SOME ASPECTS OF BIOLOGY AND EFFECT OF INFESTATION OF PINNOTHERES PLACUNAE HORNELL AND SOUTHWELL OF KAKINADA BAY*

S. LALITHA DEVI**

Department of Zoology, Andhra University, Waltair

Abstract

Various crab stages beginning with the invasive to adult stages of male and female of *Pinnotheres* placunae infesting the window-pane oyster *Placenta placenta* of the Kakinada Bay have been described for the first time. The stage-wise and sex-wise frequency occurrence of *P. placunae* is given. The growth rate of the crab from the invasive to the mature stage has been correlated with the growth rate of the oyster. The index of condition of the infested versus noninfested oysters showed significant difference. Damages to the gills and soft parts of the host were noticed. The infested oysters were mostly males. The oysters were hermaphroditic in most of the cases of multiple infestations.

INTRODUCTION

THE SPECIES of the genus Pinnotheres have a wide variety of hosts. Studies on the Indian species of Pinnotheres, mostly dealt on the description of the species (Hornell and Southwell, 1909; Southwell, 1910; Chopra, 1931; Chhapgar, 1957, 1958; Alcock, 1900; Awati and Rai, 1931; Jones, 1950; Jones and Mahadevan, 1967; Krishna Pillai, 1951; George and Noble, 1968; Ganapati and Ramasastry, 1969; Sankarankutty, 1966) and a few were made on aspects such as the frequency of occurrence, life cycle, biology, ecology and (Silas and Alagarswami, 1969; ethology. Krishna Kumari and Rao, 1974; Bhavanarayana and Lalitha Devi, 1974).

Growth and development in relation to the size of the host have been reported in the case of *Pinnotheres pisum*, *P. ostreum* and an allied species *Fabia subquadrata* (Atkins, 1926; Houghton, 1963; Christensen, 1959; Christensen and Dermott, 1958). Effect of infestation of *Pinnotheres* spp. on the host have been reported (Hale, 1927; Amemiya, 1929; White, 1937; Strauber, 1945; Sandoz and Hopkins, 1947; Berner, 1952; Egami, 1953; Sugiura *et al.*, 1960; Silas and Alagarswami, 1967; Krishna Kumari and Rao, 1974; Narasimham, 1984).

Pinnotheres placunae is a confirmed commensal, but the inadvertant damage it may cause at times has forced many to brand it a parasite. To augment our knowledge of the several facets of life of these interesting crabs, studies on *Pinnotheres placunae* a symbiont of *Placenta placenta* have been made to renew the description of male and female crabs and their developmental stages. Information on the frequency of occurrence, growth and development in relation to the size of the host and effect of infestation are dealt here.

The author wishes to express her sincere thanks to Prof. K. Hanumantha Rao, Head of the Department of Zoology for the guidance. The Scholarship awarded by CSIR for carrying out this investigation is gratefully acknowledged.

MATERIAL AND METHODS

Monthly samples of the host *Placenta pla*centa Linnaeus were obtained over a period of

[•] Formed part of Ph. D. Thesis, Andhra University, Waltair.

^{**} Present address : Kakinada Research Centre of Central Marine Fisheries Research Institute, Kotipalli Road, Kakinada - 2.

two years (1974-1975) from the Kakinada Bay. Samples were brought to the laboratory and 5-10 oysters were preserved in 5% formalin. Most of the oysters were examined in live condition in order to collect the live crabs for their macro and microscopic examination.

The length (antero-posterior axis), width (side to side in the broadest region) and height (greatest dorso-ventral distance when the valves are closed) of the oyster were measured to the nearest mm. The total weight of the oysters, meat weight, shell weight and dry weight of the meat were recorded to the nearest mg. Care was taken while opening the oysters. The precise location of the crab in the mantle cavity, extent of damage if any on the soft parts of the host were noted. The sex of the oyster, number of crabs in each host, their sex and developmental stage were also noted. Carapace length (from tip of anterior margin of the carapace to the anterior margin of first abdominal segment and width (across the carapace) of the crab were measured to the nearest mm.

"Index of condition" of the oysters was estimated by

- (1) 1000x dry weight of meat in g volume of shell cavity in ml
- (2) 100 x meat weight/total weight.

