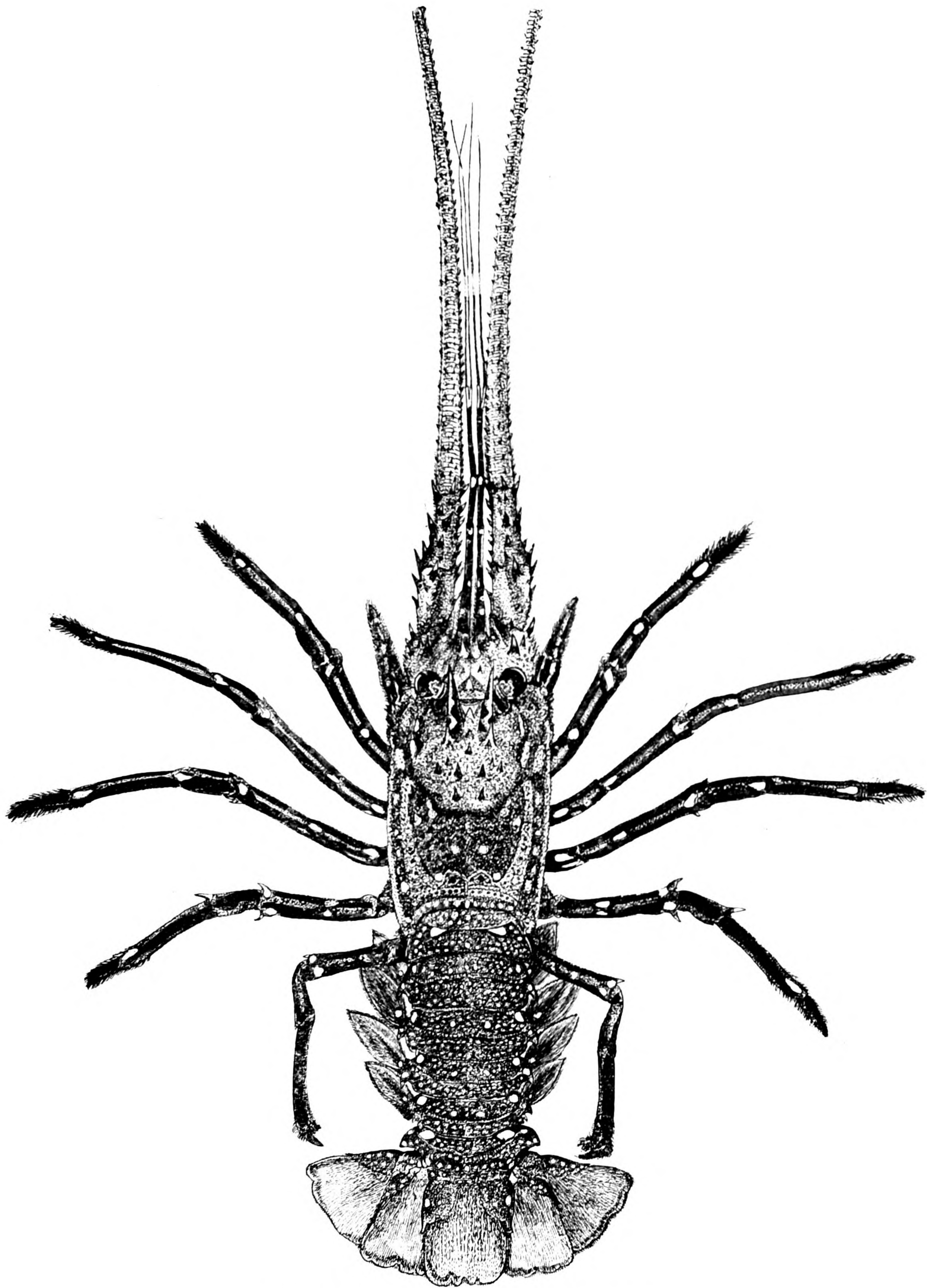


Fig. 5—*Panulirus japonicus* (VON SIEBOLD)

P. japonicus and *P. longipes* on the following grounds:—in *P. longipes* there are 4–6 tubercles anterior to the principal spines while in *P. japonicus* there are 3–5 small spines posterior to the two principal spines. According to Rathbun (1906), *P. japonicus* and *P. longipes* can scarcely be separated as distinct species. She states that “in the Hawaiian species, there are specimens in which the violet and yellow colours predominate and others which are red throughout the body except for yellow spots and abdominal stripes. Some specimens have the abdominal part hairy as in the Japanese specimens. There remains only the character of the greater or lesser development of the spinules in the antennular segment between the former as it exists in Japan and the latter as it exists in the Indo-Pacific.” The colour of the Ceylon specimens agrees with the description given by Barnard (1950) in that the ground colour is violaceous or indigo, yellow-white spots being found on the larger spines of the carapace. The abdomen is dotted with yellow-white spots, there being a large spot on the lateral border of each abdominal segment. The peduncles of both antennae have white marks, the flagella possessing white bands.

The legs and third maxillipede are violaceous in ground colour with yellowish-white longitudinal stripes and a few white spots.

A yellowish-white spot is present on the base of each pleopod except that of the first and second segments.

The Ceylon specimens agree with the description of *P. japonicus* given by Kubo (1954) in that the antennular segment has two principal spines, posterior to which are a few scattered spinules. Moreover, they agree with the Japanese specimens in that the frontal edge of the antennular somite has a few tubercles.

They differ from the description of *P. longipes* in that the spinules posterior to the two principal spines in Ceylon specimens are arranged irregularly and become smaller posteriorly.

Holthuis (1946), following Gruvel (1911) has united *P. longipes* with *P. japonicus* since he considered the difference in colouration may be without systematic significance. Kubo (1954), however, considers it justifiable to split the two species, since they have well marked morphological differences besides differences in colouration. According to Kubo, *P. japonicus* is plainly reddish-brown in colouration with small yellowish or yellowish white spots on the body. *P. longipes* is however, cobalt blue in colour—the walking legs being of the same hue. The Ceylon specimens resemble *P. japonicus* both in colour and morphological characters.

The grooves on all the abdominal segments are uninterrupted in the medial line and therefore resemble *P. japonicus*.

