

Records of the Zoological Survey of India

**Marine timber destroying organisms
of the Andaman-Nicobar Islands and
the Lakshadweep Archipelago**

**N. BALAKRISHNAN NAIR
&
M. SALIM**

Zoological Survey of India

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Occasional Paper No. 159

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of the Andaman-Nicobar Islands
and the Lakshadweep Archipelago**

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PREFACE

Ever since man began to use wood in sea water, in the form of rafts and small boats, nets and other implements to catch fish, wooden constructions of various kinds all along the waterfront, he has been confronted with the problem of biodeterioration.

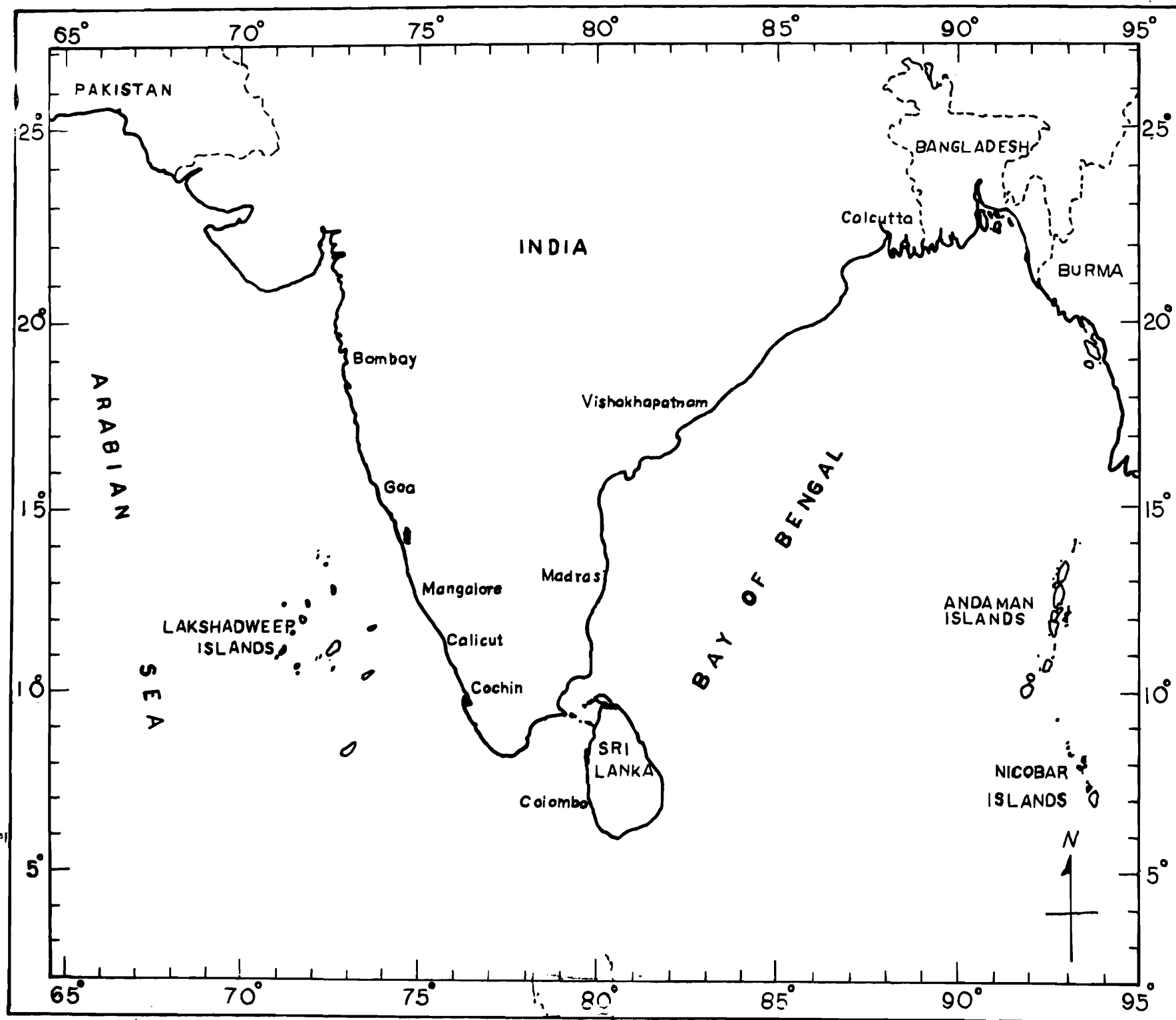
His struggle against the agents of this destruction is well documented in the literature going as far back as Theophrastus in 350 B.C. The impact of organisms that destroy wood in sea water exposures on the history of man is difficult to estimate, but it has certainly been tremendous. Known to Pliny, Ovid and Aristophanes, marine borers are mentioned even by Homer. The accounts of the voyages of Dampier, Cook and Drake reveal that these early navigators dreaded these agents of wood destruction. The damage they caused to timber gained significance throughout Europe for the first time when in the 18th century, the wood works of the dikes along the Dutch coastline were destroyed to such an extent that the low-lying lands behind them were in danger of being catastrophically flooded. In the United States two spectacular outbreaks of marine borers have been documented one in 1921 and the other in 1927. Along the entire seafront bridges collapsed, piers crashed and boat hulls and wharf-pilings crumbled. Like an unseen typhoon, it swept across the coast leaving a trail of destruction along its path. Though present in all seas, they are particularly destructive in the warm, tropical waters where they eat indiscriminately every material of plant origin. It is interesting that even though man has been fighting against the ravages of these organisms since early historic times, no effective control measures have been developed so far. Conservation and protection, have, therefore, become extremely essential for the effective utilisation of the limited resources. This involves a precise understanding of the various aspects of the organisms which are responsible for destruction. Successful control measures depend upon a knowledge of the nature of organisms against which the control is directed. Studies along these lines have been in progress in the Dept. of Aquatic Biology of the University of Kerala.

INTRODUCTION

India has a long seaboard of about 8000 km taking into account the islands in the Arabian sea and the Bay of Bengal. Large quantities of timber are used for different types of water front structures such as jetties and piles, country log-rafts, like catamarans, coastal and fishing vessels. There are also harbour works, boat building and other installations of the navy and several types of aquacultural equipments all along the sea front. The money spent on all these purposes including the losses involved due to damage by microbial deterioration as well as by marine borers is enormous. It has been reported that the fishing industry alone which depends to a large extent on wooden catamarans and boats suffers an annual loss of about Rs. 96 million.

Again it is not merely the monetary loss that is important, but the continuous and rapid drainage of timber from the forest particularly in countries where the supply of timber is far below the current demands. The magnitude of the problem can be realised from the fact that the advanced countries with all the facilities they possess and concentrated work on the same for over 200 years have still not been able to penetrate beyond the fringe of the problem and thus with the natural advantage they possess namely situated as they are in a temperate region where the activity of the borers, their number and species involved are all limited. Therefore, the task that is up against the countries in the tropics such as ours with limited resources in finance, limited area under forest and greater destructive power of borers is very formidable indeed (Purushotham and Rao 1971).

Fig. 1



Excepting perhaps for iron and steel all other objects are indiscriminately attacked by marine borers. Naturally, the question is asked why not replace water-front structures by such materials as steel and concrete? But with iron and steel the chief defects are their susceptibility to quick corrosion and their magnetic property which prevents their use in the construction of mine sweepers. According to Purushotham and Rao (1971) plastic and fibre glass offer as good materials for construction of light boats and life boats but they have very limited use and are restricted to ply only close to the coast on the mainship. Therefore, the overall picture shows that timber can be considered as an ideal material for all structures exposed to sea water. In most cases it can be readily put to use in the natural form it exists as piles, bulkheads, wharves, fenders, masts, catamarans, canoes, dinghies etc. Thus it is clear that timber is an ideal constructional material for marine water-front structures and crafts.

Thus, among the many questions of keen scientific interest that are encompassed by the broad field of marine biology, none has greater economic significance than the problem of marine biodeterioration. Though much is known about their deprecations, we are far from understanding them completely and still further from our goal of adequate and reliable control of these in all the seas and under all conditions. The problem is complicated and still farther from our goal of adequate and reliable control of these in all the seas and under all conditions. The problem is complicated because no two situations are identical either in the material (timber species) used or in the nature of attack (borer species) or the manner in which the destruction takes place.

Research perspectives on marine wood boring organisms of India and reviews of earlier literature are available in several publications more especially those of Nair (1954, 1955, 1956, 1957, 1959, 1965, 1966, 1984), Nair and Saraswathy (1971), Nair and Dharmaraj (1979, 1980); Nagabhushanam (1955, 1960), Karande (1978), Purushotham and Rao (1971), Becker (1958), Santhakumaran (1976, 1981, 1985), Srinivasan (1955, 1959, 1969). The incidence of marine borers along the coasts of the Indian mainland was reported primarily from widely separated and easily accessible areas such as harbours and areas near biological research centres. Very little is known regarding wood-boring organisms from islands such as the Andaman and Nicobar and the Lakshadweep Archipelago (Das and Roy 1980; Tewari *et al.* 1980; Nair and Dharmaraj 1983).

For more detailed further analysis of the problem in these islands, it will be most helpful if a preliminary account is available on the wood-borers in these areas. With this aim, the organisms that occur, their incidence in these isolated islands on the Arabian Sea and the Bay of Bengal are presented in the report.

Organisms that cause destruction of timber along the coasts of India

The destruction of timber in sea water exposure is caused by the concerted activity of a variety of organisms such as bacteria, fungi and marine boring organisms. The damage caused by bacteria and fungi is slow and is not spectacular when compared to that of boring organisms. The borers chiefly belong to two groups, the Mollusca and the Crustacea. The molluscs are represented by five genera of pholads namely *Pholas*, *Martesia*, *Xylophaga*, *Barnea* and *Lignopholas* (piddocks) and by 12 genera of shipworms of the family Teredinidae. The crustacean wood borers are of the order Isopoda and are represented by two genera, *Sphaeroma* (pillbugs) and *Limnoria* (gribbles). Forty species of shipworms, 9 species of piddocks 5 species and a variety of pill bugs and not less than 9 species of gribbles have so far been reported from the coasts

of India (Table 1). These are engaged in a relentless destruction of valuable timber, thereby, reducing its service life in the sea, in the brackish water and even in almost freshwater.

Of the marine wood-borers that occur and are active along our coasts, the shipworms, piddocks and pill bugs are responsible for most of the destruction. Recent studies have shown that there is severe destruction of wood by crustacean borers in the coastal areas (Dharmaraj and Nair 1980) in the estuaries, backwaters (Nair 1965, 1965a, 1966) and also in the mangrove forests (Dharmaraj and Nair 1981; Santhakumaran, 1983a).

Molluscan borers

The well known shipworms of the family Teredinidae and their nearest relatives the piddocks belonging to the family Pholadidae together constitute the molluscan borers. They are included in the suborder *Pholadinae* of the eulamellibranch order *Myoida*. The suborder *Pholadinae* is characterised by a nearly closed mantle, a somewhat discoidal foot, reduced hinge and internal ligament; considerably small ventral and anterior adductor muscles, relatively large and powerful posterior adductor muscle and greatly modified and specialised shell valves armed with denticulated ridges over the anterior outer face and having a conspicuous pedal gape for the protrusion of the foot. Conspicuous dorsal and ventral condyles are present to facilitate the rocking movements of the valves in the Teredinidae but the Pholadidae lack ventral condyles for the insertion of the pedal muscles, styloid apophyses are present beneath the umbos. While the shell valves of the bivalves can protectively cover the soft part when retracted, those of the shipworms are greatly reduced and have thus lost their protective function, but serve as effective cutting tools used for the specific purpose of excavation of the burrow. The worm-like body of the shipworms extend far beyond the posterior margin of the shell, the wood into which it burrows affording protection for its bare body. Additional protection is ensured by a calcareous tubing around the animal secreted by the mantle of this mollusc. While the shell of the piddocks is provided with accessory plates, the shipworms have unique structures known as pallets located at the base of the siphons to close the burrow when the siphons are withdrawn.

It is usually possible to judge by the size of the bore holes whether the borers within a piece of infested wood belong to the Teredinidae or the Pholadidae. Those of the teredinids are usually very small and the calcareous lining of the tube is often visible; the aperture of a mature pholad-burrow is usually 2 to 3 times that size and does not have a calcareous lining. But to distinguish between newly settled pholads and teredinids is generally difficult.

Generally wood boring pholads make burrows only slightly more than the length of the shell. Teredinids usually continue to bore as long as there is enough substratum to work on and make long tubular tunnels, the animal extending the entire length.

The generic classification of the teredinidae is based on the morphology of the soft parts in conjunction with the type of pallets. Identification of species is based almost entirely on the pallets. Though the siphons have proved useful at times, for confirmation, however, there are not sufficient data on intra- and inter-specific variation of the siphons of most species for them, to be used in identification. The type of calcareous tube may also prove useful but unfortunately it is too insufficiently known in many species to form a reliable basis for identification. The characters of the shell can be useful in a few species but only

in conjunction with the pallets. Generally the variation exhibited in a series of shells from a single locality is so great and the shells of species belonging to different genera are so similar that it is not possible to use them for taxonomic purposes (Turner, 1971).

It is often necessary to use transmitted light to see the internal structure of the pallets or the fringes on the cones of *Bankia*. Pallets which have become dried can often be restored to a condition by which identification is possible by soaking in trisodium phosphate (Turner 1971).

Members of the Pholadidae have at least one and some have as many as four accessory calcareous plates, in addition to the two calcareous valves of the bivalves. The generic classification of the Pholadidae is based on the arrangement of these accessory plate, the presence or absence of a callum in the adult and on the presence or absence of apophyses. Species identification is based on the shape of the valves, the accessory plates and the characters of the siphons (Turner 1954, 1955, 1969, 1971).

The taxonomy of the pholads and shipworms was in a state of utter confusion. The need for a comprehensive treatise on the systematics and anatomy has been a long felt need for all concerned with the problem of biodeterioration in the sea. The lack of reliable, up to date reference for identification of these organisms was a serious obstacle which made it difficult to conduct critical field and laboratory experiments with these organisms. The monumental works of Turner (1954, 1955, 1966, 1969, 1971) have clarified the systematics of this group. Among them, 'A Survey and Illustrated Catalogue of the Teredinidae' (1966) furnishes a good account towards the identification of shipworms, on the basis of careful and detailed studies on not only the pallets and shells but also on the anatomical and other characters.

Recognising as many as fourteen genera, Turner divided the family Teredinidae into 3 subfamilies, namely *Kuphinae* Tryon including the mud-boring genus *Kuphus* Guettard, *Teredininae*. Rafinesque which includes the genera, *Bactronophorus* Tapparone Canefri, *Neoterodo* Bartsch, *Dicyathifer* Iredale, *Teredothyra* Bartsch, *Teredora* Bartsch, *Uperotus* Guettard, *Psiloteredo* Bartsch, *Teredo* Linnaeus and *Lyrodus* Gould, and the new sub-family *Bankiinae* Turner which includes four genera *Nototerodo* Bartsh, *Spathoterodo* Moll, *Nausitora* Wright and *Bankia* Gray. According to this new system, the total number of valid species in the world has been reduced to 66. Some species synonymized in the catalogue were later found to be valid species (Ibrahim 1981, Reyner 1974, Hoagland and Turner 1981).

Turner divided the family Pholadidae into 3 sub-families, namely pholadinae which includes 3 genera *Barnea* Risso, *Pholas* Linnaeus and *Zirfaea* Gray; *Martesiinae* consisting of two genera *Lignopholas* Turner and *Martesia* Sowerby and *Xylophaginae* including the deeper water genus *Xylophaga* Turton. With this new classification as the basis the species have been determined.

Crustacean borers

The crustacean wood borers are mainly confined to the order Isopoda and are represented by the two well-known genera, *Sphaeroma* (pillbugs) and *Limnoria* (gribbles). The genus *Sphaeroma* can easily be identified by the shape of the body and its habit of rolling into a ball when disturbed. The attack of pillbugs is heavy in the brackish water systems, converting the timber into a honey-combed structure. Their burrows are cylindrical. Identification is largely based on the ornamentation of the dorsal side of the

body. Many publications are available on the systematics of *Sphaeroma*. Important among them are those of Richardson (1905), Racovitza (1910), Monod (1931), Barnard (1940), Pillai (1961), Hurley & Jansen (1977), Kenscely (1978), Iverson (1982). The most important character is the number and arrangement of tubercles on the posterior part of the body.

The species of *Sphaeroma* commonly reported from Indian waters are *S. terebrans*, *S. walkeri*, *S. triste*, *S. annandalei* and *S. annandalei travencorensis*. The main difference between these species is the pattern of the tuberculation on the pereon, pleon and telson. Thus in *S. terebrans* pereonite 6-7 bear 4 tubercles each, two submedian and two lateral. Composite pleon bears 4 tubercles, two submedian and two lateral as in the pereonite. The telson also bears 4 tubercles 2 submedian and two lateral. The tubercles of the pereon, pleon and telson fall in a line forming 4 longitudinal rows. *S. walkeri* has the entire dorsal surface of the body tuberculate, telson with longitudinal rows of tubercles, *S. triste* has two submedian tubercles on pereonite 7. *S. annandalei* with a 'V' – shaped arrangement of tubercles which are 5 in number this being flanked on either side by a longitudinal row of three tubercles. *S. annandalei travencorensis* has tuberculation similar to *S. annandalei* but the lateral longitudinal row consists of two instead of 3 tubercles.

The posterior part of the telson is also important, it is rounded in *S. annandalei*, angular in *S. terebrans* or curved upwards in *S. walkeri*. The shape of the epistome is another useful character of identification (Pillai 1961). The shape and structure of the 4th and 5th pleopods (Monod 1931), the arrangement of spines on the thoracic legs (Racovitza 1910) and the number of teeth arming the outer border of exopod of uropod are also important (Pillai 1961) in identification.

The family Limnoridae comprises two genera, namely *Paralimnoria* and *Limnoria*. The former contains only one species whereas the latter consists of two subgenera: *Limnoria* which are all wood-borers, and *Phycolimnoria*, the seaweed borers (Menzies 1957). About 19 species of the sub-genus *Limnoria* have been identified (Kühne 1968) and locations where many of these species were found have been described (Menzies 1959), as has the occurrence of some limnoriids in softwood exposed at numerous sites around the world (E.B.J. Jones *et al.* 1976). They are exclusively marine and generally considered inhabitants of shallow water but have been collected from depths as great as 290 fathoms (Menzies 1957).

Limnoria grows to about 5mm long with a flat almost parallel sided body. The most useful diagnostic characteristic consists of the gross and detailed shape and structure of ornamentations, tuberculation and bristles on the dorsal surface of the last segment of the body, the pleotelson. Features such as the shape of the maxillipedal epipod, and the number of articulations comprising the mandibular palp are also useful in separating some species. It is able to roll itself when disturbed as *sphaeroma* does. They make the tunnels close to the surface of the wood and give "a lace-like appearance" and "sponge-like" texture to the wood. The burrows are usually a few cms in length, the animal remaining at the blind end.