The relationship between shell weight and meat weight of the oysters was studied by fitting the regression equation of the type Y=a+bX

OBSERVATIONS

Mature female (Fig. 1 a-c)

Body soft and membranous, carapace broader than long, circular, smooth and flat the antero-lateral angles though rounded are pronounced. First and third maxilliped with epipods, second maxilliped without epipod. The 3rd maxilliped has the antero-internal angle of the ischium-merus round and evenly curved on outer border, set with long hairs on flat side, merus, ischium and carpus of the cheliped are slender, palm flat, exceeding $2\frac{1}{3}$ times the width, four pairs of swimming legs, the third longest and fourth shortest. Abdomen broad, flexed ventrally, extending forward, covering the coxopodites of all walking legs. Carapace varied from 4 mm to 10 mm in length and 6 mm to 12 mm in width.

Occurred throughout the year, but abundant during February - April and August -November.

Hard-stage female (Stage I) (Fig. 1 d)

Carapace hard and externally resembles hard stage male, eyes well developed, smaller in size, walking legs long and slender; abdomen very narrow about 1/3 the width of carapace; distinguishable from male by the absence of copulatory pleopods and presence of biramous appendages on the abdomen.

The carapace length ranges from 2.4 to 3.6 mm slightly broader, width ranges from 2.6 to 3.8 mm occurred during March - May.

Female stage - II (Soft-shelled stage) (Fig. 1 e)

Abdomen increases in size and wholly contained in sternal grove. No hairs on pleopods. The chelae are slightly more slender, with the propodus widest more distally at the base of the fingers. The ratio of carapace width to abdomen width is 1.22 and of abdomen length to abdomen width is 1.07.

Carapace length ranges from 2.8 to 3.8 mm. Found in abundance during June and July.

Female stage - III (Soft-shelled stage)

The second and third walking legs are nearly equal in length, third slightly longer. The ratio of abdomen length to width is 1: 1. The ter- are clearly segmented and possess a few disminal segment of the abdomen has a flat arch, tinctly plumose hairs.



Fig. 1. Pinnotheres placunae ovigerous female: a. Dorsal view, b. 3rd Maxilliped of the same, c. Chelate leg, palm - magnified view, d. Hard-stage female - Dorsal view, e. Soft-shelled stage female -Dorsal view, f. Dorsal view of Male - Hard-shelled stage, g. Tip of copulatory pieopod enlarged, h. Soft-shelled male - Dorsal view, i. Pre-hard stage and j. Invasive stage.

usually over 1.5 times wider than long. Abdominal appendages especially the first two pairs Found throughout the year.

Carapace length ranges from 3 to 5 mm.

Female stage - IV (Soft-shelled stage)

Abdomen much broader and reaches the coxa of the legs in the majority of specimens. The sternal depression is much broader. The carapace-abdomen width ratio has also further decreased and is equal to 1.0. Abdominal legs fully developed and well supplied with hairs.

Specimens range from 4 to 7 mm in carapace length. Found throughout the year.

Male hard-shelled stage (Stage I) (Fig. 1 f, g)

Carapace hard, smooth, well calcified, the antero-lateral angles well pronounced, eyes orbicular anterior portion between eyes curved and slightly elevated, measuring about 1/4th of carapace width. Merus - ischium and carpus of cheliped moderately stout, palm prominently bulged at base of claws. The lengthwidth ratio of carapace 1: 1.2, the ratio of dactylus to the length of upper border of palm 1: 1.8, walking legs in four pairs, third pair being the longest. Dactyli and coxae of all walking legs setose, abdomen narrow, 'V' shaped.

Carapace ranges from 3 to 5 mm in length. Occurred throughout the year, dominant during March to May.

Male soft-shelled (Stage II) (Fig. 1 h)

Slightly larger than hard-shelled male, carapace soft, smooth, with antero-lateral margins pronounced. Chellipeds and walking legs slender and longer than in the preceding stage. Hairs on inner distal portions of propodi of third and fourth walking legs often longer, Abdomen narrow, 1/3rd the width of carapace.

Differences between the hard-shelled stage male and soft-shelled stage male are in the

shape of the carapace, the relatively slender and longer chelipeds and walking legs which are devoid of much of the hairs.

Carapace length ranged from 4 mm to 7 mm. Found throughout the year.