Panulirus polyphagus (HERBST)

Fig. 6

The antennular somite is armed with two principal spines, the rest of the somite being unarmed.

The cephalothorax is divided into an anterior region with few spines and a posterior region with more numerous spines. Ground colour of the carapace is bluish-green with a yellowish-white line running parallel to the length of the body in the anterior region. A few yellowish-white spots are found in the posterior region of the carapace.

The walking legs are similar in colour to the carapace with yellowish-white patches along their length.

The flagella of the antennules are distinctly banded with white and brown.

There are no grooves on the abdominal segments but the segments are pitted with yellowish white spots. A discontinuous yellowish-white line is found on the posterior border of the first abdominal segment. Continuous creamy-white lines of greater width are found on the posterior border of the next five abdominal segments. The abdomen is bright bluish green.

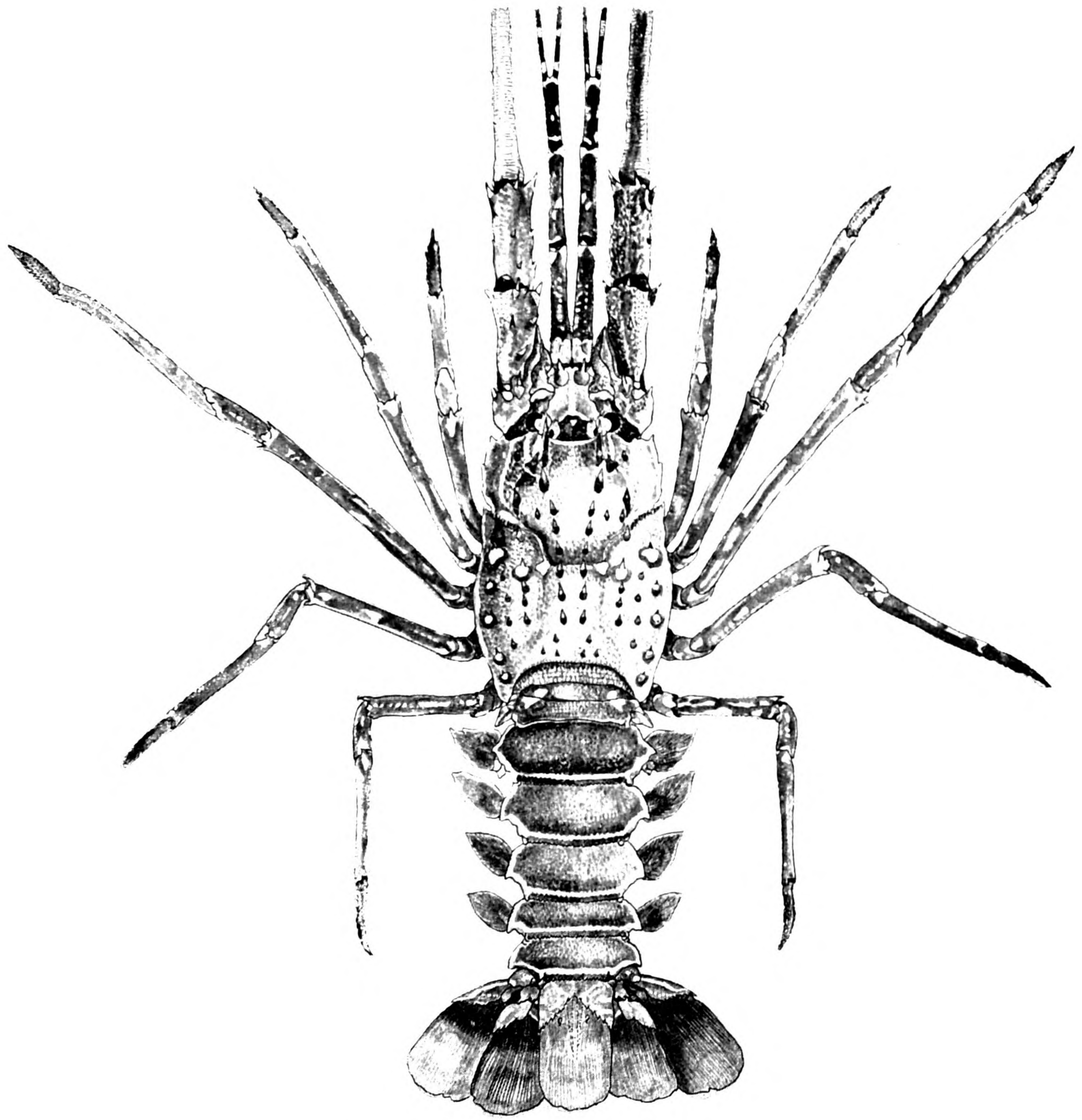


Fig. 6—*Panulirus polyphagus* (HERBST)

Key to Ceylon species of the genus *Panulirus*

1. Abdominal segments grooved.
 - A. Abdominal grooves not interrupted medially.
 - a. Exopod of mxpd. 3 present but without flagellum. Antennular somite with four spines.

P. penicillatus
 - b. Exopod of mxpd. 3 with flagellum. Antennular somite with two spines.

P. japonicus
 - B. Abdominal grooves interrupted medially

P. dasypus
2. Abdominal segments without grooves.
 - A. Exopod of mxpd. 2 without flagellum.

P. ornatus
 - B. Exopod of mxpd. 2 with single-jointed flagellum.

P. versicolor
 - C. Exopod of mxpd. 2 with many-jointed flagellum.

P. polyphagus

GENERAL DISTRIBUTION

The coastal areas around Ceylon were explored to determine the distribution of the various species of *Panulirus*. (Fig. 7). Following this general survey, a more intensive investigation was conducted in particular areas on the east and west coasts, as the sea was relatively calm during the south-west and north-west monsoons respectively.

In the northern coast, particularly close to Delft Island, Nainativu and Punkudutivu, five species of *Panulirus* were observed of which *Panulirus ornatus* was the dominant species.

<i>P. ornatus</i>	<i>P. versicolor</i>	<i>P. penicillatus</i>	<i>P. japonicus</i>	<i>P. dasypus</i>
362	10	1	1	6

Table III.—SPECIES OF PALINURID LOBSTERS CAUGHT BY BOTTOM-SET NET FISHERMEN NEAR DELFT ISLAND, NAINATIVU AND PUNKUDUTIVU.