Collection of these woodboring crustaceans is not easy. Sheard (1941) suggested a method for collecting marine invertebrates (except molluscs) hiding in burrows. This is by placing the infested piece of wood in a glass trough containing 1% solution of commercial formalin for about 30 minutes. Animals if present would come out of the burrows. Care should be taken to keep the strength of the solution as low as 1%. Otherwise, the animals would die inside the burrows. Sphaeromatids can be preserved in formalin, but for *Limnoria* 75% alcohol is advisable (Menzies 1957).

Nature and extent of damage

The nature of damage caused by the molluscs and crustaceans is different, producing different effects on timber. The shipworm larva after settlement transforms into a tiny boring mollusc and grows rapidly. Since the rate of growth is proportional to the destruction of timber each shipworm during its life time destroys a column of wood of the same dimension as its largest size (Nair 1984). They spend their adult life within the confines of the timber in which they have penetrated and the growth is effected by lengthening the burrow by the abrasive action of the bivalve shell. Hundreds of these may settle on a fresh piece of timber and honey-comb its interior and the only external evidence of their presence will be the tiny entrance holes on the surface of the timber. The tunnels of pholads are much smaller than that of the shipworms being a little larger than their body size, but their rapid growth rate and their ability to penetrate deeper and deeper in each generation cause speedy destruction of timber (Nair 1964). *Martesia* is the most destructive genus among pholads and all species in the genus do considerable damage to waterfront structures. *M. striata* is the best known and widely distributed all along the Indian coasts. Because of the density of their attack, quick development, rapid succession of generations and great tolerance to low salinities they are of great economic importance. The molluscan borers attack wood from high tide level mark to the mudline (Nair 1966; Nair & Dharmaraj 1979, 1980; Nair & Saraswathy 1971 and Turner 1966).

Attack by crustacean borers is different and among them the pillbugs are the most important, since they are of larger size and can thus effect greater damage to timber than other genera. They excavate cylindrical burrows twice as long as their body and these burrows are at right angle to the surface of the wood (Nair 1964; Pillai 1961). Their dense settlement owing to continuous breeding (Pillai 1961), gregarious habits and rapid rate of reproduction contribute to deeper penetration of timber. In case of heavy attack the surface of the timber is honey-combed. Attack is heaviest in the intertidal zone, the maximum intensity being at half tide level (Pillai 1961, John 1964; Dharmaraj and Nair 1979, 1980; Hurley and Jansen 1977). In case of sphaeromatids attack on fresh surface is effected by migrating juveniles or adults. They constitute a very serious threat to all type of timber including live trees, which are all attacked and riddled, particularly in the estuaries, backwaters and mangroves (Nair & Dharmaraj 1980a; Dharmaraj & Nair 1981; 1981a).

Along the backwaters of Kerala, embankments made out of laterite blocks are common for reclamation, protection and various other purposes. Natural banks formed of hard clay also occur in several localities. Heavy incidence of sphaeromatids has been reported (Dharmaraj and Nair 1982) from the laterite and hard clay embankments in the Ashtamudi, Kadinamkulam, Anjengo and Akathumuri backwaters.

The genus *Limnoria* which is much smaller than *Sphaeroma* is capable of excavating long tunnels many times the length of its body just below the surface. The burrows usually follow the grain and innumerable small holes produced by these give the wood a sponge-like texture and lace-like appearance (Nair 1964, 1984).

Thus, the nature of attack of the molluscs and crustaceans is different, enabling them to effectively share with little competition this common substratum which is limited in extent as a habitat. The crustaceans work from the outside and the molluscs particularly the shipworms penetrate deep into the timber. The combined action of these two groups of borers convert the wood into a highly porous, weak and fragile mass (Nair 1984).

DISTRIBUTION OF SHIPWORMS ALONG THE WEST COAST OF INDIA

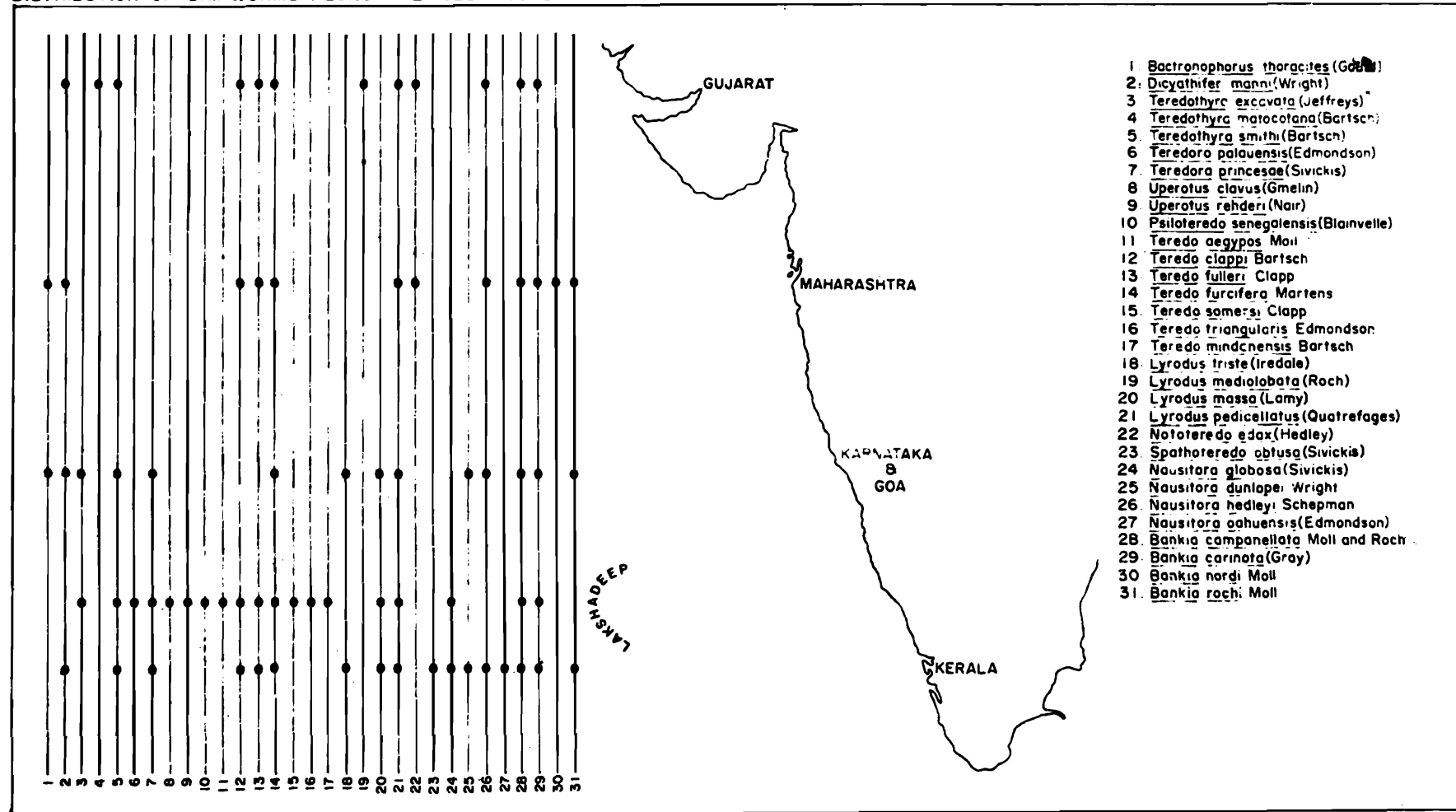


Fig. 2

DISTRIBUTION OF SHIPWORMS ALONG THE EAST COAST OF INDIA

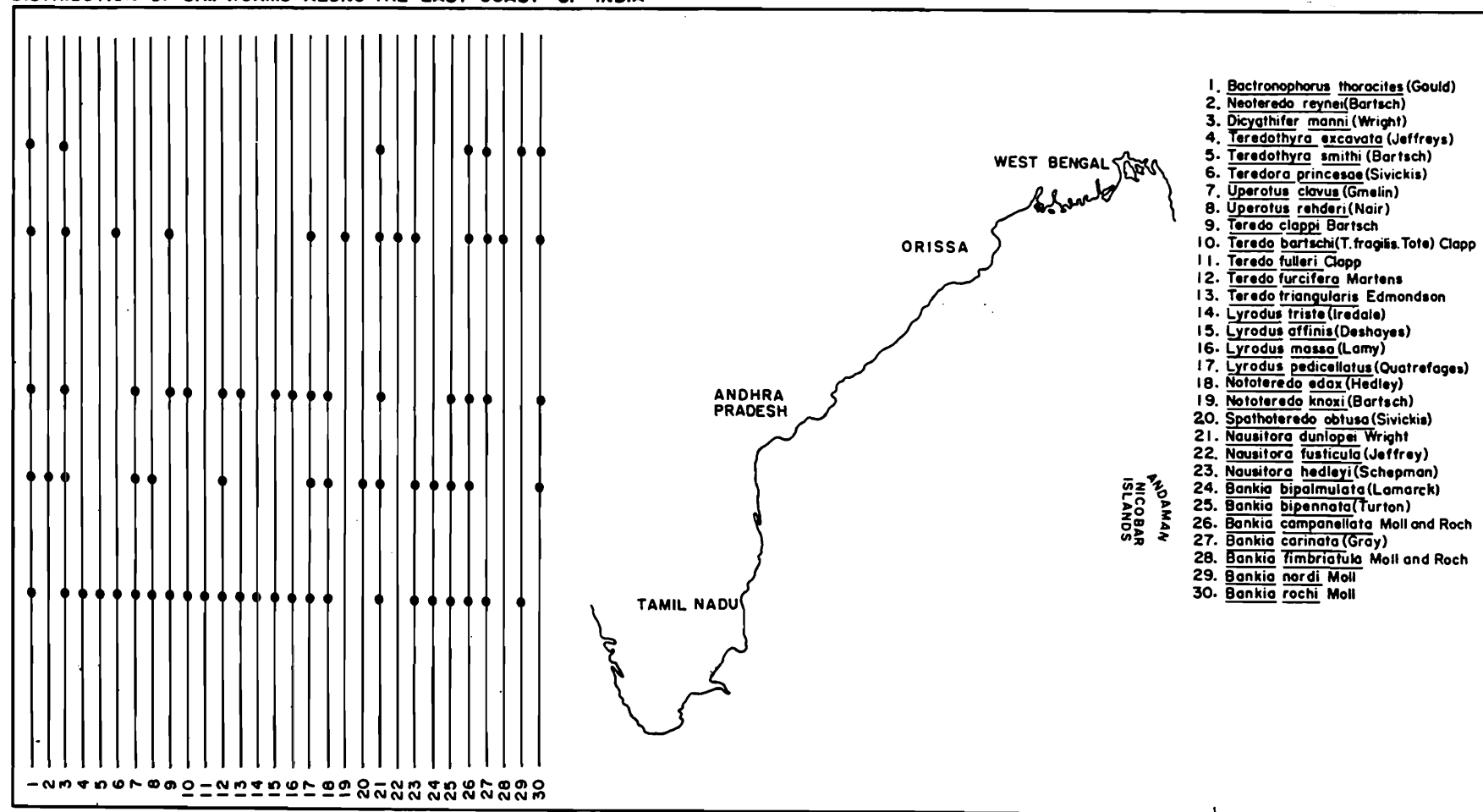


Fig. 3

The extent of damage caused by the marine wood-boring organisms is enormous to all maritime countries. The problem is more acute in the developing countries than in developed countries, because wood is still used more extensively as a constructional material for fishing craft. The financial loss incurred by the fishing industry owing to wood-borers is difficult to assess as the boats are often dry-docked for purposes other than repairing or resorting to remedial measures against wood-borers. Santha kumaran & Jain (1982) reported that for protecting the indigenous boats, the fishermen incur an annual expenditure of Rs. 200/- to Rs. 1000/- per boat depending on the size and Rs. 2000/- to Rs. 15,000/- in case of bigger mechanised boats depending on the nature of damage. The number of indigenous and mechanised fishing crafts in operation along the Indian coasts is about 94924 and 16034 respectively (Santha Kumaran & Jain 1983). The total annual loss is thus estimated as about 94 million rupees (Santha Kumaran & Jain 1983). More boats are being added annually, thus increasing the loss. Further, timber is also used to provide necessary infrastructural facilities at about 1300 main fish landing centres along the coasts and also for mariculture at several places, the impliments of which are also attacked by marine borers.

Thus, the financial loss due to the destructive activities of marine borers soars to a staggering figure with expanding fishing industry.

*Systematic and distributional account of wood-borers of the
Andaman, Nicobar and Lakshadweep Islands*

The Andaman and Nicobar group of islands are located in the south-eastern Bay of Bengal, between lat. 6° and 14° N and long. 91° and 94°E. The two groups comprise 321 islands, of which only 38 are inhabited. They collectively have an area of 8293 km² although this does not included a number of exposed islets and rocks. All the islands are the exposed peaks of a long range of submerged mountains which extend from Burma to Sumatra. A deep oceanic ridge, about 1500 m in depth runs between the Nicobars and Sumatra and another oceanic ridge along 10° N separates the Andaman and Nicobar group of islands. Most of these islands are surrounded by fringing reefs on their eastern side and barrier reef on their western side. They harbour a rich population of corals and molluscs and most of them have a luxuriant mangrove vegetation around them.

The Andaman sea is influenced by large quantities of fresh water run off from the perennial rivers of Burma, Thailand and Malaysia. This run off largely influences the water quality of the surface layer.

Lakshadweep Archipelago is a group of 10 small inhabited and 12 uninhabited atolls along with a few adjoining islets, off the western coast of India in the eastern Arabian Sea. This small Union Territory of India, lie scattered about 200 to 400 kms off the coast of Kerala between lat. 8-12° N and long. 74-76° E. The total land area of the archipelago is only 32 km² the largest atoll (Androth) occupies 4.8 km² and the smallest inhabited atoll Bitra 0.1 km² area. Timber structures along the shores of these islands are varied. Since timber is absent except coconut stem, wood used for various constructions is transported from the mainland and therefore, the cost is enormous when compared to that of the mainland. There are wooden jetties and suberged installations, which are used by the boats and ships that provide the only means of transportation to the atolls. Fishing operations also use a variety of timber structures and wooden crafts. The atolls are comparatively clean except for oil pollution and tar deposition along the beaches. The atolls lie close to the major highway through the Arbian sea - the sea route for both traditional wooden boats and large ships belonging to several nations sailing for centuries. Consequently, the wood boring community

of the Lakshadweep sea represents, in fact a heterogeneous community resulting from human activities and from natural dispersal through oceanic currents and drift wood.

A total of 22 species of molluscan borers; 19 shipworms belonging to 7 genera, 3 piddocks belonging to 2 genera and six species of crustacean borers, (4 sphaeromatids and 2 limnorids) have so far been reported from various atolls of the Lakshadweep Archipelago (Nair and Dharmaraj 1983). From the Andaman Nicobar Islands a total of 14 molluscan borers - 11 shipworms and 3 piddocks, and 9 crustacean borers - 2 sphaeromatids and 7 limnorids have so far been reported (Das and Dev Roy 1980, 1981; Ganapati and Rao, 1959, 1960; Karande, 1978; Tewari *et al.* 1980).

The present report represents a compilation of the systematics and distribution of the marine wood-boring organisms that occur in these two groups of islands.

Phylum MOLLUSCA

Class BIVALVIA

Order MYOIDEA

Suborder PHOLADINA

Family TEREDINIDAE

Subfamily KUPHINAE Tryon

1966. *Kuphinae* Tryon Turner p. 57, 73.

Genus *Kuphus* Guettard

1770. *Kuphus* Guettard, p. 139.

1966. *Kuphus* Guettard, Turner p.20.

1971. *Kuphus* Guettard, Turner p. 24.

Salient features : Pallets simple, solid, non-segmental and calcareous.

Blade triangular, flat on the inner side, convex on outer side with the distal end forming a shallow cup. Stalk long and heavy.

Shell valves greatly reduced with sinuate anterior margin, calcareous lining thick and divided posteriorly. Strong muscular collar present at the posterior end of the valves. Siphons long and separate. A caecum is absent, intestine traverses the pericardium (Turner 1966).

Represented by *Kuphus polythalamia* (Linnacus). This is a mud-boring species reported from the mangrove swamps of the Indo-Pacific region.

Sub-family TEREDININAE Rafinesque 1815

1966. *Teredininae* Rafinesque Turner p.57, 73.

1971. *Teredininae* Rafinesque. Turner p. 27.

Includes genera in which the pallets are non-segmental in structure. In this family there is a trend toward increased protection of young culminating in the genus *Lyrodus* which retains the young within the mantle cavity to the late veliger stage. Shell typical of the family.

A muscular collar absent, pallets varied, non-segmental, caecum present for the storage of grated particles of wood, intestine not traversing the heart.

Genus Group I

Genus *Bactronophorus* Tapparone-Canefri 1877

1. *Bactronophorus thoracites* (Gould) 1856.

Genus *Neoterredo* Bartsch 1920.

2. *Neoterredo reynei* (Bartsch) 1920.

Genus *Dicyathifer* Iredale 1932.

3. *Dicyathifer manni* (Wright) 1866.

Genus *Teredothyra* Bartsch 1921.

4. *Teredothyra excavata* (Jeffreys) 1860.

5. *Teredothyra smithi* (Bartsch) 1927.

Genus Group II

Genus *Teredora* Bartsch 1921

6. *Teredora palauensis* (Edmondson) 1959.

7. *Teredora princessae* (Sivickis) 1928.

Genus *Uperotus* Guetard 1770.

8. *Uperotus clavus* (Gmelin) 1791.

9. *Uperotus rehderi* (Nair) 1956.

Genus *Psiloterredo* Bartsch 1922.

10. *Psiloterredo senegalensis* (Blainville) 1828

Genus Group III

Genus *Teredo* Linnaeus 1758.

11. *Teredo aegypos* Moll 1941.
12. *Teredo bartschi* Clapp 1923.
13. *Teredo clappi* Bartsch 1923.
14. *Teredo fulleri* Clapp 1924.
15. *Teredo furcifera* von Martens 1894.
16. *Teredo mindanensis* Bartsch 1923.
17. *Teredo portoricensis* ? Clapp 1924
18. *Teredo somersi* Clapp 1924.
19. *Teredo triangularis* Edmondson 1942.

Genus *Lyrodus* Gould 1870.

20. *Lyrodus massa* (Lamy) 1923.
21. *Lyrodus pedicellatus* (Quatrefages) 1849.

Subfamily BANKIINAE Turner 1966.

Genus *Nototeredo* Bartsch 1923.

22. *Nototeredo edax* (Hedley) 1895.

Genus *Spathoteredo* Moll 1928.

23. *Spathoteredo obtusa* (Sivickis) 1928.

Genus *Nausitora* Wright 1864.

24. *Nausitora dunlopei* Wright 1864.
25. *Nausitora hedleyi* Schepman 1919.

Genus *Bankia* Gray 1842

26. *Bankia bipalmulata* (Lamarck) 1801.
27. *Bankia bipennata* (Turton) 1819.
28. *Bankia campanellata* Moll & Roch 1931.
29. *Bankia carinata* (Gray) 1827.
30. *Bankia rochi* Moll 1931.