Pre-hard stage (Fig. 1 i)

Carapace more or less circular, slightly broader than long, soft, front slightly elevated, eyes prominent, chelipeds and walking legs elongate and slender. Third pair of walking legs the longest and the last pair shortest. Externally sexes indistinguishable. White in colour, with reddish brown eyes. Carapace ranged from 1.5-2.4 mm in length. Occurred in March - May.

Invasive stage (Fig. 1 j)

Carapace flat, slightly wider than length, front elevated, slightly bilobed, prominently angled at side and 1/3 the width of carapace Eyes large, cheliped stout, palm hairy and proportionately wider than in other stages. Claws slender and much overlapping. The propodi of third and fourth pairs of legs have branched setae. Dactyli of all legs claw-like, sharp and pointed, bear long setae on the outer and inner borders.

Grey in colour with reddish brown eyes. Carapace dimensions ranged from 1.4 - 1.6 mm in length. This is the smallest crab stage observed in fair numbers during March - May.

FREQUENCY OF OCCURRENCE

Examination of 1,642 oysters revealed that 1,100 oysters were infested with one or more crabs. The infestation varied from 28% in May (during 1974 and 1975) and 93% in September (1974 and 1975).

Oysters with single, double and triple infestations formed 83.09%, 11.27% and 5.63%respectively. Data on sex-wise occurrence of crabs, stage of development and the frequency of the single and multiple infestations are presented in Tables 1 and 2.

TABLE 1. S P	ex-wise and stage-wise placunae	occurrence	Øj
Female		Number	
Stage I	(Hard-sheiled stage)	50	
Stage II	(Soft-shelled stage)	46	
Stage III	(Soft-shelled stage)	44	
Stage IV	(adult non-ovigerous)	230	
Stage V	(adult-ovigerous)	708	
	Total	1078	
Male			
Stage I	(Hard-shelled stage)	176	
Stage II	(Soft-shelled stage)	94	
	Total	270	

Location of the crabs in the oysters revealed that mostly (50.5%) the crabs were found near the gills, in 36.9% of the cases near inhalent siphon and in the rest near the gonad.

Out of 1,646 oysters examined, 808 oysters were females, 742 males and 92 were hermaphrodites. In most of the cases, where multiple infestations were found, the oysters were hermaphroditic.

GROWTH AND DEVELOPMENT IN RELATION TO SIZE OF THE HOST

The mean sizes and size ranges of the crabs irrespective of sex and developmental stage, found in each size group of oyster showed (Fig. 2) a positive crab-host size relationship.

Immature crabs are found in the proportionately smaller oysters; eventhough the larger oysters, could obviously accommodate them. Very large oysters over 85 mm in length often contain a crab (82-97%). It is also found that rarely (2-7%) small oysters contain relatively

TABLE 2. Frequency of infestations and the sex of the Pea-crabs

Infestation	Number of oysters	Pea-crabs Female Male		Total number of Pea-crabs
Single infestation	914	880	34	914
Double infestation	124	124	124	248
Triple infestation	62	74	112	186
Total	1100	1078	270	1348.

In all cases of double infestation, a male and a female crab were present and in triple infestation the ratio was one ovigerous female to two males (1:2). It was also observed that invariably, the males were in different stages of development (hard-shelled and soft-shelled). larger crabs. The minimum size of the oyster that is infested by the crab measured 30 mm in length. The size of the crab varied from 1.4 to 1.7 mm in carapace length. Oysters of 30-60 mm in length are frequently infested by the invasive and pre-hard stage crabs during. March-April. Mature and adult stages of crabs are generally met within the larger oysters, above 90 mm in length. Small crabs may also be found in the larger oysters, but crabs with 8 mm - 12 mm carapace width are not found in the smaller oysters of length 50 - 80 mm. Crabs in the invasive stage infest smaller



Fig. 2. Relation between size of the crab and the size of the host.

oysters and concurrently reach the maximum size and maturity with the host. In 20 infested oysters (1.8%) mature crabs with a minimum carapace length of 4 mm are found in "poorly nourished" oysters of the length group 60-70 mm (wet meat weight of "poorly nourished" oysters less than the meat weight of healthy oysters of the same length group, infested by the crab).