Round the island of Kachchtivu, however, *Panulirus dasypus* was numerically the most abundant—a single catch consisting of 24 specimens of *P. dasypus* and 4 specimens of *P. ornatus*.

Off Mullaitivu, the bottom of the sea consists of mud which is not the normal habitat of lobsters. Only a single species of lobster, namely *P. polyphagus*, which has not been found in any other region, was obtained during trawling operations for prawns on these mud banks.

On the east coast, between Boulder point and Kalkudah the dominant species was *Panulirus versicolor* as can be seen in Table IV below :

<i>Panulirus versicolor</i>	<i>Panulirus dasypus</i>	<i>Panulirus ornatus</i>	<i>Panulirus japonicus</i>	<i>Panulirus penicillatus</i>
451	1	7	2	4

Table IV.—DISTRIBUTION OF SPECIES OF PANULIRUS BETWEEN BOULDER POINT AND KALKUDAH, SPECIMENS BEING CAUGHT BY HAND IN DIVING OPERATIONS

The reefs lying between Batticaloa and Arugam Bay were destitute of lobsters.

The reefs lying between Galle and Negombo were the richest in lobsters, the dominant species being *Panulirus dasypus*.

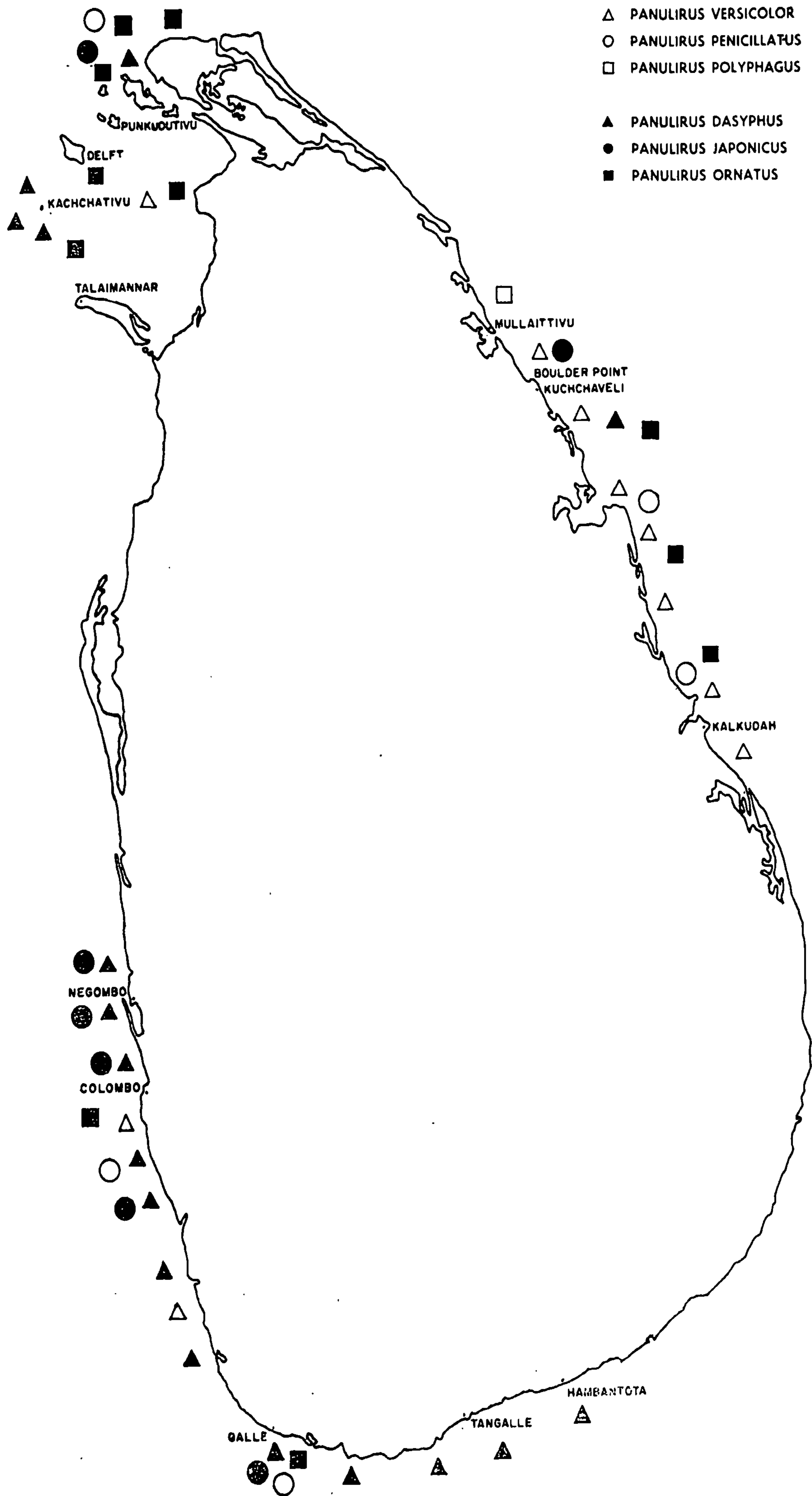


Fig. 7—Distribution of species of *Panulirus* round the coast of Ceylon.

Area	No. of specimens				
	<i>P. dasypus</i>	<i>P. japonicus</i>	<i>P. penicillatus</i>	<i>P. versicolor</i>	<i>P. ornatus</i>
Ona Gala ..	87	0	0	0	0
Fisheries Harbour Mutwal ..	40	0	0	0	0
Island Break-Water Colombo Harbour ..	75	0	0	0	0
South-West Break-Water Colombo Harbour ..	46	0	0	0	0
Off Galbokka Point ..	193	0	7	0	0
Off Galle Face ..	147	30	0	0	0
Kollupitiya ..	97	3	0	0	0
Bambalapitiya ..	211	5	0	0	0
Wellawatte ..	144	9	0	0	0
Dehiwela ..	87	0	0	0	0
Galle Harbour ..	800	30	10	0	0
Total ..	1,927	77	17	0	0

Table V—RELATIVE ABUNDANCE OF SPECIES OF PANULIRUS BETWEEN NEGOMBO AND GALLE (CAUGHT BY TRAPS)

It is noteworthy that only three species appear in the catches made by traps, *P. versicolor* and *P. ornatus* being absent. The relative abun-

dance of the various species of lobsters on the west coast deduced from catches made by hand in diving operations are given in Table VI.