Genus Group I

Stomach globular, gonads posterior to the caecum, anal canal closed (Turner 1966, 1971)

Genus 1. *Bactronophorus* Tapparone-Canefri 1877

1877. *Bactronophorus* Tapparone-Canefri p. 290.
 1966. *Bactronophorus* Tapparone-Canefri Turner p. 23, 73.
 1971. *Bactronophorus* Tapparone-Canefri Turner p. 27

Salient features : Pallels non-segmental, asymmetric,, basal portion of blade somewhat triangular in outline with a shallow cup from which a pustulose, calcarous dagger-like extension is given off, giving a stilt-like appearance to the pallet. Siphons short and fused for most of their length. The excurrent siphon with two papillae on the dorsal surface at the tip and the aperture of the incurrent siphon provided with several small papillae. Ctenidia are broadly U-shaped, flattened ventrally and extend anteriorly from the base to the siphon to slightly over lap the visceral mass and have prominent food grooves. The anterior part of the ctenidium is composed of 16 lamellae and the labial palps are prominent. Stomach is globular and the caecum is large and thin-walled. Intestine is given off from the anterior right side of stomach, loops over the crystalline style-sac and courses as in other shipworms to terminate over the posterior adductor muscle where the intestine is muscular and enlarged with longitudinal ridges internally. There is a well defined anal canal extending posteriorly beyond the pericardium and closed posteriorly by muscular folds to enable the retention of the faeces. Heart extend from beneath the posterior adductor muscle to the posterior end of the gonads. Ventricle is deeply lobed, slightly wider than the auricles which are reddish brown in colour. The kidney is long placed over the heart (Turner 1966).

Represented by *Bactronophorus thoracites* (Gould). Typical wood-borers of the mangroves and brackish water areas of the Indo-Pacific.

1. *Bactronophorus thoracites* (Gould)

1856. *Teredo thoracites* Gould p.15.
 1861. *Teredo furcelloides* Gray p. 314.
 1866. *Calobates australis* Wright p. 564.
 1928. *Bactronophorus edulis* Sivickis p. 289.
 1928. *Bactronophorus filoteoi* Sivickis p. 290.
 1936. *Bactronophorus subaustralis* Iredale p. 41.
 1954. *Bactronophorus thoracites* (Gould) Roonwal. p. 91-105.
 1955. *Bactronophorus thoracites* (Gould) Nagabhushanam p.1-11.
 1966. *Bactronophorus thoracites* (Gould) Turner p. 126.
 1971. *Bactronophorus thoracites* (Gould) Turner p. 27, 44.

Salient features : Pallels are characteristic and unique being stilt-like or as Turner calls it of the 'sheath and dagger' type exhibiting all characteristic features of the genus. The dagger-like extension is slightly convex on the outer face and flat on the inner face and may arise from the 'basal cup' itself or from any part of it. Shell valves are typically teredinid. Each valve more or less triangular in shape. Anterior slope well-developed, umbono-ventral sulcus and disc narrow but well defined. Posterior slope small, set

high on the disc with which it forms a narrow shelf internally. In adult specimens the outer dorsal portion of the valves may show erosion.

The salient features of its anatomy include all characteristic features of the genus.

Ecological notes : This is a common species in the mangroves, in estuaries and along sheltered coastlines of the Indo-West Pacific. Even though restricted to mangroves, the species occasionally appears in logs of timber and in catamarans (Nagabhushanam 1955) along the open shore. It grows to a fairly big size in mangroves, often more than 45 cms in length by 2.5 cm in diameter extending up the trunk and down the roots from the intertidal zone where they settled (Reyner 1974). The large caecum suggests it is an efficient wood feeder and the well developed kidney indicates that it is capable of dealing with a wide range of salinity.

B. thoracites is a common species and a serious pest of the mangrove swamp forests of the 24 Parganas, Forest division in the Sunderbans, West Bengal. "The borer constitutes a major forest pest attacking several species of both living and dead forest trees. Usually the base of the standing trees as well as stumps up to about two to three feet above ground level, and the tap-root up to 2 to 3 feet or more below ground level are riddled with galleries of the borer. In bent trees the galleries may extend all along the length of the lower branches. The affected tree remains green, but ultimately, with strong gusts of wind, breaks at the riddled base and topples over" (Roonwal, 1954). The trees commonly seen attacked are, among others *Exoecaria agallocha* Linn. (Euphorbiaceae); *Sonneratia seida* Linn. (Lythraceae); *Avicennia officianalis* Linn., *A. alba* Linn., (Verbanaceae); *Rhizophora conjugata* Linn., *Ceriops roxburghiana* Linn. (Rhizophoraceae), *Phoenix plaudosa* Roxb. (Palmae); *Aegiceras majns* Gaertn (Myrsinaceae); *Aegialitis rotundifolia* Roxb. (Plumbaginaceae). The borer attack extends throughout the sapwood and heartwood.

Whereas this is a very common species in the mangrove swamps of the Sunderbans, in other places its incidence is not much significant from the point of view of destruction of wood. In Visakhapatnam this borer has been noticed in a country log-raft (Nagabhushanam, 1955) and in Bombay it is rare being recorded once from Sewree timber pond on the east coast of Bombay (Island). Turner (1971) collected *B. thoracites* from as many as 23 field stations along the coast of Australia but never from test panels. Turner (loc. cit.) observes. " It is possible that sawn wood is not a favourable substrata for these typically mangrove species and that only an occasional animal successfully penetrates pilings, or that test panels are not in the water, long enough for the succession of events necessary for the settlement of the larvae. It is also possible that the types of bacteria or fungi found on mangrove differ from those on wharves for we know some bacteria attract larvae while others repel them"

Occurrence : Sunderbans, West Bengal (Roonwal, 1954, 1966; Rajagopal, 1964a), Visakhapatnam (Nagabhushanam, 1955), Mahanadi (Subba Rao, 1968); Andamans-Nicobar (Tewari *et al.* 1980 Das and Dev Roy, 1981); Porto Novo (Nair and Dharmaraj, 1980a; Bombay (Palekar and Bal, 1957); Panaji (Santhakumaran and Udaya Bhaskar, 1982).

Distribution : Freemantle, W. Australia (Wright 1866); Traveston, Burrum river, 20 miles north of Maryborough, Queensland, Australia (Iredale, 1936); Indonesia (Gray 1861); Cebu (Sivickis, 1928); New Washington, Capiz Province, Panay, Philippines (Sivickis, 1928), Tavoy, Burma (Gould, 1856).

Genus *Neoteredo* Bartsch

1920. *Neoteredo* Bartsch p. 69.
 1966. *Neoteredo* Bartsch. Turner p. 23, 73.
 1971. *Neoteredo* Bartsch Turner p. 27.

Salient features : Pallets simple, broadly oval, solid, heavy, slightly cupped at the distal end in young specimens, but often eroded to a rounded posterior margin. Posterior end of the animal with two long fleshy lobes or lappets on the dorsal surface; siphons are united for about half their length; broad, flat gills extend from the base of the siphons anteriorly to the visceral mass; food groove weak; anterior gills not evident; stomach globular; intestine opens anteriorly from the right side of the midgut, makes a loop over the crystalline style-sac anteriorly, intestine opens into the anal canal by a large funnel-shaped anus; anal canal large and thin-walled extending the length of the visceral mass, its posterior opening controlled by a large, strong, well formed sphincter muscle; heart, very long extending from the posterior adductor to the posterior end of the gonads, ventricle short, muscular and lobed posteriorly, gonads largely posterior to caecum (Turner 1966).

This genus is reported from Antigua, Lesser Antilles, north coast of S. America, from Surinam to Sao Paulo, Brazil and the coast of Africa from Sierra Leone to Congo.

Neoteredo reyni (Bartsch)
 (Plate IB)

1920. *Teredo* (*Neoteredo*) *reyni* Bartsch p.69.
 1922. *Teredo* (*Neoteredo*) *reyni* Bartsch p.30.
 1966. *Neoteredo reyni* (Bartsch) Turner p.119.
 1967. *Teredo adami* Moll. Rancurel non adami Moll.
 1971. *Neoteredo reyni* (Bartsch) Turner p. 27, 49.

Salient features : Shell sub-globular, disc large, posterior slope small, umbonal knob bears a strong, narrow apophysis extending obliquely into the cavity.

Pallets paddle-shaped, large, solid, heavy, broadly oval with a slight depression distally, particularly evident in young specimens, stalk heavy, not tapering.

Posterior end of the animal with two longitudinal lappets on the dorsal surface anterior to siphons; mantle thick; siphons united except at the tip, gills broad and flat, branchial groove weak, labial palps not free, stomach globular, caecum moderately developed, intestine looping over style-sac, anal canal closed, heart anterior with deeply pigmented auricles, heart/body length 0.8, gill/body length 0.1, visceral mass/body length 0.8 heart/gill length 7.0 (Turner, 1966).

Ecological notes : The most striking feature of this genus is the pair of large, lappets on the dorsal surface, just anterior to the siphons. Bartsch (1920) created a new sub-genus *Neoteredo* to accommodate shipworms sent by Mr. A. Reyner from Paramaribo, Dutch Guiana. These were found destroying sluices built of green heart (*Nectandra rodiaei*) in a very short time. This wood is believed to be resistant to shipworm attack.

Occurrence : Andamans (Das and Roy, 1980); Paramaribo, Dutch Guiana (Bartsch 1920, 1922).

Note : Dr. Ruth Turner feels that the identification of the Andaman specimens has to be checked and confirmed.

Genus *Dicyathifer* Iredale

- 1932. *Dicyathifer* Iredale p. 28.
- 1958. *Pseudodicyathifer* Tchang, Tsi and Li p. 248, 256.
- 1966. *Dicyathifer* Iredale Turner p. 24, 75.
- 1971. *Dicyathifer* Iredale Turner p. 27.

Salient features : Pallets solid, simple, almost entirely calcareous, somewhat triangular in outline and having a long, heavy stalk. Inner face of blade flat while outer face is convex and the distal end produced into a shallow cup which may be partially or almost completely divided by a median longitudinal ridge. Shell comparatively large bearing strong denticular ridges on the anterior, outer face. Siphons separate and moderately long, labial palps small. Anterior portion of ctenidium well developed, food grooves on the ventral outer edge; stomach globular, caecum small and flask-shaped; intestine loops over the style sac and after passing down the right side of the stomach crosses beneath it to the left side, extends posteriorly along the left side and after meandering passes beneath the pericardium to pass under and then around dorsally and then over the posterior adductor muscle. the interstine extends a short distance beyond the muscle before opening into the anal canal. Muscular folds at the end of the anal canal control the opening into the epibranchial cavity so that the faeces can be retained within the canal. The heart is approximately one half of the length of the animal extending from the posterior adductor muscle to the anterior end of the gills. Ventricle is short, broad, the auricles are long and tubular. Kidney is large extending from the posterior adductor backwards for nearly half the length of the heart. Includes species like *Dicyathifer manni* (Wright) occurring in the marine and brackish water areas of the Indo-Pacific (Turner 1966).

Dicyathifer manni (Wright) (Plate IC)

- 1866. *Kuphus* ? *manni* Wright p. 565.
- 1928. *Teredo bartschi* Sivickis p. 292.
- 1936. *Dicyathifer caroli* Iredale p. 38.
- 1956. *Teredo sivickisi* Miller p. 1575.
- 1964. *Teredo ancilla* Barnard p. 568.
- 1966. *Dicyathifer manni* (Wright) Turner p. 109.
- 1971. *Dicyathifer manni* (wright) Turner p. 27, 49.

Salient features : Pallets large and heavy, almost entirely calcareous and somewhat triangular in shape. The blade is about as wide as long, moderately cupped, with a medial ridge partially or completely dividing it. Blade flat on the inner face, and moderately convex on the outer face. The distal margin on the outer face of the blade is broadly U-shaped, that on the inner face straight or slightly curved. Shell somewhat triangular in outline with broad dorsal margin. Anterior slope large in size and shape and often eroded. Umbonal ventral sulcus and disc are narrow but well defined. Posterior slope greatly reduced and set high on the disc and does not form a shelf when viewed from within. Apophysis long, broad and flattened.

Siphons separate, gills broad and flat, branchial groove well developed, labial palps not free, stomach globular, caecum small, intestine looping over style-sac, anal canal closed, heart anterior, auricles deeply pigmented. Despite the fact that this is a large species, its caecum is small, the kidneys are well developed, anal canal long and this can be closed by a muscular fold, heart /body length 0.5, gill/body length 0.4 visceral mass/body length 0.6, heart/gill length 1.2 (Turner 1966).

Ecological notes : This species is reported to be common infesting mangrove trees in both marine and brackish water of tropical and subtropical south-east Asia. It is also found occasionally in fixed structures in brackish and marine waters.

D.manni is a large euryhaline shipworm of the Indo-Pacific region. According to Rayner (1974) this is a very common species growing to a large size in the mangrove swamps of Papua-New Guinea. It has been reported as infesting live and dead mangrove trees in the Sunderbans of West Bengal (Roonwal 1966). According to Palekar & Bal (1957) this is the most common species both in the Karwar Port and in the Sewri timber pond of Bombay and specimens measuring 6.5 cm long and 2 cm in diameter have been noted. Santhakumaran (1976) states that this is one of the most destructive shipworms on the North-west coast of India and many specimens were collected from living mangrove trees at Cuffe Parade and Jamnagar. In Papua New Guinea, this species occurs in the Marshall Lagoon estuary in salinities between 10 and 35ppt. and in laboratory tests its growth was found to be faster in 20 and 30ppt. Settlement occurred periodically along the mouth of the river in response to seasonal changes in salinity (Rayner, 1979).

Occurrence : Andaman, Nicobar (Das and Dev Roy 1980, 1981; Tewari *et al.* 1980), Sundarbans (Roonwal 1966, Rajagopal 1964a), Mahanadi estuary (Subba Rao 1968), Visakhapatnam (Nagabhushanam 1955), Pulicat Lake, Madras, Ramnand (Nair 1963, 1964, 1965), Anjengo, Mangalore (Dharmaraj and Nair 1981, 81a), Cochin (Nair 1984, Saraswathy 1964), Kasaragode (Santhakumaran 1976), Karwar (Santhakumaran and Pillai 1975; Santhakumaran 1976; Palekar and Bal, 1957), Panaji (Santhakumaran and Pillai, 1975; Santhakumaran 1976, 1981, 1983), Ratnagiri (Santhakumaran 1976), Bombay (Palekar, Santhakumaran and Bal 1964), Jamnagar kolak and Daman (Santhakumaran 1976).

Distribution : East coast of Africa (Kenya, Tanganyika, Mozambique) Comoro Islands, Madagascar, Reunion (Roch 1955). Indo-Malay Archipelago (Roch, 1955). Australia (Iredale, 1936), New Zealand, Papua-New Guinea (Roch 1961, Rayner, 1974), Philippine Islands, Pacific Ocean Islands (see Roch 1961).

Genus *Teredothyra* Bartsch

- 1921 *Teredothyra* Bartsch p. 26.
- 1927 *Ungoteredo* Bartsch p. 544:
- 1945. *Idioteredo* Taki and Habe p. 115.
- 1966. *Teredothyra* Bartsch Turner p. 26, 75.
- 1971. *Teredothyra* Bartsch Turner p. 27.

Salient features : Pallets consisting of a broad or elongate basal cup and a secondary inner cup which is divided medially. The stalk is partly sheathed by the basal cup and extends into the substance of the blade up to about the base of the inner cup.

Siphons long and separated, ctenidia extend from the base of the siphons to the posterior end of the gonads. The food grooves extend over the visceral mass to the anterior gill filaments, and the labial palps which are rudimentary. Stomach globular, caecum comparatively small and bent, intestine short with an anterior loop around the crystalline style sac and after passing below the stomach loops around the caecum and curves over the posterior adductor muscle to open into the anal canal through a large muscular anus. Heart anterior, with a short triangular ventricle, auricles long and tapering (Turner 1966).

This genus is widely distributed in tropical and subtropical areas and includes species which are usually small such as *T dominicensis* (Bartsch), *T excavata* (Jeffreys), *T matacotana* (Bartsch) and *T smithi* (Bartsch).

***Teredothyra excavata* (Jeffreys)**
(Plate ID)

- 1860. *Teredo excavata* Jeffreys p. 123.
- 1941. *Teredo tritubulata* Moll p. 221.
- 1955. *Teredo (Teredothyra) linearis* Nair p. 272.
- 1959. *Teredo (Teredothyra) subicensis* Edmondson p. 205.
- 1965. *Teredo (Bitubuloteredo) bitubula* Li Kie-Min 1-7.
- 1965. *Teredo (Teredothyra) remiformis* Li Kie-Min 1-7.
- 1966. *Teredothyra excavata* (Jeffreys) Turner p. 100.
- 1971. *Teredothyra excavata* (Jeffreys) Turner p. 27, 44.

Salient features : Shell sub-globular with the anterior slope provided with a deep sinus, posterior slope narrow.

Pallet blade is longer than wide. Distal margin on inner face nearly straight, margins of two cups on the outer face deeply U-shaped. Basal cup usually clearly visible, much shorter on outer face.

Ecological notes : This species occurs in fair numbers in the mangrove forests adjoining the mouth of the Talapady river opening into the Arabian sea about 15 km south of old Mangalore Port and the Nethravathy-Gurupur estuaries. Salinity varies from almost freshwater during monsoon to near marine condition during the pre-monsoon period. Shells and pallets have been collected from drift wood cast ashore on Lakshadweep Archipelago.

Occurrence : Floating pieces of wood cast ashore at Royapuram, Madras Coast (Nair, 1955); Mandapam (Nair and Dharmaraj, 1980); Lakshadweep (Nair and Dharmaraj, 1983); Mangalore, (Dharmaraj and Nair, 1981).

Distribution : Probably world wide in tropical and subtropical areas. Records are available from Guernsey, England; Victoria in the Cameroons, Africa (Moll, 1941), at Subic Bay, Luzon, Philippine Islands (Edmondson, 1959); Papua-New Guinea (Rayner, 1974) and from shipwreck at Koror, Palace Islands (Caroline Islands) Edmondson, 1959).

***Teredothyra smithi* (Bartsch)**
(Plate IIA)

1927. *Teredo* (*Teredothyra*) *smithi* Bartsch p. 540.
 1927. *Teredo* (*Teredothyra*) *radcliffei* Bartsch, p. 542.
 1927. *Teredo* (*Teredothyra*) *tanonensis* Bartsch p. 543.
 1937. *Teredo* (*Phylloterodo*) *lanceolata* Moll p. 171.
 1945. *Kuphus* (*Idioterodo*) *kiiensis* Taki and habe p. 115.
 1956. *Teredo* (*Zopoterodo*) *bengalensis* Nair p. 411.
 1957. *Teredo* (*Nototerodo*) *nambudalaiensis* Nair and Gurumani. p. 157.
 1966. *Teredothyra smithi* (Bartsch) Turner p. 122.
 1971. *Teredothyra smithi* (Bartsch) Turner p. 28, 44.

Sailent features : Pallets long and spatulate with a cylindrical stalk (of variable length) which continues into the flat blade, like the shaft of a feather. This extension of the stalk is noticeably prominent in the inner view of the pallet. Blade broad and elongate with a horn-coloured periostracum at the distal end which is slightly cupped. The calcareous margins when viewed from the inner side may extend as two pointed horns at the distal end with the periostracum in between. A well defined median longitudinal fold may be present on the distal outer face of the blade. The sides of the pallet blade are not straight but slope towards the posterior end.