EFFECT OF INFESTATION ON THE HOST

Index of condition

The index of condition of the windowpane oyster by employing the first formula during 1974-75 averaged 43.78 for the crab infested oysters and 51.13 for the non-infested oysters. By employing the second formula, in the infested oysters, the value is 45.64 while in the non-infested oysters the value obtained is 53.16. Meat and shell weight of the infested versus non-infested oysters show significant difference (Fig. 3). The meat - weight shell-weight relationship of the infested oysters is Y = 2.491 + 0.1891 X and non infested oysters is Y = 2.610 + 0.2008 X.

Where Y = meat weight of the oyster in grams. The analysis of covariance (Table 3) showed significant difference in the elevation, hence the equations are given separately.

The seasonal variations in the percentage meat weight by shell weight during 1974 and '75 are presented in Fig. 4.

Damages to the gills, palps and mantle of the host

There were ulcer-like structures on the mantle (Fig. 5). These are more common in the window-pane oysters of 140-160 mm length. Damages to the gills and palps were also noticed.

Effects on reproduction

The data on hand reveal that the oysters infested with the crabs are mostly males (Table 4). There were 92 hermaphroditic oysters with multiple infestation. Oysters with two or three *P. placunae* are found to be mostly hermaphroditic.

There were three instances showing gill erosion and indeterminate sex condition of the oyster, but without a crab. The hermaphroditic condition has been observed in the oysters of 138 mm to 160 mm length. In few cases (12.6% of the infested oysters) the crab lodges near the gonad and due to crawling and continuous pressure exerted by the crab, the gonad did not develop, and the sex of the oyster could not be determined even in the individuals of 53 mm - 73 mm in length (above 35 mm in length sex can be differentiated) irrespective of peak spawning season (October -December).

DISCUSSION

The description of *Pinnotheres placunae* as reported by Chhapgar (1957) differs from that

dactylus and palm of chelate legs differ from those given by Chhapgar (1957) presently the dactylus being more than threefourths of the palm, in the case of invasive and pre-hard stages, the length of dactylus and palm are equal.

The number of developmental stages in *Pinnotheres placunae* are the same as observed in *P. vicajii* (Krishna Kumari and Rao, 1974),



Fig. 3. Relation between shell-weight and meat-weight of the infested and non-infested oysters.

given by Hornell and Southwell (1909) in the lengths of the dactyli and palm of the cheliped.

Present description of *Pinnotheres placunae* agrees with the description given by Chhapgar (1957). However, there is a slight difference in the structure of the maxilliped. According to Chhapgar (1957), the antero-internal angles of the ischium - merus of the external maxiiped are rounded. Various proportions of P. ostreum (Christensen and McDermott, 1958) and Pinnotheres sp. (Silas and Alagarswami, 1969). P. placunae completes its life history from the invasive to the mature stage in Placenta placenta itself. Occurrence of soft shelled male in stage II in P. placunae agrees with the observations of Rathbun (1918), Atkins (1926), Strauber (1945), Silas and Alagarswami (1969) and Krishna Kumari and Rao (1974). . The frequency of occurrence of *P. placunae* in *Placuna placenta* of Bombay Coast was given as 90% (Chhapgar, 1957). There were four double infestations in ten oysters exastudy) is that the males have entered the oyster in search of females for copulation, or they might have entered inadvertantly while seeking an uninfested oyster. The abundance

 TABLE 3. Analysis of covariance to test the significance of differences between regression lines of the infested and non-infested Placenta placenta in the shell-weight - meat-weight relationship

Sources of variation	Deviations df	from SS	regressions MS
Due to regression within infested	296	1709.9272	5.776781
Differences between regression Co-efficients	1	5,7444	5.7444
Residuals due to regression pooled within	297	1715.6716	5.776672
Differences between adjusted mean	1	44.81344	44.81344
Total	300	1760.48504	
Comparison of slopes F=0.9943 (c	l _f 1,297) N. S.		
Comparison of elevation F=7.7576	(d _f 1,298) S.		
NS : Not significant at 1%. S : Significant at 1%.			

TABLE 4. Predominance of males over females of the infested oysters

Sex of oysters inhabiting pea-crabs	Single	Infestations Double	Triple	Total number counted	Percentage
Male	512	58	8	578	52.54
Female	397	27	6	430	39.06
Hermaphrodite	5	39	48	92	8.40
Total	914	124	62	1100	

mined, five single infestations and only one oyster was uninfested.