Year	No. of Specimens				
	<i>P. dasypus</i>	<i>P. japonicus</i>	<i>P. penicillatus</i>	<i>P. versicolor</i>	<i>P. ornatus</i>
1960 ..	618	64	6	39	0
1961 ..	684	57	5	32	1
Dec. 1962 ..	106	3	2	2	0
Total ..	1,408	124	13	73	1

Table VI—RELATIVE ABUNDANCE OF SPECIES OF PANULIRUS CAUGHT BY HAND IN DIVING OPERATIONS ON WEST COAST

The following five species are seen, therefore, to be uniformly distributed round the island :—*P. dasypus*, *P. versicolor*, *P. japonicus*, *P. penicillatus* and *P. ornatus*. *P. polyphagus* appears to be restricted to the mud banks off Mullaitivu. *P. dasypus* is dominant on the West coast while *P. versicolor* is dominant on the east coast, the three species *P. japonicus*, *P. penicillatus* and

P. ornatus being present in very small numbers on both coasts.

It is interesting to note that *P. versicolor* and *P. ornatus* are present on the west coast but do not enter traps. The failure of trapping experiments on the east coast is evidently attributable to this.

DISTRIBUTION AT VARIOUS DEPTHS

The reef lying between Galle Face and Mt. Lavinia was chosen to study in detail the distribution of lobsters at various depths. This reef is between a hundred to four hundred yards from the shore, the sea bottom between the shore and the reef consisting of fine or coarse sand. The landward edge of the reef rises steeply to a height of 20 ft. from the sea-bottom and lies a few feet under water at high tide. At low tide the reef is uncovered at some places. Near this edge of the reef are found scattered boulders of dead and living coral. The reef front gently slopes seawards, forming almost a plateau for a distance of 300-500 yards. The first ten to twenty yards of this plateau is covered by boulders of various sizes but the plateau itself is of sandstone and is characterized by shallow pot-holes apparently formed by the action of sea-urchins.

The end of the plateau is about three fathoms in depth from the sea surface after which there is a steep drop to 5-7 fathoms. The sea-bottom here is deeply fissured granitic rock with scattered coralline outgrowths. This type of rocky bottom extends from the edge of the plateau to about half a mile seawards after which the sea bottom consists of fine sand.

No lobsters were ever found on the sandy ground between the shore and the reef, their distribution being limited to the rocky and coral-line regions of the reef area. It is only very rarely that any lobsters are found on the open plateau. Five species of lobsters were found. Of these, *P. ornatus* was extremely scarce, only a single specimen being observed on the reef front during this survey lasting three years. Large numbers of *P. dasypus* and few specimens of *P. penicillatus* were captured from cracks, crevices and from under boulders on the reef front. *P. japonicus* and *P. versicolor* were absent in this area. At depths of four to seven fathoms near the sea-ward edge of the plateau large numbers of *P. dasypus* and smaller

numbers of *P. japonicus* and *P. versicolor* were taken from the fissures in the granitic mass. Neither *P. penicillatus* nor *P. ornatus* were ever found at these depths.

It may be concluded, therefore that *P. dasypus* is both abundant and ubiquitous. *P. penicillatus* occurs only in the shallow waters of the reef front while *P. versicolor* and *P. japonicus* are found in regions beyond three fathoms in depth.

HABITS

All species of spiny lobsters except *P. polyphagus* inhabit reef and rocky areas which afford cover. At day-time, especially when the water is extremely clear, all these species generally lie hidden in crevices or under boulders. The only indication of their presence is the pair of antennae projecting from under ledges. If skin-diving operations were made at day-time only a very few lobsters can be seen. At night, however, large numbers are visible in the very same areas. They are, therefore, essentially nocturnal creatures coming out into the open only at night perhaps for feeding purposes. Of the five species *P. japonicus* is strictly nocturnal. This species can only be seen at night while small numbers of the other species may be observed even at day-time.

Of the five species, *P. dasypus* and *P. versicolor* are extremely gregarious, large numbers of all sizes may be seen very close together under the same rock ledge or in the same crevice. *P. japonicus*, *P. ornatus* and *P. penicillatus*, on the other hand, are generally solitary or may be observed in pairs.

On moonlight nights, especially during the full moon, *P. dasypus* lies hidden in crevices and consequently the catch is reduced considerably. *P. japonicus*, on the other hand, may be taken in comparatively larger quantities than on dark nights, fair numbers being seen in the

open even on full-moon nights. This suggests a different reaction of the two species to moonlight.

Other factors which induce the hiding response among spiny lobsters is a strong swell, as it has been often observed that under these conditions, these creatures tend to hide.

Needless to say, on moonlight nights, when a strong swell is present, the catches made are extremely poor.

BREEDING

The sexes can be easily differentiated morphologically by the position of the genital apertures, which are found at the base of the third pair of walking legs in females and at the base of the fifth pair of walking legs in males. In females a small chela is present at the extreme end of the fifth pair of walking legs. This is absent in males.

Fertilization takes place from sperm contained in a gelatinous mass—the spermatophore, which is deposited by the male on the ventral surface of the cephalothorax of the female before the eggs are released. The spermatophore is soft and white when just deposited but later becomes black and hard. The eggs are released through the orifice on the third pair of walking legs and are then carried on the rod-like endopodites of the pleopods. When first released the eggs are bright orange in colour but gradually become dark as the eggs undergo development. Later the eggs become translucent and each egg has a dark spot which is the pigmented eye. The eggs are released from the egg membrane just after the “eyed” stage. The hatched young are called *Naupliosomas* which are planktonic and quite unlike the parents. After some moults the *Naupliosoma* takes on the distinctive features of the adult lobster. The young adult changes its mode of living and becomes a bottom-dwelling form. Young lobsters at this stage are less than 2½” in length.