Shell sub-globular, white, anterior slope sculptured by closely set denticulated ridges, disc prominent, posterior slope well defined and quite conspicuous in young specimens but may be badly eroded in old specimens, umbonal reflection and callus prominent, apophyses broad, long and slightly oblique springing from the underside of the umbo.

Siphons, relatively long and separated (Turner 1966).

Ecological notes : Live specimens have been collected from the mangrove swamps of Talapady, Mangalore, India. At Madras, Nambudalai, Pamban, and Lakshadweep, only shells and pallets could be collected from drift material whose origin is not known. That this species occurs in faairly deep water is evident from its incidence at 28 fathoms off Linao point, Gulf of Davao, Mindaneo; and at 300 fathoms off Pecadoe Island in Tenon strait, Philippine Islands and Turner (1966) has reported it from a depth of 5050 in (not living specimens).

Occurrence : Madras, Pamban (Nair 1955, 1961), Trivandrum and Mangalore (Dharmaraj and Nair 1981, 1981a), Tondi, Ramnad (Nair and Gurumani 1957, 1957a) Lakshadweep (Nair and Dharmaraj 1983), Okha (Santhakumaran, 1976, 1976a).

Distribution : Indo-Pacific in Tropical and sub-tropical areas. Records are available from Tanganyika (Tanzania) (Moll and Roch, 1937); Kii, Japan (Taki and Habe 1945); Matacot point, Western Luzon (Bartsch, 1927); Off Linao Point, Gulf of davao, Mindanao, (Bartsch, 1927); Off Pcoador Islands, Tenon strait, Philippine Islands (Bartsch 1927), Papua-New Guinea (Rayner 1974).

Genus Group II

Stomach globular, anal canal open, gonads dorsal to caecum (Turner 1966, 1971)

Genus *Teredora* Bartsch

1847. *Malleolus* Gray (non Rafinesque 1815; non Ehrenberg 1838) p. 188.
 1921. *Teredora* Bartsch p. 26.
 1966. *Teredora* Bartsch Turner p. 28, 75.
 1971. *Teredora* Bartsch Turner p. 28.

Salient features : Pallets solid, entirely calcareous, blade oval to broadly oval in outline with a short sometimes stout stalk. Blade thick at the base, the outer convex face resembling a nail in its nail bed marked by concentric lines of growth, in the young the blades of the pallets are double cupped. These double cups often remain as tubes at the base of the depressions in older specimens. In young, the pallet blade is wider than long. A median rib may occur extending from the base to the tip of the blade. Radiating wrinkles may also be present on the outer face of the pallet blade. Shell valves with small, high, posterior slope and with the venral margin of the shelf forming a nearly right angle to the dorso-ventral axis of the valves. The posterior slope is placed high on the dorsal margin that nearly half of it projects as a shelf inwardly and the other half outwardly.

Siphons are united for most of their length, incurrent siphon with numerous large papillae; the ctenidia are blade-like, continuous extending from siphons to mouth; labial palps free; stomach elongate-globular; caecum long and doubled upon itself to the right, intestine anteriorly loops around the style sac and posteriorly loops around the caecum and curves over the posterior adductor to open into the anal canal; heart relatively small with a short, broad ventricle and short, tapering auricles, kidney placed dorsal to heart.

The genus *Teredora* has a wide distribution in tropical and warm temperate waters and contain species such as *T. malleolus* (Turton) and *T. princesae* Sivickis.

Teredora palauensis (Edmondson);
 (Plate IIB)

1959. *Teredo* (*Teredothyra*) *palauensis* Edmondson p. 203.

Salient features : Pallets white and small, entirely solid and calcareous. No trace of periostracum even in young specimens. Oval to broadly oval in outline with short stalk. Blade convex on the outer and concave on the inner face. Distally the blade is double cupped, the two cups resembling burrows excavated from the distal end leaving a thin calcareous wall between them. Shell with characters of the genus. The posterior slope is large and obliquely placed high on the posterior dorsal margin. Gills extend from the siphons to the mouth of the specimen.

Ecological notes : The species was originally described on the basis of valves and pallets alone and Turner (1960) has stated that it may be a synonym of *Teredothyra excavata* (Jeffreys). Considered as a

pelagic species invading drift wood. Occurs occasionally in submerged fixed wooden materials also. However, careful examination of the specimens from fixed wood along the shore waters of the Lakshadweep Archipelago revealed that *T. palauensis* is a valid species (Dissection of this material by Ruth. Turner, revealed that this species belongs to the genus *Teredora* and not *Teredothyra*) (Nair and Dharmaraj, 1984).

Occurrence : Lakshadweep Archipelago, abundantly in drift wood and occasionally in fixed wood also (Nair and Dharmaraj 1983).

Distribution : Koror Palan Islands (Caroline Islands, from hull of a wrecked ship) Edmondson (1959).

***Teredora princessae* (Sivickis)**
(Plate IIC)

- 1928. *Teredo princessae* Sivickis p. 291.
- 1928. *Teredo petersi* Moll p. 282.
- 1929. *Teredo diderichseni* Roch & Moll p. 6.
- 1929. *Teredo gazellae* Roch & Moll p. 6.
- 1931. *Teredo sparcki* Roch p. 15.
- 1938. *Teredo (Teredora) gregoryi* Dall, Bartsch and Rehder p. 212.
- 1914. *Teredo alfredensis* van Hoopen p. 176.
- 1955. (1958) *Teredo (Teredora) minori* Nair p. 274.
- 1966. *Teredora princessae* (Sivickis) Turner p. 118.
- 1971. *Teredora princessae* (Sivickis) Turner p. 28, 48.

Salient features : Pallets solid, broadly oval somewhat leaf-shaped. Blade thick at the base and thin at the distal end. The outer face has a conspicuous thumb-nail like depression marked by concentric lines. Thickened area at the base and sides smooth. Stalk short and thick and extends into the blade as a longitudinal rib.

Shell with characters of the genus. The posterior slope is large and obliquely placed high on the posterior dorsal margin.

Siphons united except at the tip, gills blade-like extending from base of siphons to the mouth. That part of the ctinidia over the visceral mass reduced in area when compared to those behind it with well developed branchial groove, labial palps free at the end, caecum clongate and doubled upon itself to the right. Intestine loops over style-sac in front and over the caccum behind, anal canal open, heart anterior with no pigmentation for auricles. Heart/body length 0.17, gill/body length 0.9, visceral mass/body length 0.4, heart/gill length 0.17 (Turner 1966).

Ecological notes : This is a temperate to tropical Indo-Pacific species found in drift wood and boat hulls. According to Edmondson (1962) this is typically an open ocean species and attacks drift logs. Some

of the recovered shells in Hawaii were 19 mm in height and the largest burrows exceeded 60 cm in length making the species the largest in Hawaiian waters. This is a species habitually adapted to floating wood. Some observations indicate that it can grow to about 75 cms in 140 days in Douglas fir test panels in Kaneohe Bay, Oahu. A maximum penetration of 70 mm was recorded in Koa wood at Waimanalo, Oahu during a 180 day period, the shells attaining a height of 8 mm during that time. Shells 14 mm high were recovered from a floating raft of California red wood anchored on Waikiki reef for 2 years (Edmondson, 1942).

Teredora and *Uperotus* have been reported from pilings, floats and other fixed timbers along the coasts of India (Nair and Saraswathy 1971) and in drift wood on the East coast of Australia and on the N. coast of Papua New Guinea (Turner, 1966 Rayner 1974). There are obviously enough wooden stepping stones across the Pacific ocean to allow the continuous distribution of these genera.

Occurrence : Mahanadi Estuary (Subba Rao, 1968); Madras (Nair, 1954, 1955, 1956; Daniel 1958); Porto-Novo (Dharmaraj and Nair 1980a); Pamban (Nair 1962, 1965; Nair and Dharmaraj 1980); Cochin (Nair 1964; Saraswathy 1964); Lakshadweep (Nair and Dharmaraj 1983); Mangalore (Dharmaraj and Nair 1981).

Distribution : *T. princessae* is well distributed in the Indo-Pacific from temperate to tropical region. It has been reported from Korimba Islands, Mozambique, Portuguese E. Africa (Moll, 1929); Port Alfred, Union of South Africa (Van Hoepen, 1914), Malay Archipelago (Roch & Moll 1929); Puerto Princesa, Palawan, Philippines (Sivickis 1928); Manila, Philippines, Java (Roch & Moll 1929), Panay, Philippines (Roch 1931); Keaukaha, Hilo, Hawaii (Dall, Bartsch and Rehder 1938), Hawaii (Edmondson, 1942), Papua New Guinea (Rayner 1974).

Genus *Uperotus* (Guettard)

- 1970. *Uperotus* Guettard p. 126, 128.
- 1799. *Fistulana* Lamarck p. 90.
- 1840. *Guetera* Gray p. 154.
- 1847. *Hyperotus* Herrmannsen p. 671.
- 1936. *Glumebra* Iredale p. 42.
- 1966. *Uperotus* Guettard Turner p. 28, 75.
- 1971. *Uperotus* Guettard Turner p. 28.

Salient features : Solid calcareous pallets which vary from oval to rectangular in outline with a short, heavy stalk. The proximal portion of the blade smooth while the distal portion marked by well defined radiating ribs. Shell variable depending on the substratum into which it bores. Specimens boring into nuts have narrow shells and those boring into hard wood have more typical shells, while those living in softer woods have intermediate type of shells. Both the anterior and posterior slopes especially the latter are comparatively small and placed high on the shell. The protective calcareous tubing that lines the burrow is concamerated at the opening. Gills extend continuously from the base of the siphons to the mouth. Siphons united to the tip, labial palps free, stomach globular, caecum long and bent on itself to the right, intestine makes an anterior loop around the style sac and a posterior loop over the caecum. This interesting genus is circumtropical in distribution and includes such species as *Uperotus clavus* (Gmelin), *U. panamensis* (Bartsch), *U. rehderi* (Nair), *U. lieberkindi* (Roch).

***Uperotus clavus* (Gmelin)**
Plate III)

- 1791. *Teredo clava* Gmelin. p. 3748.
- 1792. *Teredo nucivorus* Spengler p. 105.
- 1801. *Fistulana cornicula* Lamark p. 129.
- 1801. *Fistulana gregata* Lamark p. 129.
- 1818. *Fistulana corniformis* Lamark p. 435.
- 1820. *Fistularia gregaria* 'Lamark' Blainville p. 83.
- 1823. *Serpula retorta* Mawe p. 193.
- 1848. *Teredo foliiformis* 'Valisniere and Sellius' Laurent p. 359.
- 1848. *Teredo plumiformis* 'Valisniere and Sellius' Laurent p. 359.
- 1851. *Guetera corniformis* Gray p. 386.
- 1936. *Glumebra elegans* Iredale p. 43.
- 1952. *Glumebra shionomisakiensis* Habe, p. 140.
- 1966. *Uperotus clavus* (Gmelin) Turner p. 94.
- 1971. *Uperotus clavus* (Gmelin) Turner p. 28, 46.

Salient features : Pallet somewhat spoon-shaped, blade long narrow and sub-triangular, almost straight sided with the distal margin bluntly rounded. Proximal portion of the blade solid, thick and smooth, the distal part marked by radiating longitudinal ribs like the leaf of a palm. Shell valves curiously narrow and high, anterior and posterior slopes greatly reduced, the denticulated ridges of the anterior slope few and widely spaced, the posterior slope small placed in the posterior-dorsal aspect, ventral knob quite prominent. Turner (1966) states that "the difference in shell characters of various species in *Uperotus*, probably results from the material in which they are living. All species found in nuts have a narrow shell, while others with very similar pallets living in the same general area, but boring into wood have a more typically shaped shell....." *Uperotus* found in the vicinity of Madras and Mandapam camp, indicate that *clavus* (nut borer) and *rehderi* (wood-borer) are probably the same species, for it was possible to get transition forms, the valves of specimens boring into soft wood being much closer in appearance to the nut borers than those taken from hard wood", Turner, however, concludes that this cannot be stated definitely until it has been shown experimentally that the young of *clavus* when boring into wood mature to look like *rehderi*.

Siphons united except at the very tip, gills blade-like extending from the siphons to the mouth as in *Teredora*, branchial groove well developed, labial palps free, stomach globular, caecum long and doubled on itself, intestine looping over the style-sac anteriorly and over the caecum posteriorly before curving over the posterior adductor to open into the anal canal, heart anterior with no pigmentation for auricles. Heart/body length 0.22; gill/body length 0.9; visceral mass/body length 0.5; heart/gill length 0.2 (Turner 1966).

The burrows of this species are lined by a thick-walled calcareous tubing. These tubes are closely crowded and very often twisted together in floating nuts.

Ecological notes : This species is usually seen in floating nuts and drift wood. It has also been reported (not living) from the nuts of *Pandanus* dredged out from a depth of 7488 metres in the Bunda Sea (Turner, 1966). *U. rehderi* is probably an ecological variation of *U. clavus*, found only in floating wood rather than nuts in the tropical to subtropical Indo-Pacific. The large and extensive gills suggest that this

species can more effectively utilise phytoplankton as food in the over crowded substratum. This is probably an ecological adaptation for oceanic species to survive where wood is scarce.

Uperotus clavus is a remarkable ocean traveller (Edmondson, 1962). It lives a curious gregarious life in ocean-borne seeds of mangroves, cocos palms and *Pandanus*. Iredale (1936) reported this species living gregariously in calcareous tubes in the husk of a coconut, floating in sea water off south Queensland. Seeds of *Xylocarpus molucensis* growing near the ocean in Samoa, Fiji and other Pacific Islands and getting drifted in ocean currents get infested at mid ocean by this species and cast ashore on the beaches of Canton Island. Edmondson (1962) stated that "When the solid substance of the seed is destroyed by the invading borers their cutting function ceases. In the meanwhile calcareous deposits have been forming strong protective tubes about individual animals, tubes which fuse into compact clusters. Cavities of larger seed cases stranded on Canton Island were almost completely filled with calcareous tubes of *T. clava* (= *U. clavus*). However, the living organisms once encased in these calcareous tubes had perished, leaving only their shells and pallets. When the cutting activity of the living *Teredo* is complete, the anterior end of the tubes which has been its protection is closed permanently and the animal soon perishes". Edmondson further states that commensurate with the animals which once occupied them, the calcareous tubes vary greatly in size, the larger ones, usually twisted and bent, may exceed two inches in length and reach a diameter of 15 to 18 mm at the broader closed end. The presence of well developed calcareous tubes and the recovery of shells of larval borers from the fibrous walls of the seed cases indicate that attack occurred at various times during the ocean voyage"

A correlation between the character of the shell and the environment in which the bivalve lives is discernible. The absence of well-defined teeth on the anterior lobe of the shell indicates that the substance through which it is boring is relatively soft, offering little resistance. The development of a strong tube suggests that much of its energy is expressed in chemical, rather than physical activity. "The valves are curiously narrow and strongly incurved. The nature of the valves support the view of a slowing down or a complete cessation of the cutting activities of the animal. The posterior slope of the shell is reduced to a rudimentary lobe, indicating a minimum of muscular activity. The physical aspect of the shell as a whole, with power and weight so near the fulcrum, points to a limited range of rocking movements of the valves, thereby greatly reducing the cutting potential of the shell (Edmondson 1962).

Occurrence : Visakhapatnam (Purushotham and Rao 1971); Madras beach from floating nuts of the mangrove *Carapa molucensis* (Gravelly 1941; Nair 1954; Crichton 1941; Daniel 1958); Tondi, Ramnad district of Tamil Nadu from a drift log cast ashore (Nair and Gurumani 1957); Pamban, Mandapam (Nair and Dharmaraj 1980); Lakshadweep (Nair and Dharmaraj 1983).

Distribution : Distributed in the Indo-Pacific in tropical areas. It has been reported from Indian Ocean Islands, Green Islands, off Cairns, North Queensland, Australia (Iredale, 1936); Shionomisaki, Wakayama Pref. Honshu, Japan (Habo, 1952).

Remarks : Nair (1954) described a new species *Teredo (Teredora) rehderi* from drift wood collected from Madras beach. After comparative studies of material from the Indo-West Pacific, Dr. C.H. Edmondson, B.P. Bishop Museum one of the authorities on shipworm taxonomy also confirmed the identification. Dr. Turner (1966) feels that this is probably a young wood boring form of *Uperotus clavus* in which the shell is more typically developed. According to her *T (T) vattanensis* is the adult form of the same species. Nevertheless, Turner states that this cannot be stated definitely, until it has been shown experimentally that the young of *clavus* when boring into wood mature to look like *rehderi*.

***Uperotus rehderi* (Nair, 1954)**
(Plate IIIA)

1954. *Teredo (Teredora) rehderi* Nair, p. 408.
 1957. *Teredo (Teredora) Vattanansis* Nair and Gurumani
 1966. *Uperotus rehderi* Nair Turner 28, 76.
 1971. *Uperotus rehderi* Nair Turner p. 29, 47.

Salient features : Pallets spoon-shaped with a broadly oval blade and short stalk. Outer face of the blade ribbed with radiating longitudinal rows of ridges and troughs. These ribs protrude slightly at the distal end of the blade which is entirely of calcareous material with no trace of periostracum. Valves small and nearly resemble those of the genus *Teredora*.

Ecological notes : This species invades fishing craft off the coast of Madras. It is a pelagic species commonly found in drift wood and rarely in fixed wooden objects.

Occurrence : Andamans (Das and Dev Roy 1980), Madras (Nair 1954, 1956); Ramnad (Nair and Gurumani, 1957b); Mandapam, from both fixed and drift wood (Nair and Dharmaraj 1980); Lakshadweep Archipelago (Nair and Dharmaraj 1983).

Distribution : Distributed in the Indo-Pacific in tropical areas. Reported from Papua New Guinea (Rayner, 1974).

Genus *Psiloteredo* Bartsch

1922. *Psiloteredo* Bartsch p. 36.
 1941. *Dactyloteredo* Moll p. 193.
 1966. *Psiloteredo* Bartsch Turner p. 28, 76.
 1971. *Psiloteredo* Bartsch Turner p. 29.

Salient features : Pallets solid, almost entirely calcareous, broad to elongate, oval in outline, and with a short stalk, blade thick at the base, becoming thin at the distal margin, slightly concave on the inner face and convex on the outer. Outer face with a moderate to deep thumb-nail-like depression or a slight depression with two finger-like projections extending from it in the young stage, the pallets becoming paddle-like in the adult. Valves with prominent condyles and moderate to large, ear-shaped posterior slopes which are usually flaring. Tubes of all species probably concamerated at the posterior end. Siphons united except at the tip. Gills reduced to the food groove only over the visceral mass.

This genus includes species such as *P. healdi* (Bartsch), *P. megotara* (Hanley), *P. senegalensis* (Blainville).

***Psiloteredo senegalensis* (Blainville)**
(Plate IIIB)

1828. *Teredo senegalensis* Blainville p. 267.
 1941. *Teredo adami* Moll p. 221.

1966. *Psiloteredo senegalensis* (Blainville) Turner p. 121.

1971. *Psiloteredo senegalensis* (Blainville) Turner p. 29, 48.

Salient features : Pallets heavy and almost entirely of calcareous material with a thin film of periostracum adhering to the outer face, blade elongately oval in outline with a short stalk. Posterior slope (auricles) of the valves large and usually flaring. In the specimens of the present collection the posterior slope is small.