The possible explanation for the double and triple infestations (observed in the present of females over males is due to short life span of males (Christensen and Mc Dermott, 1958) and free living habit of males. The present observations on the growth and development of *P. placunae* in relation to the size of host,

120

Placenta placenta are in agreement with the works on *P. pisum* by Houghton (1963) and Christensen (1958), *P. ostreum* by Atkins (1926) and Christensen and Mc Dermott (1958); and an allied species of *Pinnotheres, Fabia subquadrata* by Wells (1940) and Pearce (1966). Occurrence of mature crabs (4 mm in carapace length) in the oysters of 60-70 mm in length exhibit stunted growth; however, the crabs

crabs were also immature, and this is corroborated by the present observations. They have not come across the instances of the occurrence of mature, but small size crabs in the immature, small oysters. Heavy gill damage and abnormal growths on the mantle of the oysters of 140-160 mm length may be due to the greater time availability for more extensive damage in the older hosts. Damage to tissues



Fig. 4. Seasonal change in percentage of meat-weight/shell-weight of *Placenta* placenta during the year 1974 and 1975.

attained maturity. The factors that limit the growth of the host also directly or indirectly limit the growth of the crab.

According to Hornell and Southwell (1909) immature *Placenta placenta* are less frequently infested by the crab, whereas in the present study, prehard and invasive stage crabs are often found in the oysters of 30-60 mm length. They further stated that in such instances of immature oysters infested by the crabs, the would appear to be due to the movements of the crab, resulting in abrasion. As the crabs feed on the food of the oyster, malnutrition may be expected leading to debility.

Present observations on the index of condition of the infested oysters are in agreement with those of Sandoz and Hopkins (1947). Narasimham (1984) while studying the biology of window-pane oyster *Placenta placenta* from Kakinada reported the condition index



Fig. 5. Abnormalities in the mantle of Placenta placenta.

to be slightly lower in infested ovsters when compared to uninfested oysters. Present observations are in agreement with those of Awati and Rai (1931), where the change of sex is due to infestation of Pinnotheres sp. The abundance of male Placenta placenta over the females of the infested oysters is also documented in investigations of Amemiya (1929), and Egami (1953). According to Berner (1952). besides environmental factors, the presence of a pea-crab indirectly affects the sex phase of the host. Due to continuous pressure exerted on the gonad of the host, changes in the gonad occur. This may be the reason for the indefinite sex determination of the oysters of 53-73 mm in length, irrespective of spawning season.

REFERENCES

ALCOCK, A. 1900. Materials for a Carcinological fauna of India. No. 6. The Brachyura catometopa or Grapsoidea, J. Asiat. Soc. Bengal., 69 (2) 3: 279-456.

AMEMIYA, I. 1929. On the sex change in the Japanese common Oyster Ostrea gigas Thumberg. Proc. Imp. Acad. Acad. Tokyo, 5: 284-286.

ATKINS, D. 1926. The moulting stages of the peacrab (pinnotheres pisum). J. Mar. Biol. Ast. U.K., 14: 475-493.

AWATI, P. R. AND H. S. RAI 1931. The Indian Zoological Memoirs. III Ostrea cacadata, pp. 1-107.

BERNER, L. 1952. Biologic de Pinnotheres pisum Pean. (Decapode, Brachyoure). Bull. Soc. Zool, France, 77: 344-349.

BHAVANARAYANA, P. V. AND S. LAUTHA DEVI 1974. Frequency of occurrence of *P. planuae* from windowpane syster *Placenta placenta* of Kakinada Bay. *Curr. Scl.*, 43 (8): 255-250.

CHEAFGAR, B. F. 1957. Marine crabs of Bombay State. Taraporevala Marine Biological Station Bombay, pp. 89.

variety of crabs (Decapoda, Brachyura) from Bombay State, Rec. Indian Mus., 53: 251-259.

CHOPRA, B. 1931. Further notes on crustacea Decapoda in the Indian Museum. II. On some Decapod Crustacea found in the clouca of Holothurians. *Ibid.*, 33: 303-324.

CHRISTENSEN, A. M. 1959. On the life history and biology of *Pinnotheres pisum*. Proc. XV Int. Conger. Zool. London, (1958): 267-270.

AND J. J. Mc DERMOTT 1958. Life history and biology of the oyster crab *Planotheres ostreum* Say. *Biol. Bull.*, 114 : 146-179.