Sex Ratio

The sex ratio of samples of lobsters obtained in traps on the west coast are given in Table VII.

	<i>P. dasypus</i>	<i>P. japonicus</i>	<i>P. penicillatus</i>
Total No.	1927	78	17
% Males	66.0	87.0	71.0

Table VII—SEX RATIO OF PALINURID SPECIES (CAUGHT BY TRAPS)

In all three species collected by traps males are found in significantly greater numbers than females.

The sex ratio of the same species from the same areas collected by hand in diving operations are given in Table VIII.

	<i>P. dasypus</i>	<i>P. japonicus</i>	<i>P. penicillatus</i>	<i>P. versicolor</i>
Total Number	1408	124	13	73
% Males	50.5	49.0	58.3	54.4

Table VIII—SEX RATIO OF PALINURID SPECIES (CAUGHT BY HAND)

In contrast to the samples collected by traps, the sex ratio of samples collected by hand in all species is nearly 1:1—probably this is the natural sex ratio. The greater proportion of males in samples collected by traps may be attributed to the greater foraging activity among males.

Breeding cycle

The breeding cycle of species of *Panulirus* may be studied from the presence of berried females in samples obtained throughout the year. Samples of lobsters were collected off the west coast between Colombo and Galle and the percentage of berried females of *P. dasypus* calculated for the different months are given in Table IX.

Month	Total No. of Females	% of Berried Females
January	180	51.8
February	131	65.0
March	163	55.0
April	156	13.0
May	163	0
June	—	No sample
July	—	No sample
August	149	60.4
September	116	50.1
October	153	50.9
November	170	50.0
December	205	76.6

Table IX—BREEDING CYCLE OF *P. dasypus*

Over 50% of the females of *P. dasypus* were seen to be berried during the months of August to March—the peak being in December. In April the percentage drops to 13.0 while in May there were no berried females. It is clear, therefore, that breeding is cyclical and ceases during the south-west monsoon which commences in April and eases off in August. This cessation of breeding during the monsoon is possibly due to the continuous swell.

The breeding cycle of the other species could not be determined accurately as only a few of them were present in the samples collected. However, specimens of berried females were present only during the months of August to April. Their breeding cycle may, therefore, be similar to that of *P. dasypus*.

The percentage of females of *P. dasypus* carrying spermatophores for the different months of the year are given in Table X.

Month	Total No. of Females	% of Females carrying spermatophores
January	180	49.3
February	131	39.7
March	163	54.4
April	156	40.1
May	163	23.5
June	—	—
July	—	—
August	149	49.1
September	116	50.2
October	153	50.5
November	170	55.2
December	205	60.0

Table X—PERCENTAGE OF FEMALES OF *P. dasypus* CARRYING SPERMATOPHORES

It is seen that nearly 40% or more of the females carried spermatophores from August to April, with a peak in December while a drop is noticeable in May—the onset of the south-west monsoon.

Length of berried females

Several hundred specimens of *P. dasypus* were obtained from the reef off the south-west coast of Ceylon. These were measured from the middle of the U-shaped anterior border of the carapace to its posterior edge and it was noted whether or not the specimens carried eggs.

Carapace Length	Number Examined	Number Berried	% Berried
40-44 m.m.	1	0	0
45-49 m.m.	3	0	0
50-54 m.m.	17	3	17.6
55-59 m.m.	75	37	49.3
60-64 m.m.	160	87	54.3
65-69 m.m.	209	131	62.6
70-74 m.m.	200	124	62.0
75-79 m.m.	76	46	60.5
80-84 m.m.	16	8	50.0
85-89 m.m.	2	1	50.0
Total 40-89 m.m.	759	437	57.5

Table XI—LENGTH OF BERRIED FEMALES OF *P. DASYPUS*

It is apparent that the majority of females were between 55–80 m. m. in carapace length. Though the number of females below 55 m. m. in carapace length was extremely small, they are probably immature because only a very few of them carried eggs. Maturity appears to set in after they reach a carapace length of 55 m. m.

Table XII shows the length of berried females of *P. japonicus*.

Carapace Length	Number of Females	Number Berried	% Berried
35–39 m.m.	1	0	0
40–44 m.m.	0	0	0
45–49 m.m.	2	0	0
50–54 m.m.	4	2	50.0
55–59 m.m.	15	6	40.0
60–64 m.m.	15	8	53.3
65–69 m.m.	18	11	61.1
70–74 m.m.	10	6	60.0
75–79 m.m.	1	0	0
Total 35–79 m.m.	66	33	50.0

Table XII—LENGTH OF BERRIED FEMALES OF *P. japonicus*

The majority of females of *P. japonicus* were between 55–75 m. m. in carapace length and reproductive activity appears to begin after they have reached a carapace length of 50 m. m. as females below this length were not seen to carry eggs. The proportion of berried females was extremely high as in *P. dasypus*.

LENGTH-GROUP FREQUENCIES

The length-group frequency graphs of samples of *P. dasypus* obtained from west coast reefs