Ecological notes : This is reported as a variable species with striking differences occurring with age. Monod (1952) discussed and illustrated the variation occurring in the pallets of *senegalensis* and showed that *petitii* Recluz is the young form. Rancurel has since shown that specimens growing in areas of low salinity and in uncrowded conditions retain the *petitii* form throughout life. Thus it appears that *petitii* is a young and ecological form of *senegalensis* Blainville (Turner 1966).

Occurrence : Lakshadweep Archipelago (Nair and Dharmaraj, 1983)

Distribution : Niger, Senegal (Blainville 1928), Marigot de Diabakar, Senegal (Moll, 1941)

Genus Group III

Stomach elongate, young held in brood pouch to straight hinge or pediveliger stage (Turner 1966, 1971).

Genus *Teredo* Linnaeus

1758. *Teredo* Linnaeus p. 651.

1923. *Coeloterredo* Bartsch, p. 99.

1923. *Zopoterredo* Bartsch, p. 96.

1932. *Pingoterredo* Iredale p. 30.

1952. *Austroterredo* Habe p. 249.

1966. *Teredo Linnaeus* Turner p. 29, 76.

1971. *Teredo Linnaeus* Turner p. 29.

Salient features : Pallets variable, blade in one piece with a small cup-like depression at the distal end which may be divided medially. A thin periostracum closely adhering to the calcareous portion is present but is never in the form of a cap as in *Lyrodus*. A solid stalk of varying length extends into the basal part of the blade for a short distance. The shell is typically teredine and indistinguishable from those of *Lyrodus* and *Bankia*.

Siphons long and separate. Ctenidia blade-like and extend from the base of the siphons to about the middle of the visceral mass, labial palps evident, stomach elongate, caecum cylindrical and large with a highly coiled typhlosome inside. Intestine does not loop around the style-sac in front but curves over the caecum and passes over the posterior adductor to open into the anal canal. Heart is dorsal to the caecum with an elongate, posteriorly lobed muscular ventricle and unpigmented, tubular, posteriorly tapering auricles.

Fertilization is internal in the genus *Teredo* which brood their young in the epibranchial cavity. The larvae are retained in the brood pouch for varying lengths of time in the different species. Development of eggs takes place in the branchial chamber and young are retained until the veliger stage (Turner 1966).

The Genus *Teredo* as constituted above by Turner (1966) is the largest and most variable genus in the Teredinidae and may eventually be split into two or more genera. This genus occurs throughout the world in marine habitats and rarely in brackish water.

This genus includes species like *T. aegypos* Roch, *T. bartschi* Clapp, *T. clappi* Bartsch, *T. fulleri* Clapp, *T. furcifera* von Martens, *T. johnsoni* Clapp, *T. mindanensis* Bartsch, *T. navalis* Linnaeus, *T. poculifer* Iredale, *T. portoricensis* Clapp, *T. somersi* Clapp, *T. triangularis* Edmondson.

***Teredo aegypos* Moll 1941**
(Plate IIIC)

1941. *Teredo aegypos* Moll p. 225.
1966. *Teredo aegypos* Moll Turner p. 86.
1971. *Teredo aegypos* Moll Turner p. 29, 50.

Salient features: Pallet spatulate, blade slightly longer than stalk, distal margin of inner face slightly concave, outer face deeply concave, distal end of pallet covered with a dark brown periostracum, rest of the pallet grayish ivory in hue with base of blade and stalk almost translucent (Turner 1966).

Occurrence : Lakshadweep (Nair and Dharmaraj 1983).

Distribution : Beira, South-East Africa, Mozambique (Moll, 1941).

***Teredo bartschi* Clapp**
(Plate IIID)

1923. *Teredo (Teredo) bartschi* Clapp p. 33.
1924. *Teredo (Teredo) batilliformis* Clapp p. 282.
1932. *Teredo balatro* Iredale p. 31.
1932. *Teredo shawi* Iredale p. 30.
1935. *Teredo aegyptica* Roch p. 267.
1937. *Teredo (Teredo) grobbai* Moll p. 182.
1942. *Teredo (Teredo) hiloensis* Edmondson p. 113.
1955. *Teredo (Teredo) navalis* Nagabhushanam p. 1-11.
1966. *Teredo bartschi* Clapp Turner p. 90.
1971. *Teredo bartschi* Clapp Turner p. 29, 50.

Salient features : Pallets typically teredo-like, outer face of blade convex and inner face flat, stalk about as long or slightly larger than blade. Distal margin broadly U-shaped, the outer more deeply excavated than the inner. Lower half of blade calcareous without the ridge at midpoint, distal half covered over by a closely adhering golden brown periostracum produced into two horns laterally.

Shell sub-globular, ridges on the anterior lobe widely spaced and spread fan-wise from anterior to posterior end. Posterior slope prominent.

Occurrence : Vishakapatnam harbour (Nagabhushanam 1955); Pamban (Nair and Dharmaraj 1980), Lakshadweep (Nair and Dharmaraj 1983).

Distribution : World-wide tropical to subtropical. It has been reported from Basra, Iraq (Moll 1937); Port said, Ismailia, Suez canal, Egypt (Roch 1935); East coast of Africa; Mediterranean; Madagaskar; Red sea; Persian gulf (see Turner 1966); Pyrmont, Port Jackson, Sydney harbour, N.S.Wales, Australia (Iredale 1932), Hilo, Hawaii, Hawaii islands (Edmondson, 1942), St. Georges, Bermuda (Clapp 1924); Port Tampa, Florida (Clapp, 1923)

***Teredo clappi* Bartsch**
(Plate IVA)

- 1923. *Teredo (Zopoterodo) clappi* Bartsch p. 96.
- 1924. *Teredo trulliformis* Miller p. 150.
- 1929. *Teredo hermitensis* Roch & Moll p. 14.
- 1935. *Teredo adanensis* Roch p. 265.
- 1935. *Teredo renschi* Roch p. 267.
- 1941. *Teredo horstii* 'Roch' Moll p. 160, 176.
- 1955. *Teredo (Zopoterodo) trulliformis* Nagabhushanam 1-11.
- 1966. *Teredo clappi* Bartsch Turner p. 94.
- 1971. *Teredo clappi* Bartsch Turner p. 30, 51.

Salient features : Pallet with a short, broad solid blade having a convex outer face and flat inner face and a well defined long stalk which instead of tapering toward the end becomes gradually expanded like the handle of a trowel. Distal part of the blade covered by a brownish periostracum with a crescent-shaped excavation at the end. Pallets of young may have a small median cleft on the outer face.

Shell with a reduced posterior slope.

Siphons separate, gills blade-like, branchial groove well developed, labial palps not free, stomach elongate, caecum moderate, intestine not looping over style-sac, anal canal open, heart median, auricles not pigmented. Larviparous, heart/body length 0.2, gill/body length 0.6, visceral mass/body length 0.3, heart/gill length 0.3 (Turner, 1966).

Ecological notes : This species occurs in the Indo-Pacific area. At Cuffe parade, Bombay it is reported as attacking live mangrove trees (Santhakumaran, 1966). *T. clappi* occurs abundantly and is one of the most destructive species in the Lakshadweep area.

Occurrence : Off Puri, Orissa (Ganapati and Rao, 1961); Visakhapatnam (Nagabhushanam 1955); Godavary estuary (Ganapati and Rao 1959 ; Purushotham and Rao 1971); Madras (Daniel 1958), Ramnad (Nair 1965); Pamban (Srinivasan and Chandramohan 1973); Cochin (Nair, 1964); Lakshadweep (Nair and Dharmaraj 1983); Panaji, Goa. Bombay (Santhakumaran 1966, 1976); Diu, Okha and Jafrabad (Santhakumaran 1976).

Distribution : Distributed world-wide from tropical to sub-tropical regions. Reported from Port Aden, Aden Protectorate (Roch, 1935) India (Nagabhushanam 1955); Singapore (Roch & Moll 1929); Hermit Islands, Bismark Archipelago (Roch & Moll 1929); Honolulu, Oahu, Hawaii Islands (Miller, 1924); Curacao (Dutch West Indies) (Moll, 1941), Key West Florida (Bartsch, 1923).

***Teredo fulleri* Clapp**
(Plate IVB)

1924. *Teredo (Zopoterredo) fulleri* Clapp. p. 12.
 1935. *Teredo bicorniculata* Roch p. 265.
 1935. *Teredo indomalaica* Roch p. 264.
 1966. *Teredo fulleri* Clapp Turner p. 102.
 1971. *Teredo fulleri* Clapp Turner p. 30, 51.

Salient features : Shell sub-globular, anterior slope small, posterior slope small or medium in size placed posteriorly slightly to the dorsal side of the disc without forming a shelf on the inner side.

Pallet spatulate with a narrow margin of yellowish or brownish periostracum at the distal end which is slightly cupped. A median longitudinal cleft splits the distal half of the outer face of the pallet, pallet stalk distinct, cylindrical, attenuating towards the tip about as long as the blade.

Siphons separate, gills blade-like, branchial groove well developed, labial palps not free, stomach elongate, caecum moderate, intestine not looping over style-sac, anal canal open, heart anterior, heart/body length 0.2, gill/body length 0.7, visceral mass/body length 0.5, heart/gill length 0.4 (Turner 1966).

Ecological notes : This is a common species in the atolls of the Lakshadweep Archipelago, and is highly destructive both to fixed underwater structures as well as to wooden crafts in the area, (Nair and Dharmaraj 1983).

Occurrence : Krusadi Islands and Hare Island (Nair and Dharmaraj 1980); Pamban (Nair, 1965); Mandapam (Nair and Dharmaraj, 1980); Lakshadweep (Nair and Dharmaraj 1983), Okha (Santhakumaran 1985).

Distribution : Distributed world-wide from tropical to subtropical areas. Reported from San Diego Suarez; Vintano to Sainte-Marie near Madagascar (Roch, 1935); Singapore (Roch, 1935); Christiansted, St. Coix, Virgin islands (Clapp, 1924).

***Teredo furcifera* von Martens**
(Plate IVC)

1894. *Teredo furcifera* von Martens p. 95.
 1921. *Teredo (Teredo) parksi* Bartsch p. 28.
 1924. *Teredo furcillatus* Miller p. 149.
 1935. *Teredo australasiatica* Roch p. 268.
 1935. *Teredo furcata* Moll p. 267.
 1935. *Teredo krappei* Moll p. 268.
 1935. *Teredo lanciniata* Roch p. 269.
 1946. *Teredo (Teredo) bensoni* Edmondson p. 214.
 1955. *Teredo (Teredo) parksi* madrasensis Nair p. 265.
 1955. *Teredo (Teredo) parksi* Nagabhushanam 1-11.
 1966. *Teredo furcifera* von Martens Turner p. 102.
 1971. *Teredo furcifera* von martens Turner p. 30, 50.

Salient features : Pallet highly variable, largely calcareous. Blade with a transverse ridge at widest point, outer face of pallet blade slightly convex and the distal end deeply indented in the form of U or V, inner face flat with the distal end having a shallower excavation. A thin, light, yellowish brown or brownish, black periostracum which closely adheres to the distal aspect of the blade is present.

Shell typical of the genus, anterior slope small marked by closely packed denticulated ridges.

Siphons separate, gills blade-like, branchial groove well developed, labial palps not free, stomach elongate, caecum cylindrical, intestine not looping over style-sac, anal canal open, heart median with no or light-brown pigmentation for auricles, larviparous, heart/body length 0.1, gill/body length 0.6, visceral mass/body length 0.3, heart/gill length 0.2 (Turner 1966).

Ecological notes : This is a very important and dominant wood boring mollusc along the coasts of India. It occurs in most of the harbours in India attacking wooden water-front structures, it also occurs in wooden stakes and other water front structures in the backwaters of Kerala. This species readily settles on test panels exposed at Cochin harbour during the hot, highly saline pre-monsoon period. One of the serious impediments for the culture of oysters around Tuticorin is the massive infestation by this species. It also occurs in the piles of the turtle pens in places such as Tondi and Adiramapatnam on the east coast of India.

According to Karande and Pendsey (1969) *T. furcifera* breeds throughout the year in Bombay Harbour. It attains sexual maturity when it is barely 20 days old and may liberate larvae after 56 to 60 days in the laboratory tanks if fed on nanno-plankton. Pediveliger larvae under laboratory conditions may attack timber within 24-72 h and their settlement is independent of salinity, light intensity and the primary film. The larvae need no food prior to settlement. Adults may live exclusively on timber for over 4 months and need no nannoplankton for their sustenance. The laboratory life of this species has been found to be not less than 18 months. At Cochin Harbour its settlement is confined to the hot, highly saline pre-monsoon period Feb.- June with sparse settlement during the early part of monsoon and later part of the post-monsoon periods (Nair and Saraswathy, 1971). At Visakhapatnam, it settles on test panels all through the year with a peak during the summer months between March and June (Nagabhushanam 1959). In the Gulf of Cariaco, Venezuela, Nair (1975) noticed its incidence almost continuously throughout the year on test panels with a peak in Oct. - Nov. *T. furcifera* occurs at the mouth of the Gonema River in the Macfarlane Harbour ? Papua-New Guinea where settlement, as reported by Rayner (1979) is periodical in response to changes in salinity, occurring in salinities over 20ppt. with faster growth rates in 30ppt.

Occurrence : This is a very common species all along the coasts of India. Andaman Islands (Karande 1978), Visakhapatnam (Nagabhushanam 1955, 1960); Godavari Estuary (Ganapati and Rao 1959), Pulicat Lake (Nair 1963, Srinivasan 1969), Madras (Nair 1955, 1956, Daniel 1958); Porto Novo (Radhakrishnan et al. 1983); Muthupet (Srinivasan and Chandramohan, 1973); Tondi (Nair and Gurumani, 1957); Pamban (Nair and Dharmaraj 1980) Tuticorin (Nair and Dharmaraj 1979); Trivandrum, Anjengo, Kadinamkulam, Quilon, Neendakarai (Dharmaraj and Nair 1980, 1981a; Shanthakumari & Nair 1975), Cochin (Saraswathy 1964, Nair, 1965); Lakshadweep (Nair and Dharmaraj 1983); Mangalore (Dharmaraj and Nair 1981); Bombay, Daman, Okha (Palekar, Santhakumaran and Bal, 1964, Santhakumaran, 1976).

Distribution : *T. furcifera* has a world-wide distribution, from tropical to subtropical areas. It has been reported from, East coast of Africa, Medagaskar, Reunion (Roch 1935); Colombo, Ceylon (Moll,

1935); Singapore (Roch, 1935); Amboina, Molucca Island (von Martens, 1894); Tutuila, Samoa (Miller, 1924); Pearl Harbour, Oahu, Hawaii (Bartsch, 1921); Sao Francisco, Brazil (Moll, 1935); Venezuela (Nair 1975).

***Teredo mindanensis* Bartsch**
(Plate IVD)

- 1923. *Teredo (Coeloteredo) mindanensis* Bartsch p. 99.
- 1927. *Teredo (Coeloteredo) mindanensis* Bartsch p. 539.
- 1955. *Teredo (Coeloteredo) bayeri* Roch p. 130.
- 1966. *Teredo mindanensis* Bartsch Turner p. 111
- 1971. *Teredo mindanensis* Bartsch Turner p. 30, 51.

Salient features : "Pallet blade triangular to conical, hollow to stalk, periostracum thin, yellow, not extending as border, stalk short, irregular and knobby at proximal end" (Turner 1971).

Occurrence : Lakshadweep (Nair and Dharmaraj, 1983)

Distribution : Off Linao Point, Gulf of Darao, Mindanao, Philippine Islands at 28 fathoms (Bartsch, 1923), Sumatra, Indonesia (Roch, 1955).

***Teredo portoricensis* ? Clapp 1924**
(Plate VA)

- 1924. *Teredo (Teredo) portoricensis* Clapp p. 2.
- 1966. *Teredo portoricensis* Clapp Turner p. 118.
- 1971. *Teredo portoricensis* Clapp Turner p. 30, 51.

Salient features : Pallets slender. The golden yellow periostracum is thin, closely adhering to the calcareous portion, covering the distal half of the blade and extends as a border, through which the calcareous portion is visible. Blade sheathing the stalk for a short distance. Stalk long, slender and solid, shells typical of the genus.

Ecological notes : This is the first record of this species from Indian waters and has been collected from Lakshadweep Archipelago.

Distribution : Western Atlantic, tropical to subtropical, San Juan, Porto Rico (Clapp 1924).

***Teredo somersi* Clapp**
(Plate VC)

- 1924. *Teredo (Zopoteredo) somersi* Clapp p. 284.
- 1937. *Teredo (Teredo) radialis* Moll p. 182.
- 1966. *Teredo somersi* Clapp Turner p. 122.
- 1971. *Teredo somersi* Clapp Turner p. 30, 51.

Salient features : "Stalk usually equal to or shorter than blade, straight and thick. Distal half of the blade covered by medium to dark red brown periostracum, cavity often filled with debris". (Turner 1971).

Occurrence : Lakshadweep (Nair and Dharmaraj, 1983).

Distribution : Western Atlantic, tropical to sub-tropical. Ireland, Bermuda (Clapp, 1924); East London, Dutch East Africa, Union of S. Africa (Moll, 1937).

***Teredo triangularis* Edmondson 1942**
(Plate VB)

- 1942. *Teredo (Zopoterodo) triangularis* Edmondson p. 126.
- 1945. *Kuphus (Coeloterodo) teredoides* Taki and Habe p. 116.
- 1966. *Teredo triangularis* Edmondson Turner p. 126.
- 1971. *Teredo triangularis* Edmondson Turner p. 31, 51.

Salient features : Pallet-blade thick and heavy like an elongated triangle or goblet-shaped, flattened on the inner face and strongly convex on the outer face, broadening distally where the concave border is capped by a zone of brownish periostracum. Distal border of calcareous portion of blade irregularly truncate. Extent and colour of periostracum variable. Stalk stout tapering, shorter than the blade normally.

Shell higher than broad, anterior slope small, posterior slope short internally overlapping the disc.

Ecological notes : This species has been noticed rarely in the Visakhapatnam harbour and at the Lakshadweep Archipelago.

Occurrence : Visakhapatnam (Nagabhushanam 1960), Mandapam (Nair and Dharmaraj, 1980), Lakshadweep (Nair and Dharmaraj, 1983).

Distribution : Distributed in the Indo-Pacific from tropical to sub-tropical region. Reported from Suzaki-tyo, Takaoka-gun, Kochiken, Japan (Taki and Habe, 1945); Kahului, Maui, Hawaiian Islands (Edmondson, 1942).

Genus *Lyrodus* Gould

- 1870. *Lyrodus* Gould pp. 33-34.
- 1921. *Teredops* Bartsch p. 26.
- 1966. *Lyrodus* Gould Turner p. 29, 78.
- 1971. *Lyrodus* Gould Turner p. 31.

Salient features : Pallet blade with a basal calcareous portion which is narrowly to broadly rounded and marked by concentric lines of growth. Brown or black easily removable periostracal portion caps the calcareous portion. Distal margin of the periostracal part may be straight, curved, or may be produced into lateral horns. The periostracal part may be solid, hollow, or may be produced into a knob-like structure.