EGAMI, N. 1953. Studies on sexuality of Japanese oyster Ostrea gigas VII. Effects of gill removal on growth and sexuality. Annotationes Zoologicae Japonenses, 26 (3): 145-150.

GANAPATI, P. N. AND RAMASASTRY 1969. On the occurrence of the pre-crab *Pinnotheres* sp. in the mantle cavity of the Gastropod *Turbo intereostalis* (Menke). *Curr. Sci.*, 38 (1) 22.

GLORGE, M. J. AND A. NOBLE 1968. Occurrence of Pea crabs *Pinnotheres gravitis* Burger and *Pinnothers* mediolicolus Burger in the Indian Coast, J. Mar. biol. Ass. India, 10 (1): 392-394.

HALE, H. M. 1927. The ernstaceous of South Australia Parts 1 and 11. Harrison Wier, Government Printer, North Terrace, Acellaide. HORNELL, J. AND T. SOUTHWELL 1909. Description of a new species of *Pinnotheres* from *Placuna placenta*, with a note on the genus. *Rept. to Government of Baroda on Marine Zool of Okhamandal in Kathlawar* Part I: 99-103, London.

HOUGHTON, D. R. 1963. The relationship between tidal level and the occurrence of *Pinnotheres pisum* (Pennant) in *Mytilus edulis*. L. J. Anim. Ecol., 32 (2): 253-257.

JONES, S. 1950. Observations on the bionomics and fishery of the brown mussel (Mytilus sp.) of the Cape Region of Peninsular India. J. Bombay nat. Hist. Soc., 49 (3): 519-528.

AND S. MAHADEVAN 1967. Notes on animal associations. J. mar. biol. Ass. India, 7 (2): 377-380.

KRISHNA PILLAI, N. 1951. Decapoda (Brachyura) from Travancore. Bull. Central Res. Inst. Univ. of Travancore, Trivandrum., 2 (1) Ser. C: 1-46.

KRISHNA KUMARI, L. AND K. VIRABHADRA RAO 1974. Life cycle of *P. vicaji*, Indian J. Mar. Sci., 3 (2): 165-172.

NARASIMHAM, K. A. 1984. Biology of windowpane oyster Placenta placenta (Linnaeus) in Kakinada Bay. Indian J. Fish., 31 (1): 272-284.

PBARCE, J. B. 1966. The biology of the Mussel crab Fabia subquadrata from the waters of Sanjuan Archipelago, Washington. Pacific Science, 20 (1): 3-33.

RATHBUN, M. J. 1917. Grapsoid crabs of America. Bull. U. S. Nat. Mus., pp. I-461. SANDOZ, M. AND S. H. HOPKINS 1947. Early life history of the oyster crab *Pinnotheres ostreum* Say. *Biol. Bull.*, 93: 250-258.

SANKARANKUTTY, C. 1966. On Decapoda, Brachyura from the Gulf of Mannar and Palk Bay. Proc. Symp. on Crustacea. J. mar. biol. Ass. India, 1: 341-362,

SOUTHWELL, T. 1910. Description of new species of *Pinnotheres* and the female of *P. margaritifera* Laurie. Ceylon Mar. Biol. Rep., 19 (5): 226-227.

SILAS, E. G. AND K. ALAGARWAMI 1969. On an instance of parasitation by the Pea-crab (*Pinnotheres* sp.) on the backwater clam *Mererix casta* (Chemnitz) from India with a review of the work on the systematics, ecology, biology and ethology of the Pea-crabs of the genus *Pinnotheres* Latraile. *Proc. Symp. Crustacea*, *MBAI*, 3: 1161-1228.

STRAUBER, L. A. 1945. Pinnotheres ostreum, parasite on the American Oysters Ostrea (Gryphaea) virginica. Biol. Bull., 88: 269-291.

SUGIURA, Y., M. KIHARA AND A. SUGITA 1960. The ecology of Pinnotherid crabs pest in culture of *Tapes japonicus* - I and II. *Bull. Japanese Soc. Sci. Fish.*, 26 (2): 89-94 and 565-569.

WELLS, W. W. 1940. Ecological studies on the Pinnotherid crabs of Puget Sound. Bull. Univ. Washington. Publ. Oceanogr., 2: 19-50.

WHITE, K. M. 1937. L. M. B. C. Memories, 31 Mytilus. The University press of Liverpool, pp. 1-177.