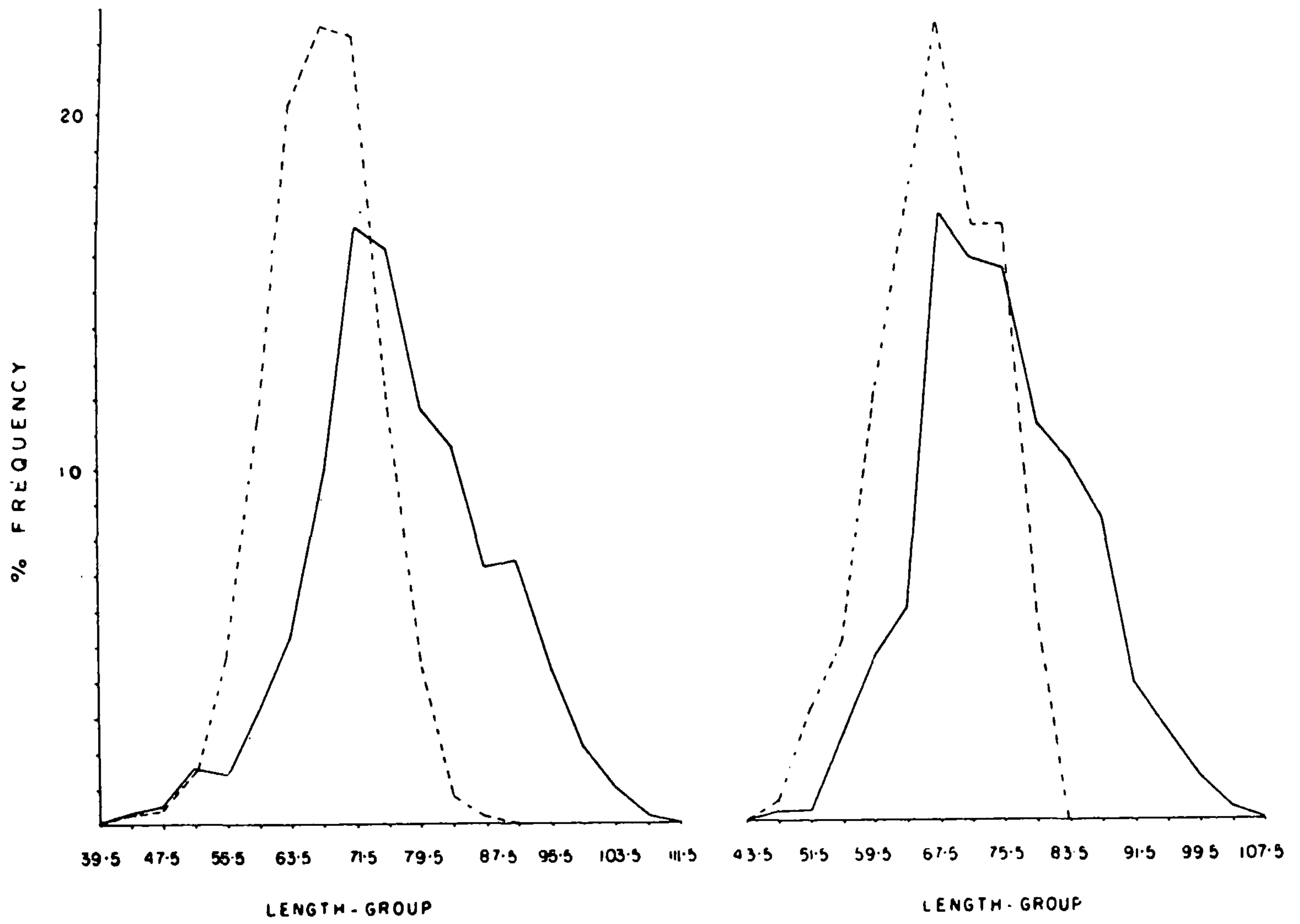
for the full period from 1960–1961, males and females separately, are illustrated in Fig. 8.

It is seen that the graphs of the males and females display considerable overlapping within the range of 38–50 m. m. after which there is distinct separation. It should be noted that sexual maturity in females occurs after they reached a carapace length of 50 m. m. (see Table XI). The overlapping of the graphs within the range of 38–50 m. m. might be attributed to similar growth rate or similar natural mortality rates. The separation of the graphs after 50 m. m. on the other hand might be due to different growth rates or different natural mortality rates between the two sexes, the former being the more likely explanation, the difference occurring only after sexual maturity is attained.

Females greater than 94 m. m. in carapace length are not found in the samples while males greater than this length constitute a large percentage of the male population. The modal values of the length-group frequency graphs of the male and female populations are 71.5 m. m. and 68 m. m. respectively.

The corresponding length-group frequency graphs of populations of *P. japonicus* and *P. versicolor* are illustrated in Fig. 9. These graphs as well are similar to that of *P. dasypus*. Females of *P. japonicus* above 78 m. m. in carapace length are absent while a large percentage of males are found to be above this length. The modal values of the length-group frequency graphs of the female and male populations are 59.5 m. m. and 79.5 m. m. respectively. In *P. versicolor* there are no females above 90 m. m. in carapace length while a substantial percentage of the males are above this length.

There is apparently a marked sexual dimorphism in all three species of *Panulirus* obtained from west coast reefs due either to different growth patterns or different natural mortality rates between the two sexes.



A

B

Fig. 8—Length-group frequency graphs of samples of *P. dasypus* obtained from west coast reefs from 1960–1961.

A.—Samples obtained in diving operations.

B.—Samples obtained in trapping operations.