Shell typically teredine, siphons short and separate, young are carried in the mantle cavity until late veliger stage. General anatomy similar to that of *Teredo*.

This genus is distributed widely in tropical and warm temperate seas and includes species such as *Lyrodus affinis* (Deshayes), *L. bipartita* (Jeffreys), *L. massa* (Lamy), *L. medilobata* (Edmondson), *L. pedicellatus* Quatrefages and *L. takanoshimensis* (Roch).

In this genus the fertilization is internal as in the genus *Teredo* and the young ones are retained in the epibranchial chamber for varying periods of time.

***Lyrodus pedicellatus* (Quatrefages)**
(Plate VIA)

- 1849. *Teredo pedicellatus* Quatrefages p. 26.
- 1865. *Teredo pedicellata truncata* Jeffreys p. 174.
- 1870. *Teredo chlorotica* Gould p. 23.
- 1916. *Teredo diegensis* Bartsch p. 48.
- 1922. *Teredo diegensis* Bartsch p. 29.
- 1922. *Teredo (Teredops) floridana* Bartsch p. 28.
- 1924. *Teredo samoanensis* Miller p. 149.
- 1927. *Teredo (Teredo) siamensis* Bartsch p. 59.
- 1929. *Teredo lamyi* Roch & Moll p. 10.
- 1929. *Teredo yatsui* Moll p. 10.
- 1931. *Teredo calmani* Roch p. 208.
- 1931. *Teredo (Lyrodus) hibicola* Kuroshima p. 295.
- 1931. *Teredo (Teredops) tateyamensis* Kuroshima p. 295.
- 1932. *Teredo pertingens* Iredale p. 31.
- 1935. *Teredo arabica* Roch p. 269.
- 1936. *Teredo (Pingoteredo) tristi* Iredale p. 35.
- 1938. *Teredo (Teredops) hawaiiensis* Dall, Bartsch and Rehder p. 213.
- 1945. *Teredo (Lyrodus) taiwanensis* Taki and Habe p. 113.
- 1946. *Teredo (Teredo) honoluluensis* Edmondson p. 222.
- 1954. *Teredo (Teredo) madrasensis* Nair p. 401.
- 1955. *Teredo (Teredo) indica* Nair p. 268.
- 1966. *Lyrodus pedicellatus* (Quatrefages) Turner p. 116.
- 1971. *Lyrodus pedicellatus* (Quatrefages) Turner pp. 31, 46.

Salient features : Pallels highly variable, calcareous portion being club-like with a long, slender stalk and blade consisting of an oval, knob-like portion usually marked by concentric growth lines capped by an elongated dark brownish or black periostracum which can be separated from the base. The periostracal cap may be more or less straight sided, the distal margin concave or 'u'-shaped occasionally extending as lateral horns. Distal margin in older specimens may be eroded exposing the knob-like calcareous portion.

Shell similar to that of *Teredo* or *Bankia*.

Siphons separate, gills blade-like, branchial groove well developed, labial palps not free, stomach elongate, caecum moderate, intestine not looping over style-sac, anal canal open, heart anterior, auricles

not pigmented, larviparous. Heart/body length 0.2, gill/body length 0.7, visceral mass/body length 0.3, heart/gill length 0.5 (Turner 1966).

Ecological notes : This is one of the highly destructive species occurring both along the east and west coasts of India. It attacks live mangrove in the Godavary Estuary and causes severe damage to oyster culture poles at Tuticorin. *L. pedicellatus* is an incubatory species. This species settles in Bombay harbour in great numbers from late January to late October. After October only a few specimens are seen on panels until January. Santhakumaran (1973) found that seasonal abundance and vertical distribution are both influenced by the prevailing hydrographic conditions and also by the presence or absence of fouling organisms. Santhakumaran and Alikunhi (1971) reported that at Trombay attack started in March, gradually increased in intensity up to July and reached a peak in August. After September only a few specimens were settling till March. In the Gulf of Cariaco this is the most destructive shipworm with continuous settlement and a peak in October-November (Nair 1975). In the Gonema River, Papua-New Guinea it is found in areas with salinities over 20ppt. (Reyner, 1979). Edmondson observed its larva to survive for 10 days in a salinity of about 15ppt. It is reported that the larvae had a wide salinity tolerance. Even though 7.2ppt. was lethal in a few they could survive for a day in 9.7ppt., 2 days in 13.1ppt., 3 days in 18.7ppt. and 10 days in 31.3ppt. But pediveligers could not form protective caps and died when attempting to bore into wood in salinities below 25.2ppt. According to Rancurel (1951) the larvae are photopositive up to metamorphosis and Greenfield (1952) has suggested the effect of a negative geotactic response.

Occurrence : Andaman Nicobar Islands (Taki and habe 1945; Das and Dev Roy, 1980, 1981); Mahanadi (Subba Rao 1968); Visakhapatnam (Nagabhushanam 1955, 1960); Pulicat Lake and Madras (Nair 1954, 1956, 1964; Srinivasan 1969); Portonovo (Nair & Dharmaraj 1980a) Muthupet (Srinivasan and Chandramohan 1973); Tondi and Adiramapatnam (Nair and Gurumani 1957); Ramnad, Pamban and Tuticorin (Nair 1962, 1965; Nair and Dharmaraj 1979); Trivandrum, Anjengo, Kayamkulam and Cochin (Erlanson 1936, Nair 1954, 1964; Saraswathy 1964, Dharmaraj and Nair 1981a); Karwar, mangalore, Panaji, Ratnagiri, Kolak, Daman, Kandla, Okha, Veraval, Diu and Cambay (Santhakumaran 1976, 1981, 1983; Santhakumaran and Pillai 1975), Lakshadweep (Nair and Dharmaraj 1983), Bombay (Palekar, Santhakumaran and Bal, 1964; Santhakumaran 1976).

Distribution : World-wide from temperate to tropical areas. Reports are available from Togo, West Africa (Roch & Moll 1929); British Isles (Jeffreys, 1865); Guipuscoa, Spain (Quatrefages 1849); Naples, Italy; Mediterranean sea (Roch & Moll, 1929); Port Aden (Roch 1935); Port said, Ismailia, Egypt (Moll, 1936); Siamons Town, South Africa (Roch 1931); East and West coasts of India (Nair, 1955, 1955a); Colombo, Sri Lanka (Moll, 1936); Singapore (Roch, 1935); Singora, Siam (Bartsch, 1927); Port Lincoln, S. Australia (Roch 1931); Pymont, Port jackson, N.S. Wales, Australia (Iredale, 1932); Sandgate, Moreton Bay, Brisbane Australia (Iredale, 1963); New Zealand (Mckoy, 1980); Japan (Moll, 1928), Tateyama Bay, Chiba Prefecture, Japan (Kuronuma 1931); Kusatus, Hiroshima Prefecture, Japan (kuronuma 1931); Taiwan, Formosa (Taki & Habe, 1945); Off Linao point, Mindanao, Philippine Islands in 28 fathoms (Bartsch, 1927); Midway Islands (Edmondson, 1946); Tutuila, Samoa (Miller, 1924); Off South coast of Oahu, Hawaiian Islands from 211-253 fathoms (Dall, Bartsch & Rehder, 1938); Honolulu Harbour, Oahu, Hawaii (Dall, Bartsch & Rehder, 1938); Tampa, Florida (Bartsch, 1922); Massachusetts from ships that have cruised in the Pacific (Gould, 1870); San Diego, California (Bartsch, 1916); South San Francisco, Carolina (Bartsch 1922); Gulf of Cariaco, Venezuela (Nair 1975); Brazil (Roch 1931)

***Lyrodus massa* (Lamy)**
(Plate VD)

1923. *Teredo massa* 'Jousseume' Lamy p. 176
 1935. *Teredo infundibulata* Roch p.265
 1935. *Teredo singaporeana* Roch p.265
 1966. *Lyrodus massa* (Lamy) Turner p. 109
 1971. *Lyrodus massa* (Lamy) Turner p. 32, 45

Salient features : Pallet blade variable in shape, almost entirely calcareous, periostracal covering thin following the outline of the calcareous portion, not extending beyond or only slightly so in young specimens. Periostracal cap inserted in calcareous base varying from light golden brown to dark red brown or nearly black.

Siphons separate, gills blade-like, branchial groove well developed, labial palps attached, stomach elongate, caecum moderate, intestine not looping over style-sac, anal canal open, heart median, auricles not pigmented, larviparous, heart/body length 0.15, gill/body length 0.6, visceral mass/body length 0.04, heart-gill length 0.2 (Turner, 1966).

Ecological notes: This species has been collected in fair numbers from all the atolls of the Lakshadweep archipelago and is apparently a highly destructive species in that area.

Occurrence : Visakhapatnam (Nagabhushanam 1955); Pamban (Nair, 1965); Trivandrum (Dharmaraj and Nair, 1980); Lakshadweep (Nair and Dharmaraj 1983); Goa (Santhakumaran, 1983a).

Distribution : Aden, Massaouah, Mer Rouge (Arabia) (Lamy, 1923); Singapore, (Roch, 1935).

Subfamily BANKIINAE Turner

1966. *Bankiinae* Turner p. 57 and 78
 1971. *Bankiinae* Turner p. 32

Includes genera having segmented pallets, mostly external fertilization and planktonic larval stage.

Genus *Nototeredo* Bartsch

1923. *Nototeredo* Bartsch p. 100-101
 1966. *Nototeredo* Bartsch Turner p. 29,78
 1971. *Nototeredo* Bartsch Turner p. 32

Salient features : Pallets paddle-like, segmented, blade oval to broadly oval in outline with a short stalk. Blade composed of calcareous material laid down in closely packed segments separated by thin layers of periostracum which may extend laterally to form small awns. The pallet blade has a convex outer face and is covered by a pale yellow periostracum which extends as a border distally. The stalk extends the entire length of the blade.

Shell typically teredine, calcareous tube segmented distally with a median partition making the entrance hole double.

Siphons, short, of equal length and united for about one half their length: labial palps free; ctenidia broad and flat extending from the base of the siphons to the visceral mass with well developed food groove, anterior part of the ctenidium with ten or more filaments. Stomach globular; caecum large; intestine quite elongated with an anterior loop around the sac of the crystalline style and considerably convoluted at the posterior end of the caecum, Heart short, placed dorsal to the gonad with a thin subquadrangular ventricle and tubular, short tapering auricles (Turner 1966).

The genus occurring typically in marine conditions ranging from tropical to cold temperate seas, includes such species as *N. norvegica* (Spengler), *N. edax* (Hedley), *N. konxi* (Bartsch).

Nototeredo edax (Hedley)
(Plate VIB)

- 1895. *Teredo edax* Hedley p. 501
- 1928. *Teredo apendiculata* Sivickis p. 295
- 1928. *Teredo hydei* Sivickis p. 294
- 1932. *Nototeredo remifer* Iredale p. 32
- 1945. *Psiloteredo (Phylloteredo) kirai* Taki and Habe p. 114
- 1952. *Psiloteredo (Phylloteredo) yakushimae* Habe p. 252
- 1955. *Terdo (Dactyloteredo) juttingae* Roch p. 135
- 1956. *Teredo (Psiloteredo) tondiensis* Nair and Gurumani p. 361
- 1955. *Teredo (Teredora) thomsonii* Nagabhunhanam p. 1-11
- 1960. *Psiloteredo (Phylloteredo) septa* Mawatari & Kitamura
- 1966. *Nototeredo edax* (hedley) Turner p. 99
- 1971. *Nototeredo edax* (Hedley) Turner p. 32, 52

Salient features : Pallets paddle-shaped, ovately broad with convex outer and concave inner faces, stalk short extending through the length of the blade, outer distal end of the blade has an irregular thumb nail-like depression, which in some cases get filled with calcareous deposits and may become indistinct, periostracal cover light-brownish in hue.

Shell moderately large, anterior lobe sculptured with widely spaced finely denticulated ridges, more closely spaced and coarsely denticulated ridges cover the anterior median area, dorsal knob large, shelf well developed in older specimens, posterior slope small.

Ecological notes : This species is known to occur throughout the Indo-Pacific. It occurs in marine conditions, in estuarine situations, as well as in the mangroves. According to Rayner (1974) "It is well adapted to a diet of both wood and phytoplankton having well developed gills, food grooves and labial palps as well as a large caecum" Turner (1966) believes that the species may be able to obtain enough nutrition from plankton alone to survive, as specimens have been found with their tubes completely calcified at the boring end even though more wood was available. *N. edax* is reported to be abundant in the mangroves of the Godavari Estuary (Ganapati and Rao, 1956). Mckoy (1980) reports that in New Zealand a temperature of above 18-20° C is required for successful spawning and settlement.

Occurrence : Visakhapatnam (Nagabhushanam 1956, 1960); Godavari Estuary (Ganapati and Rao 1956), Andamans (Das and Dev Roy, 1980), Madras (Purushotham and Rao, 1971); Tondi (Nair and Gurumani 1956); Bombay and Diu (Santhakumaran 1971, 1976).

Distribution : Indo-Pacific, tropical to warm temperate. Kagoshima Prefecture, Japan (Mawatari, & Kitamura, 1960); Doza-wan, Kochi-Ken, Japan in 200 fathoms (Taki and Habe, 1945); Nagasaki, Japan (Taki and Habe 1945); Yukushima, Japan (Habe, 1952); Port Adelaide, S. Australia (Hedley 1895); Darling Harbour, Port Jackson, N.S. Wales, Australia (Iredale, 1932; Turner and Marshall, 1973); New Zealand (Mckoy, 1980), Papua New Guinea (Rayner, 1974); Rhiouw Archipelago, Sumatra (Roch, 1955); Puerto Princesa, Palawan, Dalahican, Cavite Luzon, Philippine Islands (Sivickis, 192).

Genus *Spatheteredo* Moll

1928. *Spatheteredo* Moll p. 278-285
 1966. *Spatheteredo* Moll Turner p. 30, 78
 1971. *Spatheteredo* Moll Turner p. 33

Salient features : Pallets paddle-shaped, with a somewhat rectangular blade composed of compactly packed indistinct segments, with a pustulose calcarous incrustation at the distal end and a dark band of periostracum at about the mid portion. The blade especially in young specimens is covered by a brownish periostracum which extends laterally as awns. The pallet stalk extends through the blade.

Shell typically teredine resembles that of *Teredo*. Siphons short and united for nearly half their length, ctenidia narrow to broadly U-shaped, food groove well developed, anterior part of the ctenidium with about 20 filaments, stomach and caecum resemble those of *Nausitora*, heart dorsal to caecum, ventricle long and deeply lobed posteriorly, auricles long and tapering (Turner 1966).

This genus includes species restricted mainly to tropical and sub-tropical waters of the Indo-Pacific and Western Atlantic such as *S. obtusa* (Sivickis), *S. Spatha* (Jeffres).

Spatheteredo obtusa (Sivickis) (Plate VIC)

1928. *Teredo obtusa* Sivickis p. 290
 1928. *Teredo variegata* Sivickis p. 291
 1928. *Teredo semoni* Moll p. 9
 1935. *Teredo murrayi* Moll p. 208
 1935. *Teredo palula* Roch p. 271
 1945. *Psiloteredo* (*Phylloteredo*) *amboinensis* Taki & Habe p. 120
 1966. *Spatheteredo obtusa* (Sivickis) Turner p. 114
 1971. *Spatheteredo obtusa* (Sivickis) Turner p. 33, 53.

Salient features : Paddle-shaped pallets, blade somewhat rectangular composed of compactly packed indistinct segment with a pustulose calcarous incrustation which is thin, usually light brown and finely papillose. Stalk extends through the blade.

Siphons united except at the tip, gills blade-like, branchial groove well developed, labial palps attached, stomach elongate, caecum moderate, intestine not looping around the style-sac, anal canal open,

heart median, auricles deeply pigmented, heart/body length 0.1, gill/body length 0.5, visceral mass/body length 0.24, heart gill length 0.3 (Turner 1966).

Ecological notes : This species has been collected from Nicobar Islands and once from the brackish waters of the Neendakara Port at the mouth of the Ashtamudi Lake.

Occurrence : Nicobar Islands (Taki and Habe 1945); Neendakara, Quilon (Dharmaraj and Nair, 1981b).

Distribution : Indo-Pacific, tropical Madagascar (Roch, 1935a), Amboina Molucca Islands, Indoneia (Taki & Habe, 1985b); Batavia (Moll & Roch, 1931); Christmas Islands, off java (Moll, 1935); Palawan, Cebu Philippine Islands (Sivickis, 1928), Amboina, Ralum, Bismarck Archipelago (Moll, 1928).

Genus *Nausitora* Wright

- 1864. *Nausitora* Wright p. 451-454
- 1966. *Nausitora* Wright Turner p. 30, 78-80
- 1971. *Nausitora* Wright, Turner p. 33

Salient features : Pallets elongate with blade composed of closely packed and fused but quite distinct segments built around a central stalk. A brownish periostracum covers the blade and may be produced as awns especially on the proximal part of young specimens. Shell valves large with conspicuous anterior slope, siphons short, united for nearly half their length.

This genus occurs chiefly in brackish waters and mangrove swamps of tropical and subtropical waters and is common in the Indo-Pacific, Eastern Pacific and Western Atlantic and includes species such as *N. hedleyi* Schepman, *N. dunlopei* Wright, *N. dryas* (Dall) and *N. fusticula* (Jeffreys).

Nausitora dunlopei Wright (Plate VID)

- 1864. *Nausitora dunlopei* Wright p. 435
- 1898. *Calobates fluviatilis* Hedley p. 93
- 1927. *Bankia (Nausitora) smithi* Bartsch p. 61
- 1928. *Bankia globosa* Sivickis p. 288
- 1928. *Bankia quadrangularis* Sivickis p. 287
- 1928. *Bankia triangularis* Sivickis p. 286
- 1932. *Nausitora Messeli* Iredale p. 37
- 1935. *Nausitora madagassica* Roch p. 271
- 1935. *Bankia pennaanseris* Roch p. 274
- 1935. *Nausitora schneideri* Moll p. 271
- 1936. *Nausitora queenslandica* Iredale p. 37
- 1954. *Bankia (Nausitora) madrasensis* Nair p. 399
- 1964. *Nausitora lanceolata* Rajagopal p. 109
- 1966. *Nausitora dunlopei* Wright Turner p. 99
- 1971. *Nausitora dunlopei* Wright Turner p. 33, 53

Salient features : Pallets asymmetrical, blade with a broad, smooth basal part covered with light brown periostracum. Rest of blade composed of close-set V-shaped almost fused, often eroded cones. Distally the blade narrows considerably. Pustules or small wart-like protuberances occur at the tips of the pallets.

Shell, large sub-globular, anterior slope large, disc comparatively small and narrow, posterior slope greatly reduced or absent in outer views of shell.

Siphons partially separate, gills blade-like, branchial groove weak, labial palps attached, stomach elongate, caecum large, intestine not looping over style-sac, anal canal open, heart posterior, auricles deeply pigmented, fertilization external, heart/body length 0.1; gill/body length 0.2; visceral mass/body length 0.7; heart/gill length 0.7 (Turner, 1966).