— — — Females

———— Males

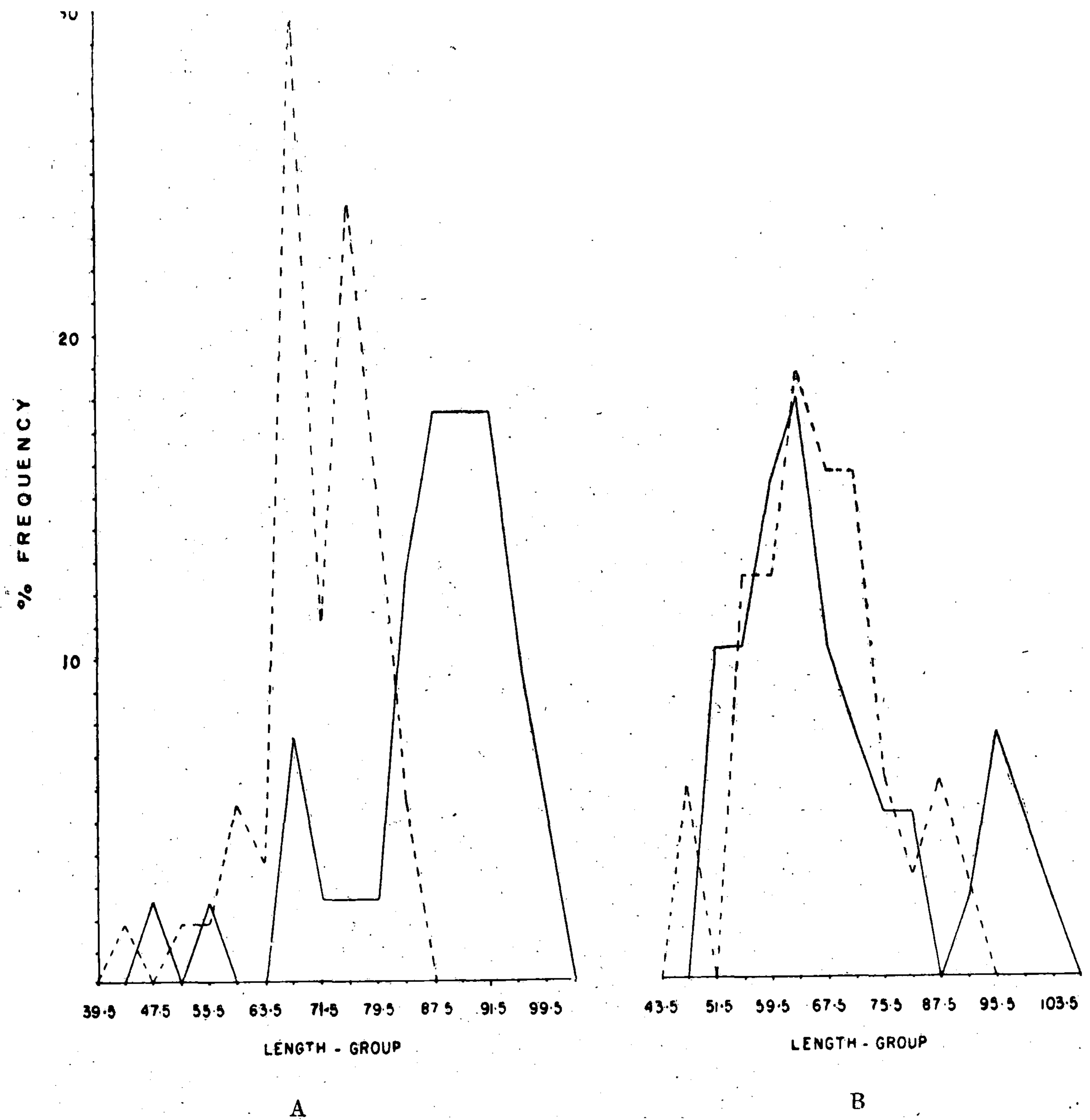


Fig. 9—Length-group frequency graphs of samples of lobsters from west coast reefs from 1960–1961.

A.—*Panulirus japonicus*. B.—*Panulirus versicolor*.

----- Females ————— Males

MONTHLY VARIATIONS

The length-group frequency graphs of samples of *P. dasypus* obtained during the corresponding months of 1960 and 1961 are illustrated in Fig. 10. The graphs of the two sexes are drawn separately since there was an observed difference between them. It may be seen that there is considerable overlapping of the graphs for the

corresponding months of 1960 and 1961, suggesting a marked consistency in the characteristics of the population even though the stock was fished for two consecutive years. This is seen more clearly if the characteristics of the samples obtained during the corresponding months of 1960 and 1961 are analysed in greater detail. (Table XIII).

Month	No.	Males				Females				
		Mean Carapace Length	Mode	S.D.	Coefficient of variation	No.	Mean Carapace Length	Mode	S.D.	Coefficient of variation
JAN. 1960	105	74 m.m.	75.5	1.23	16.6%	89	65 m.m.	63.5	0.72	11.10%
JAN. 1961	110	78 m.m.	71.5	1.06	13.69%	91	68 m.m.	63.5	0.63	9.31%
FEB. 1960	121	80 m.m.	71.5	0.98	12.21%	60	65 m.m.	63.5	0.48	10.65%
FEB. 1961	109	77 m.m.	71.5	1.08	14.05%	71	68 m.m.	63.5	0.68	9.98%
MAR. 1960	89	82 m.m.	67.5	1.27	15.60%	72	70 m.m.	71.5	0.60	8.13%
MAR. 1961	102	80 m.m.	75.5	1.02	12.70%	91	68 m.m.	67.5	0.58	8.60%
APR. 1960	106	76 m.m.	79.5	1.31	17.2%	70	66 m.m.	67.5	0.60	9.10%
APR. 1961	94	75 m.m.	79.5	1.11	14.80%	86	67 m.m.	71.5	0.70	10.50%
DEC. 1960	83	74 m.m.	71.5	0.90	12.20%	100	65 m.m.	71.5	0.70	10.84%
DEC. 1961	115	72 m.m.	67.5	1.66	23.10%	105	65 m.m.	67.5	0.71	11.00%

TABLE XIII—CHARACTERISTICS OF THE POPULATIONS OF *P. DASYPUS* FOR THE CORRESPONDING MONTHS OF 1960 AND 1961

Applying the *t* test to find out whether the differences between the mean carapace lengths for the corresponding months of 1960 and 1961 are significant it is seen that:—

$$t=0.27 \text{ (4 degrees of freedom)}$$

The differences are, therefore, not significant.

COMMERCIAL POSSIBILITIES OF A SPINY LOBSTER FISHERY

The first step in the investigation into the possibilities of exploiting the spiny lobster was the designing of suitable gear. After intensive trials a collapsible form of the Canadian "parlour and bed-room" trap, made locally of steel and hemp netting was found to be most efficient and convenient (De Bruin 1960). In areas where traps are ineffective, diving operations or the use of bottom-set nets are suitable alternatives.

A detailed investigation of the abundance of lobsters in all reefs and rocky areas off Ceylon was too vast a project to be undertaken with the facilities available. Therefore, a particular area of the sand-stone reef between Wellawatte and Dehiwela on the west coast was chosen for this investigation. Fishing was carried out in this area in 1960 and 1961 by two skin-divers working six months per year and operating approximately seven days per month.

These operations yielded nearly 8,000 lobsters and it is interesting to note that no significant reduction in the daily catch or in the mean carapace length of the population was observed on this test ground of 52,000 sq. ft. Investigations conducted at other points between Negombo and Galle (a distance of nearly 100 miles) have shown that spiny lobsters are present in equal abundance in these areas as well.

Lobsters can be kept alive in traps in the sea for several weeks without being fed or for

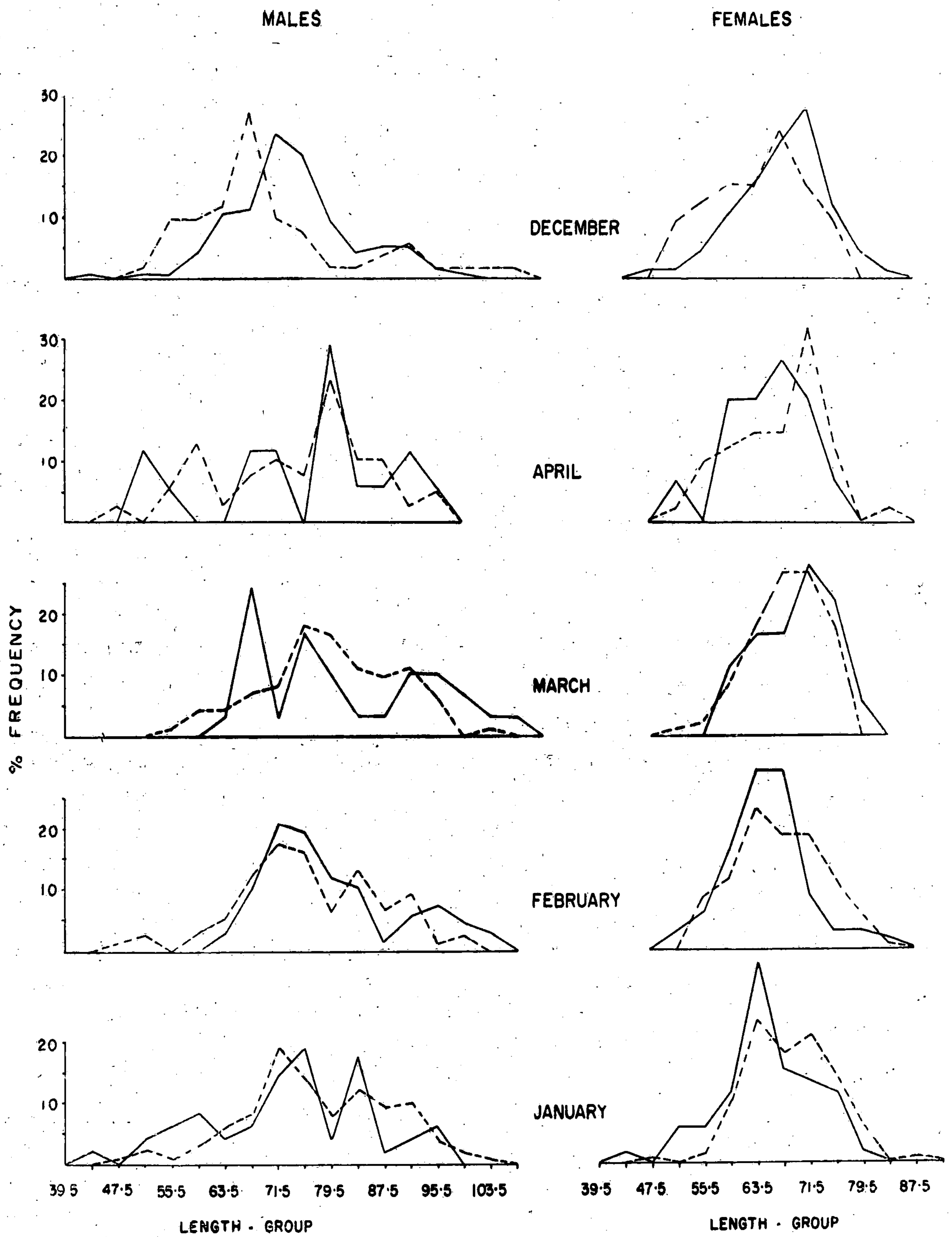


Fig. 10—Length-group frequency graphs of samples of *P. dasypus* obtained from west coast reefs.

————— 1960 - - - - - 1961

several months if fed. As many as fifty lobsters can be crowded together in a trap of three cubic feet with negligible losses. Lobsters also keep alive out of water for about six hours.

Experiments on the freezing of lobsters for export showed that unboiled or boiled tails could be frozen and stored at -5°F for periods as long as three months without showing any signs of deterioration.

A marketing test with an importer in the U. S. A. proved successful and the prices quoted for this product are encouraging. The prospects for the development of a spiny lobster fishery on a commercial scale are therefore good.

SUMMARY

1. Six species of the genus *Panulirus* are found in Ceylon waters, namely, *P. dasypus*, *P. versicolor*, *P. japonicus*, *P. penicillatus*, *P. ornatus* and *P. polyphagus*. *P. burgeri* is considered unlikely to be a species distinct from *P. dasypus*. Full descriptions and a key to their identification are given.

2. All species, except *P. polyphagus*, are uniformly distributed in the reefs and rocky areas round the island, with *P. dasypus* dominant on the west coast, *P. ornatus* in the north and *P. versicolor* in the east. *P. dasypus* is found in depths up to 12 fathoms, *P. penicillatus* only in shallow areas subject to surf while *P. versicolor* and *P. japonicus* occur only beyond three fathoms in depth. *P. polyphagus* was found only on mud banks off the north-east coast at depths of 8-10 fathoms.

3. All species are mainly nocturnal in habits, hiding under rocks and ledges in the day time and on moon-light nights. *P. japonicus* is strictly nocturnal but comes out to the open on moon-light nights. A heavy swell evokes the hiding response in all species. *P. dasypus* and *P. versicolor* are gregarious while *P. ornatus*, *P. penicillatus* *P. japonicus* are solitary or occur in pairs.

4. There is a marked sexual dimorphism in all species, the males being very much larger than females. The natural sex ratio as judged in diving operations is 1:1 but more males ($>2:1$) are caught in traps probably because of their greater foraging activity. Breeding on the west coast is continuous from August to April with a peak in December but ceases during the south-west monsoon possibly due to the continuous swell.

5. Fishing in a restricted area of 52,000 sq. ft. for two consecutive years, six months per year and seven days per month showed no effect on the modal or mean carapace length of the populations or on the average catch per day. The total catch for this period was 8,000 lobsters, the average catch in two hours by two skin-divers being 50 lobsters. Lobsters can be kept alive crowded together in traps, for several weeks if unfed or several months if fed.

6. There appears to be a good export market for Ceylon lobster tails which can be frozen and stored for as long as three months without deterioration.

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