Ecological notes : *N. dunlopei* is a typical brackish water species of the tropical to warm temperate Indo-Pacific areas, well adapted to waters of low salinity. It is a common species in the mangroves and being tolerant of very low salinities, grows to a large size in the upper reaches of rivers where the salinity may be as low as 0.2ppt. (Rayner, 1974). In Papua-New Guinea this species occurs in abundance in the Onema river. In the Marshall Lagoon estuary it is noticed mostly in salinities 1-10ppt. in which it grew at a faster rate than in higher salinities and could tolerate a salinity of even 30ppt. Watson *et al* (1936) found that in the Brisbane River this species occurred in salinities between 1-10 ppt., rarely between 10 and 15 ppt. and never in salinities over 30 ppt. They report that the transfer of adults from 5 to 30ppt. was fatal in 3 weeks.

Occurrence : Hooghly River (Calcutta) (Wright 1864); Sundarbans (Rajagopal 1964a); Mahanadi Estuary (Subha Rao, 1968); Visakhapatnam (Nagabhushanam 1955, 1960); Nicobar Islands (Rajagopal and Daniel 1972; Tewari *et al.* 1980); Madras (Nair 1954, 1956); Pamban (Srinivasan and Chandramohan, 1973); Cochin (Mohan 1981); Goa (Santhakumaran 1985).

Distribution: Indo-Pacific, tropical to warm temperate brackish water. Port choisel, Maroantesetra, Vintano, Madagascar (Roch, 1935a); Chao Phya River at Bang Sorn, Siam (Bartsch, 1927); Rewa and Navua Rivers, viti Levu, Fijian Islands (Hedley, 1898); Palawan, Dalahican, Cavite, Luzon, Cebu, Philippine Islands (Sivickis, 1928); Karai, Neupommern, Bismarck Archipelago (Moll, 1935); Port Jackson and Cattai Creek, Hawkesbury River, N.S.Wales, Australia (Iredale 1932); Chelmer, upper Brisbane River, Queensland, Australia (Iredale 1936).

Nausitora hedleyi Schepman

- 1919. *Nausitora hedleyi* Schepman p. 195
- 1955. *Bankia (Nausitora) gabrieli* Nair p. 262
- 1966. *Nausitora hedleyi* Schepman Turner p. 104
- 1971. *Nausitora hedleyi* Schepman Turner p. 33, 54

Salient features : Pallets long, feather-like and inequilateral, stalk cylindrical, stout and much shorter than the blade. Outer surface of blade convex, and inner surface flat, blade composed of compactly packed segments those on the broad basal portion extending straight across the blade, those on the distal

part V-shaped the edges of the segments are fluted. The basal portion of pallet blade is covered over by an yellowish brown periostracum.

Shell large sub-globular with large anterior slope. In older specimens especially, the disc is narrow and the posterior slope may be eroded or completely absent.

Siphons partially separate, gills blade-like, branchial groove weak, labial palps attached, stomach elongate, caecum large, intestine not looping over style sac, anal canal open, heart body length 0.2; gill/body length 0.2, visceral mass/body length 0.5; heart/gill length 0.7 (Turner 1966).

Ecological notes : This is one of the most destructive species of shipworms in the brackish water areas in the Vembanad Lake, S.W. coast of India. *N.hedleyi* is a brackish water species well adapted to waters of low salinity. It shows a discontinuous distribution along the coasts of India occurring in certain brackish water lakes and back waters and also in the mangrove swamps. The average water content of this species in Cochin Harbour is 82.63% of body weight at 12 ppt.; 57.4% of body weight at 36ppt. indicating some degree of osmoregulation to adapt to fluctuating salinity of the habitat. It spawns during the monsoon season when the salinity of the ambient medium is comparatively low at Cochin Harbour. Fresh settlement of the species in the area is noticed only during the period of low salinity, even though the species is found to exist throughout the year. Tests conducted to ascertain the effect of salinity changes on the activity showed that though it can endure a wide range, the most suitable salinity range for early development is from 11.24-14.54ppt., with the range 8.73 to 16.80 being tolerable. In grades above and below this range, segmentation was abnormal and the percentage of normally developing embryos fell considerably (Saraswathy and Nair 1974).

Records of the occurrence of *Nausitora* clearly shows that this species is sensitive, to higher salinities and is therefore, restricted to areas where estuarine conditions prevail. In common with other typical estuarine organisms this species shows characteristics of individual and species vigour. Thus great damage has been reported by this species in the Cochin Harbour (Nair and Saraswathy, 1971) and other similar habitat where species sensitive to the stress of low salinity cannot survive.

Tests carried out to examine the salinity toleranee of the adults showed that they are capable of surviving the entire range of salinity that occurs in the Cochin Harbour i.e. 0.65-33.68ppt. and are capable of considerable amount of acclimatisation in its habitat. Rayner (1979) found the species quite common in the Gonema River in Papua New Guinea in salinities less than 10ppt. It grew well in 1ppt. and survived in 20 and 30ppt. in the aquaria. However, it has never been collected from the upper tidal reaches of the Gonema River Where the water is constantly below 1ppt. and was not common at the mouth of the estuary when salinities were constantly over 20ppt. The heaviest settlement occurred towards the mouth of the river during dry and intermediate season in salinity fluctuations between 5 and 30ppt.

In Cochin Harbour the growth of this species is most rapid during the period between 45 and 135 days with the maximum growth rate during 105-120 days of age (Saraswathy and Nair, 1974).

Occurrence: Mahanadi Estuary (Subba Rao 1968); Pulicat Lake (Nair, 1963); Andamans (Das and Dev Roy 1980; Tewari *et. al.* 1980); Madras (Nair 1956); Porto-Novo (Nair & Dharmaraj 1980a); Kadinamkulam (Dharmaraj and Nair, 1981a); Cochin (Nair 1955, 1964, Saraswathy 1964); Mangalore (Dharmaraj and Nair 1981); Karwar, Goa, Bombay and Kandla (Santhakumaran 1971, 1976, 1981, 1983; Santhakumaran and Jain 1981).

Distribution: South-East Asia, tropical brackish (Rayner, 1974); Merauke, New Guinea (Schepman 1919, Rayner 1974).

Genus *Bankia* Gray

- 1842. *Bankia* Gray p. 410, 411.
- 1966. *Bankia* Gray Turner p. 32, 80.
- 1971. *Bankia* Gray, Turner p. 34.

The eight subgenera recognised under this genus namely *Bankia* Gray, *Bankiella* Bartsch, *Clupibankia* Moll, *Deviobankia* Iredale, *Liliobankia* Clench and Turner, *Lyrodobankia* Moll, *Neobankia* Bartsch and *Plumulella* Clench and Turner on the basis of the structure of the pallets have been considered as invalid by Turner (1966) owing to the existence of transitional species between them.

Salient features : Pallets greatly elongate with blade composed of a central stalk. Each segment consists of a calcareous base covered with periostracum which extends as a border. The width and ornamentation of the periostracal border varies greatly. It may be smooth, coarsely to finely serrated or produced into lateral awns. Siphons long and separate, fertilisation and development of young external. Gills broadly U-shaped, to flattened, extend from base of siphons anteriorly to about a third of the visceral mass; stomach elongate; caecum large; heart anterior, dorsal to the caecum, ventricle long, posteriorly lobed, auricles tubular and unpigmented (Turner 1966).

Except for two species namely *Bankia setacea* and *B. martensi* occurring in cold waters, all others are reported from temperate and tropical waters.

This large genus includes species such as *B. carinata* (Gray), *B. bipalmulata* (Lamarck), *B. bipennata* (Turton), *B. campanellata* Moll & Roch, *B. anechoensis* Roch, *B. australis* Calman, *B. barthelowi* Bartsch, *B. brevis* (Deshayes), *B. cieba* Clench and Turner, *B. destructa* Clench and Turner, *B. fimbriatula* Moll and Roch, *B. fosteri* Clench and Turner, *B. gouldi* (Bartsch), *B. gracilis* Moll, *B. martensi* (Stempell), *B. nordi* Moll, *B. orcutti* Bartsch, *B. philippinensis* Bartsch, *B. rochi* Moll, *B. setacea* (Tryon), *B. zeteki* Bartsch,.

Bankia bipalmulata (Lamarck) (Plate VIIB)

- 1801. *Teredo bipalmulata* Lamarck p. 129.
- 1818. *Teredo palmulatus* Lamarck p. 440.
- 1828. *Teredo palmulata* 'Adanson' Blainville, p. 268.
- 1928. *Bankia rubra* Sivickis p. 288.
- 1942. *Banki* (*Neobankia*) *konaensis* Edmondson, p. 134.
- 1966. *Bankia bipalmulata* (Lamarck) Turner p. 91.
- 1971. *Banka bipalmulata* (Lamarck) Turner p. 34 55

Salient features : Pallet long with blade consisting of a series of widely spaced cones, both the calcareous part and periostracum strong and heavy. Outer periostracal margin smooth and broadly U-shaped, inner margin almost straight and coarsely serrated, awns of unequal length one being almost twice the length of the other especially in old specimens but in young of nearly equal length.

Shell large with a distinct shelf on the inside where the disc and posterior slope overlap, umbonal knob strong.

Occurrence : Andaman Islands (Karande, 1978), Madras, Kovilam (Nair 1954, Becker 1958); Pondicherry (Lamarck 1801, 1818,; Becker 1958); Pamban (Nair 1962, 1965).

Distribution : Indo-Pacific, tropical to subtropical (Turner 1966); Honolulu Harbour, Oahu; Kealakekua Bay, Kona, Hawaiian Islands (Edmondson, 1942); Puerto Galera, Mindoro Philippine Islands (Sivickis, 1928).

***Bankia bipennata* (Turton)**
(Platc VIIC)

- 1819. *Teredo bipennata* Turton p. 184.
- 1828. *Teredo pennatifera* Blainville p. 269.
- 1860. *Teredo cucullata* Jeffreys p. 126.
- 1875. *Teredo carinata* 'Gray' Sowerby
- 1927. *Bankia* (*Neobankia*) *johnsoni* Bartsch p. 536.
- 1929. *Bankia kingyokyensis* Roch and Moll p. 20.
- 1955. *Banki* (*Neobankia*) *lineata* Nair p. 109.
- 1956. *Bankia* (*Neobankia*) *denticuloserrata* Daniel p. 593.
- 1966. *Banki bipennata* (Turton), Turner p. 91.
- 1971. *Bankia bipennata* (Turton) Turner p. 34. 57.

Salient features : Pallets long and feather-shaped calcareous portion funnel shaped, cones tapering, periostracal border narrow and yellowish brown, outer margin of periostracum broadly U-shaped and serrations closely spaced, truncated, with calcareous portion extending into them, serrations of inner margin long, thin, comb-like, awns coarsely fringed, stalk thick and long.

Shell with posterior slope set high and nearly at right angles to umbonal ventral axis, anterior lobe reaching as far as half the distance to ventral margin, disc large, umbonal-ventral sulcus well defined and crossed by growth lines.

Occurrence : Visakhapatnam (Nagabhushanam 1960); Madras (Nair 1955a, Daniel 1956, 1958); Andamans (Das and Dev Roy, 1980; Tewari *et. al* 1980); Pamban (Nair 1962, 1965).

Distribution : World-wide, tropical to subtropical. In drift wood from English channel (Sowerby 1875); drift wood, Guernsey (Jeffreys 1860); mouth of River Ex, Devonshire, England (Turton 1819); W. African coast; India; Indian ocean Islands; Batangas Bay, Luzon, Philippine Islands in 100 fathoms (Bartsch 1927); Kingyoku, Takanoshima, Japan (Roch and Moll 1929).

***Bankia campanellata* Moll & Roch**
(Platc VIIIA)

1931. *Bankia campanellata* Moll & Roch p. 215.
 1946. *Bankia (Liliobankia) katherinae* Clench & Turner p. 18.
 1949. *Bankia campanellata* Clench & Turner p. 27.
 1954. *Bankia (Bankia) bengalensis* Nair, p. 388.
 1966. *Bania campanellata* Moll & Roch, Turner, p. 92.
 1971. *Bankia campanellata* Moll & Roch, Turner p. 34, 54.

Salient features : Pallet consists of a series of widely spaced, cone-in-cone elements forming the blade, with a cylindrical stalk shorter than the blade. Cones forming the blade are bell-shaped with their distal margin reflected forming a broad rim. The distal 1/3 of each joint is covered by a golden brown periostracum. Periostracal margin of outer face less concave than that of the inner face. Lateral portions broadened and upwardly curved forming wide blunt awns. The embryonic cones at the distal end are not crowded.

Shell subglobular, anterior slope large with closely set denticulated ridges. Posterior slope well developed projecting over posterior part of the disc of a shelf. Umbonal knob strong. Apophyses blade-like and curved.

Siphons separate, gills blade-like, branchial groove well developed, labial palps attached, stomach elongate, caecum moderate, intestine not looping over style-sac, anal canal open, heart anterior, auricles not pigmented, heart/body length 0.31, gill/body length 0.31, visceral mass/body length 0.48, heart/gill length 1.00 (Turner 1966).

Ecological notes : At visakhapatnam harbour *B. campanellata* settles on freshly immersed test panels during August to February and has not been found in the summer months March to July (Nagabhushanam, 1962). This is in contrast with the seasonal distribution of the other two important molluscan borers in the local harbour i.e., *Matresia striata* and *Teredo furcifera* which occur throughout the year, the maximum attack being in the summer months (Nagabhushanam 1962). At Madras it occurs throughout the year with a slight increase in attack during the summer months. At Trombay (near Bombay) attack occurs during March, gradually increasing till September with a peak during August. From October onwards no further settlement is noticed, the peak spawning being from late July to late September. Rate of settlement increases with depth. In the Godavary Estuary, this species occurs in waters of fluctuating salinity. *B. campanellata* is a protandric species, the majority of individuals passing through a preliminary male phase before reaching the female phase. Full grown specimens have the appearance of either males or females with an indication of being ambisexual (Ganapati and Nagabhushanam, 1959). *B. campanellata* is an oviparous species, fertilization is extranal, breeding season extends from August to February in Visakhapatnam. Sexual maturity is reached when it attains a length of 12 mm. It grows on an average of 51.5 mm per month, the maximum (60.00 mm) is recorded in December. From March to July there was no settlement (Nagabhushanam, 1959).

Occurrence : Sundarbans (Roonwal 1966, Rajagopal 1964a); Mahanadi Estuary (Subba Rao, 1968); Godavary (Ganapati and Rao, 1959); Visakhapatnam (Nagabhushan 1955, 1960); Pulicat Lake (Srinivasan 1968); Madras (Nair 1954); Muthupet (Srinivasan and Chandramohan, 1973); Mandapam and neighbouring Islands (Nair and Dharmaraj 1980). Andamans (Karandae 1978); Vizhingam, Anjengo (Dharmaraj and Nair 1980, 1981a); Cochin (saraswathy 1964); Lakshadweep (Nair and Dharmaraj 1983); Mangalore (Santhakumaran 1976,; Dharmaraj and Nair 1981); Karwar, Goa. Ratnagiri, Bombay Gholvad, Daman, Camban, Bhavanagar, Diu, Veraval, Okha and Kandla (Santhakumaran 1976, 1981; Santhakumaran and Pillai 1975).

Distribution : World-wide, tropical, Indo-Malay Archipelago (Roch, 1955); Bahia, Brazil (Clench & Turner, 1946).

***Bankia carinata* (Gray)**
(Plate VIIB)

- 1792. *Teredo navalis* Spengler p. 100.
- 1827. *Teredo carinata* Gray p. 411.
- 1828. *Teredo minima* Blainville p. 268.
- 1829. *Teredo bipalmata* Delle Chiaje p. 28, 32, 115.
- 1836. *Teredo stuchburyi* ' Leach' Blainville p. 268.
- 1851. *Xylotre philippi* Gray, p. 386.
- 1929. *Nausitora kamiyai* Roch & Moll p. 17.
- 1929. *Bankia kuronunii* Roch & Moll p. 19.
- 1929. *Nausitora orientalis* Roch & Moll p. 17.
- 1929. *Bankia segaruensis* Roch & Moll p. 20.
- 1931. *Bankia (Bankia) nakazawai* Kuronuma p. 296.
- 1935a. *Bankia syriaca* Roch p. 4.
- 1946. *Bankia (Bankiopsis) caribbea* Clench & Turner p. 16.
- 1954. *Bankia (Bankiella) indica* Nair p. 393.
- 1956. *Bankia (Bankiella) edmondsoni* Nair p. 396.
- 1966. *Bankia carinata* (Gray), Turner pl. 93.
- 1971. *Bankia carinata* (Gray), Turner p. 34, 54.

Salient features : Pallet elongate, with long cylindrical stalk, blade composed of a series of moderately to closely spaced cone-like units, each cone having the calcareous portion funnel - shaped with the inner margin higher than the outer margin, periostracal margin of these cones shallowly U-shaped, narrow and smooth both on the inner and outer faces. In intact pallets the embryonic cap is seen formed of compact and flattened cones. Shell variable, globular, posterior slope well formed and placed high on the posterior margin of the disc in young specimens.

Siphons separate, gills blade-like, branchial groove well developed, labial palps attached, stomach elongate, caecum moderate, intestine not looping over style-sac, anal canal open, heart anterior, fertilization external.

Ecological notes : At Madras this species occurs in fair numbers in the wooden floats employed in pomfret fishing. Occasionally it has also been collected from wooden structures, discarded country

canoes as well as from drift wood cast ashore. This species is common all along the coasts of India, is quite destructive and appears readily on test panels exposed in the sea. Specimens measuring 28 cm have been collected. *Bankia carinata* is protandric, all females passing through a preliminary functional male phase before reaching the female phase. The female after a functional phase can revert to the male phase and produce spermatozoa (Nair 1956a). Breeding is continuous marked by seasonal intensity. Abundant occurrence of larvae in the plankton and intensive settlement in July and August respectively suggest that this period is conducive for larval development and settlement in Madras. *B.indica* is oviparous, fertilization is external, typical pediveliger stage is reached on the 15th day. Larvae are pelagic feeding on the plankton, and when 17 days old are ready for settlement. It can retain the larval organs and postpone metamorphosis if a substratum is not available and continue as a free-swimming larva for some days. After settlement and metamorphosis growth is very rapid during the first 90 days and thereafter becomes slackened and the trend indicates the rate of growth becoming nil at the end of the eighth month, the growth is impeded apparently on account of the depletion of woody material of the substratum (Nair, 1959).

Occurrence: Calcutta (Becker 1958; Nair 1964); Mahanadi Estuary (Subba Rao 1968); Godavary Estuary (Ganapati & Rao 1959); Vishakhapatnam (Nagabhushanam 1960); Madras (Nair 1954, 1956, Daniel 1958); Portonovo (Nair & Dharmaraj 1980a; Radhakrishnan *et al.*, 1983); Tondi (Nair & Gurumani 1957); Pamban (Nair 1965); Mandapam and nearby Islands (Nair and Dharmaraj 1980); Vizhingam, Trivandrum, Kadinamkulam, Ashtamudi (Dharmaraj and Nair 1981a); Cochin (Saraswathy 1964); Lakshadweep (Nair and Dharmaraj 1983); Mangalore (Dharmaraj and Nair, 1981); Goa (Santhakumaran, 1983a); Bombay (Becker 1958; Karande 1968).

Distribution : World-wide, tropical and sub-tropical, Mediterranean (Blainville, 1828), Sicily (Philippi, 1936), Naples, Italy (Delle Chiaje 1829), Jaffa, Israel (Roch, 1935a); Africa West coast (Roch, & Moll 1929); India, Indian Ocean Islands, Indo-Malay Archipelago (Roch, 1955); Sumatra (Gray, 1827); Philippine Islands; Pacific ocean Islands; Gulf of Mexico, Caribbean (Turner, 1966); Kingyoku, Takanoshima (Roch & Moll 1929); Tateyama Bay, Chiba pref, Japan (Kuronuma, 1931); Gulf of Cariaco, Venezuela (Nair 1975).

Bankia rochi Moll (Platc VIIIC)

- 1935. *Bankia rochi* Moll p. 215.
- 1935. *Bankia thielei* Roch p. 275
- 1961. *Bankia* (*Neobankia*) *roonwali* Rajagopalaiengar p. 550.
- 1966. *Bankia rochi* Moll, Turner, p. 119.
- 1971. *Bankia rochi* Moll Turner, p. 35, 55.

Salient features : Pallet elongate, solid and calcified with a long, slender and cylindrical stalk, the blade composed of a series of closely to moderately spaced conical units, the calcarous portion of each unit broadly U-shaped and covered by a brownish amber-coloured periostracum which extends as a wide border with the free margin serrated on both the inner and outer face, the awns are short and smooth.

Ecological notes : In sundarbans, W. Bengal it attacks trees such as *Avicennia officinalis*, *A. alba*, *A. marina* of Verbenacea; *Excoecaria agallocha* of Euphorbiaceae; *Ceriops decandra* (*C.roxburghiana*),

C. tagal (= *C. candolleana*) of the Rhizophoraceae; *Aegiceras corniculatus* of the Myrsinaceae and *Xylocarpus mollucensis* (= *Carapa mollucensis*) of Meliaceae. All the above mentioned trees except the last one are found attacked in the living condition. The burrow is lined by a calcareous tubing which is fairly thick, particularly at the posterior end (Ragagopal, 1964).

Occurrence : Sajnakhali (Sundarbans), West Bengal (Rajagopalaiengar, 1961, 1964a, Roonwal, 1966); Mahanadi Estuary (Subba Rao 1968); Vishakhapatnam (Nagabhushanam 1960); Andamans (Tewari *et al.* 1980); Karwar, Goa (Santhakumaran, 1976, 1981, 1983, Santhakumaran and Pillai 1975); Bombay (Palekar *et al.* 1964 Santhakumaran 1976).

Distribution : Indo-Pacific, tropical to sub-tropical. East coast of Africa (Turner 1966); Madagascar (Roch 1935); Red Sea, Persian Gulf; Indian ocean Islands, Papua -New Guinea (Rayner 1974); Pacific ocean Islands, Christmas Island, South of Java, (Moll, 1935); Japan (Turner 1966).

Family : PHOLADIDAE

Subfamily : PHOLADINAE

The group is rarely found in wood, generally found in firm mud, peat or rock (Turner 1954, 1971).

Anteriorly the shell is not closed by a callum in the adult. Number of accessory plates variable but hypoplax and siphonoplax always lacking. Apophyses present. Valves not divided into two regions by an umbonal-ventral sulcus except in the genus *Zirfaea* where the sulcus is rather weak. Foot well developed, not atrophying in the adult. Animal not capable of complete retraction within the shell (Turner 1954).

Three species are represented in this genus, *Pholas dactylus* Linnaeus, *Pholas campechiensis* Gmelin and *Pholas chiloensis* Molina.

Pholas (Thovana) chiloensis (Molina)

- 1782. *Pholas chiloensis* Molina p.204.
- 1834. *Pholas chiloensis* var. *parva* Sowerby p. 69.
- 1849. *Pholas laqueata* Sowerby p. 161.
- 1860. *Pholas (dactylina) retifer* Morch p. 177.
- 1932. *Pholas dilecta* Pilsbry and Lowe p. 88.
- 1954. *Pholas (Thovana) chiloensis* (Molina) Turner p. 51.
- 1971. *Pholas chiloensis* (Molina) Turner p. 22, 38.

Salient features : Shells rather large, elliptical to oval in outline, rounded and gaping slightly at both ends, with double septate umbonal reflections, and generally lacking sculpture on the posterior slope. Umbos prominent and located near the anterior fourth of the shell. There are very prominent and laminated ridges on the anterior slope, and only growth lines on the posterior slope. The interior of the shell is marked by a series of grooves, which are the manifestations of the external sculpture. apophyses rather heavy, slightly enlarged at the free end. Proto-plax divided longitudinally into two parts, each half is truncate

posteriorly, acuminate anteriorly and has well marked growth lines and mesoplax transverse and nearly diamond-shaped in outline. Metaplex long and narrow.

Siphons separated slightly at their posterior extremity and with small uniform papillae covering the entire surface. Foot elliptical in outline, long and thin.

Ecological notes : Shell valves of the species were collected from a piece of water logged partially rotten wood at Amini atoll of Lakshadweep Archipelago (Nair and Dharmaraj 1983). This was the first record of the species from Indian waters. Previously reported from the eastern Pacific, Mexico to Chile. The species usually occurs in firm mud, clay, peat and soft rock.

Occurrence : Lakshadweep Archipelago (Nair and Dharmaraj, 1983).

Distribution : Its distribution extends from Mexico to Chile.

Subfamily MARTESIINAE

Salient features: Shells closed anteriorly by a callum in the adult but gaping in the young stage, without a callum. Number of accessory plates variable, but always lacking a protoplx. Apophyses present, valves divided into two distinct areas by an umbonal ventral sulcus. Animal capable of complete retraction within the shell (Turner 1954, 1969, 1971). This is a large subfamily but only two genera have species which bore into wood.

Genus *Martesia* Sowerby

- 1824. *Martesia* 'Leach' Sowerby p. 2.
- 1825. *Martesia* 'Leach' de Blainville p. 632.
- 1840. *Martesia* Gray p. 154.
- 1875. *Martesia* 'Gray' Paetel p. 119.
- 1945. *Martesia* 'Leach' Bartsch and Rehder p. 2
- 1955. *Martesia* Sowerby Turner p. 101.
- 1971. *Martesia* Sowerby Turner p. 23, 37.

Salient features : Shells not reaching over 50 mm in length, generally pear-shaped in outline, divided into two distinct regions by an umbonal-ventral sulcus with a callum in the adults. Shells beaked and widely gaping anteriorly in the young stage. Valves narrowly to broadly rounded posteriorly and closed. Siphons capable of complete retraction into the shell. Umbos prominent, protoplx absent, mesoplax variable ranging from circular to cunei-form in outline, metaplex and hypoplex long, narrow with pointed anterior ends. Posteriorly they may be pointed, truncate or divided. Interior of the shell with a pronounced umbonal-ventral ridge with a ventral condyle at the ventral margin. Thin, long and fragile apophyses.

The genus *Martesia* is characterised by the teredo-like shell in the young stage, by the presence of a mesoplax, metaplex, hypoplex and the funnel-shaped bit below the umbonal reflection (Turner 1955).

Species of *Marteria* occur throughout the world from temperate to tropical areas. The genus is represented by 3 species, *M. fragilis* Verrill and Bush, *M. cuneiformis* (Say) and *M. striata* (Linnaeus).

***Martesia fragilis* Verrill & Bush 1890.**
(Plate IXB)

- 1890. *Martesia (Martesiella) fragilis* Verrill and Bush p. 777.
- 1908. *Pholadidea (Penitella) minuscula* Dall p. 425.
- 1945. *Martesia (Diploplax) exquisita* Bartsch and Rehder p. 10.
- 1945. *Martesia (Diploplax) bahamensis* Bartsch and Rehder p. 11.
- 1945. *Martesia (Martesia) fragilis* Verrill and Bush Turner pp. 111-114.
- 1971. *Martesia fragilis* Verrill and Bush Turner p. 22,43.

Salient features : Shell small, not reaching over 3/4 inch in length. Mesoplax more or less circular, concentrically sculptured and covering the anterior adductor muscle. Attachment area for anterior adductor muscle raised as a sickle-shaped flange over the umbo. Metaplax long and narrow, pointed anteriorly and broadening posteriorly to a rounded or truncate posterior margin. Hypoplax long and narrow pointed anteriorly, rounded posteriorly and extends from the umbonal ventral sulcus to about two thirds the distance to the posterior margin (Turner 1955, 1971).

Ecological notes: *M. fragilis* is closely related to *M. striata* and has been confused with it often. Only in India it has been considered destructive (Turner and Johnson 1971). It is usually found in floating wood or nuts in the open sea (Turner 1955). Daniel and Srinivasan (1956) and Srinivasan (1959) reported *M. fragilis* from Madras, India. The specimens were collected from catamarans and fishing boats that play in the open sea but were not found inside the harbour. Nair and Dharmaraj (1983) reported it from floating coconuts and drift wood gathered from the atolls of Lakshadweep archipelago. The only area where specimens were collected from fixed structures was the Texas coast and here their occurrence was very irregular (Turner 1955).

Occurrence : Andaman Island (Karandae 1978); Vishakhapatnam (Becker 1958); Madras (Becker 1958; Daniel, 1958; Daniel and Srinivasan, 1956; and Srinivasan 1959); Portonovo, (Srinivasan 1959); Ramnad (Nair 1965, Nair and Dharmaraj 1980 a); Pamban (Nair and Dharmaraj 1980); Cochin (Nair 1964); Lakshadweep (Nair and Dharmaraj 1983).

Distribution : Probably world-wide in warm temperate and tropical seas. Known distribution is discontinuous, ranges from Cape Charles, Virginia (in Gulf Stream) to Rio Grande do Sul, Brazil and from Sonora, Mexico to the Gulf of Panama in the eastern Pacific (Turner and Johnson 1971).

***Martesia striata* (Linnaeus)**
(Plate IXC)

- 1758. *Pholas striata* Linnaeus p. 669.
- 1818. *Pholas clavata* Lamark p. 446.
- 1849. *Pholas teredinaeformis* Sowerby p. 490.
- 1850. *Pholas rosea* C.B. Adams p.75-76.
- 1852. *Pholas pusillus* Linnaeus Dodge p. 27.

- 1862. *Martesia striata* Linnaeus Tryon p. 92.
- 1909. *Martesia curta* 'Sowerby' Dall p. 161.
- 1924. *Pholas cupula* Yokoyama p. 37.
- 1927. *Martesia striata tokyoensis* Yokoyama p. 428.
- 1932. *Martesia pulchella* Yokoyama p. 238.
- 1936. *Hiata infelix* Zetek and McLean p. 110.
- 1938. *Martesia bawaiensis* Dall, Bartsch and Rehder p. 205.
- 1945. *Martesia (Diploplax) funisicola* Bartsch and Rehder p. 14.
- 1950. *Martesia intercalata* 'Carpenter' Hertlein and Strong p. 250.
- 1955. *Martesia (Martesia) striata* Linnaeus Turner pp. 103-111.
- 1971. *Martesia striata* (Linnaeus) Turner p. 22, 37, 41.

Salient features : Shell variable in size and shape, larger specimens reaching 5 cm in length and 2 cm in height, beaked anteriorly and widely gaping in the young and producing a callum in the adult. Posteriorly the shell is closed and broadly to narrowly rounded depending upon the age and rate of growth. Anteriorly the shell is sculptured with close-set denticulated ridge, umbonal-ventral sulcus which divide the valve into two regions is distinct. Posterior region sculptured with smooth concentric ridges. Umbos prominent and located nearly at the anterior end of the shell in adult specimens. A sickle-shaped flange extends over the umbo. Protoplax absent. Mesoplax in young transverse, more or less semicircular in outline and is marked with concentric growth lines. In the adult mesoplax is large, inflated nearly circular in outline often with a slight notch posteriorly and a small point anteriorly and sculptured only by irregular wrinkles. In specimens boring into hard wood or in over crowded condition the mesoplax may be malformed, often having a rough irregular surface and scalloped edges (Turner, 1955), metaplax and hypoplax pointed at both ends, long and narrow.

Umbonal-ventral sulcus seen as a beaded ridge internally which forms a condyle at the ventral margin. Apophyses long and thin; well marked muscle scars, the anterior adductor muscle being attached to the sickle-flanges over the umbos. Pallial sinus broad and deep.

Siphons are separated distally. The incurrent siphon when extended flares at the aperture, bearing numerous submarginal tentacles at the inner surface and farther in, about half as many larger tentacles which extend internally as ridges. The excurrent siphon is slightly shorter than the incurrent, does not flare and lacks tentacles. Foot in young large, nearly circular and truncate, but atrophied in the adult (Turner 1955).

Ecological notes : *M. striata* is the most destructive and widely distributed species of the genus *Martesia*. It has a world wide distribution ranging from warm temperate to tropical areas in salinities ranging from normal sea water to as low as 6ppt. (Nagabhushanam, 1955a, 1961; Turner and Johnson 1971). They burrow only slightly deeper than the length of the shell. Nair and Dharmaraj (1983) collected shells of *M. striata* from a plank-built cargo boat dry docked at Minicoy Atoll for repair, which frequently anchored at estuarine ports of the Indian main land.

Factors controlling its presence include temperature, turbidity, salinity and pH of the water.

Occurrence : Found in almost all localities surveyed for marine borer incidence along the coasts of India. Andaman Islands (Karande 1978; Das and Dev Roy 1980); Mahanadi Estuary (Subha Rao 1971);

Visakhapatnam (Nagabhushanam 1955); Godavary Estuary (Ganapati and Rao 1956); Krishna Estuary (Rao, Murthy and Krishnakumaran 1957); Madras (Gravelly 1941, Melvill and Standen 1898; Daniel 1958; Daniel and Srinivasan 1956; Srinivasan 1959); Beypore (Beeson 1936); Porto-Novo (Srinivasan 1959; Nair and Dharmaraj 1980a); Point Calimere (Spengler 1779); Krusady Islands (Sathyamurthy 1956), Ramnad (Nair 1965), Pamban (Nair 1965; Nair and Dharmaraj 1980), Tuticorin (Srinivasan 1959; Nair and Dharmaraj 1979), Trivandrum, Anjengo (Dharmaraj and Nair 1981a), Neendakarai, Kayamkulam (Santhakumari and Nair 1975); Cochin (Erlanson 1936; Santhakumari and Nair 1975; Nair 1966, 1968); Lakshadweep (Nair and Dharmaraj 1983); Mangalore (Santhakumaran 1976; Santhakumaran and Pillai 1975); Panaji, Ratnagiri and Alibagh (Santhakumaran 1976, 1981, 1983b; Santhakumaran and Pillai 1975); Bombay (Melvill and Standen 1907; Palekar and Bal, 1955; Santhakumaran 1976). Kandla, Okha, Veraval, Daman and Gholvad (Santhakumaran 1976).

Distribution : *M. striata* has a world-wide distribution ranging from warm temperate to tropical areas. It has also been reported from Kure Beach, North Carolina, South to Florida, the Gulf of Mexico, the West Indies and South to Rio de Janeiro, Brazil, Sonora, Mexico, south to the Gulf of Guayaquil, Peru, Hawaiian Islands West to Japan and South through the East Indies to Brisbane, Australia.

Phylum : ARTHROPODA

Class : CRUSTACEA

Order : ISOPODA

Order : ISOPODA LATREILLE, 1817

Salient features : Body dorso-ventrally compressed, telson almost always fused with last pleon segment to form a pleotelson; eyes sessile; first and 2nd antennae uniramous with a minute scale or 'squama' in a few genera. Thoracic limbs without exopodites. Pleopods biramous, with flattened rami specialised for respiration. Generally the 2nd and sometimes also the first pair modified in the male. Heart located wholly or partially in the pleon. Maxillary glands usually present in adults. Young leave the brood pouch in the 'manca' stage, that is before the appearance of last pair of pereopods.

The order Isopoda includes 9 suborders, which may be identified based on the key of Brusca and Iverson (1985).

Suborder : FLABELLIFERA

Salient features : Body depressed. Eyes well developed in most species but some are blind. First and 2nd antennae well developed, rarely longer than body, with multiarticulate flagellum. Pereon segments free with well developed coxal plates. Pereopods 1-7 usually ambulatory, prehensile in some families. Pleon usually consists of five free segments plus pleotelson. All pleopods biramous. Uropods usually biramous, the flattened rami forming a 'caudal fan' with the pleotelson.

This is the largest suborder of the order isopoda and comprises of members which are primarily littoral or shallow benthic in habit.

Family : SPHAEROMATIDAE

Salient features : Body oval convex with pleon of two distinct free somites including telson. First antenna with peduncle of three articles and second antenna with peduncle of five articles. Uropods lateral, exopod free and movable, endopod firmly attached to peduncle, immovable. Pronounced sexual dimorphism.

The most obvious characteristic of this family is the ability to roll into a sphere when handled. Unlike in other isopods the fertilized eggs are deposited in an internal brood pouch. This family contains about 75 genera.

Group Hemibranchiata

Pleopod 1, inner ramus broad; pleopod 3 both rami with long plumose setae on distal margin; pleopods 4 and 5, inner rami thick and fleshy with transverse folds, outer rami membraneous, two segmented, both rami without plumose marginal setae; pleopod 5 outer ramus with high apical, squamiferous protuberance (Hurley and Jensen 1977).

Genus *Sphaeroma* Latreille, 1802

- 1802. *Sphaeroma* Latreille p. 182.
- 1961. *Sphaeroma* Pillai p. 1-2.
- 1977. *Sphaeroma* Hurley and Jansen p. 1-2.
- 1985. *Sphaeroma* Kensley.

Salient features : Hemichordate sphaeromatid, capable of rolling into a ball when disturbed; posterior margin of pleotelson not notched in both sexes. Both rami of uropods similar, outer ramus denticulate along outer margin, movable; inner branch immovable. Endopod of pleopod 2 of mature males with well developed appendix masculina in most species. Endopod of pleopod 3, unsegmented. All pereopods ambulatory; pereopods 1-3 with long plumose setae on articles 3-4. Articles 2-4 of maxillipedal palp not lobed, but bearing long hairs.

Sphaeroma Bate 1866 has been extensively studied by Stebbing (1900, 1940, 1911); Hansen (1905); Baker (1926, 1928); Monod (1931); Pillai (1955, 1961); John (1968); Hurley and Jansen (1977) and Iverson (1982). The study of Indian species of this began with the description of *S. vastator* by Bate (1866). Four species and a variety of this genus have been reported from Indian waters, viz., *S. terebrans*, *S. triste*, *S. walkeri*, *S. annandalei* and *S. annandalei travencorensis*. Of these *S. triste* is purely a marine form, *S. walkeri* is mainly marine with sparse occurrence in brackish water. The other three are mainly brackish water forms.

Sphaeroma terebrans Bate 1866 (Plate X, Fig. 2.)

- 1866. *Sphaeroma terebrans* Bate p. 28.
- 1955. *Sphaeroma terebrans* Pillai p. 129.
- 1961. *Sphaeroma terebrans* Bate Pillai p. 2
- 1978. *Sphaeroma terebrans* Bate Kensley.

Salient features: Body oblong, almost parallel sided, cephalon longer than succeeding pereon segments, with a small antero-median rostrum, eyes small. Pereon segments, with a small antero-median rostrum, eyes small. Pereon segments 2-7 with a transverse ridge situated anteriorly in the anterior segments and slightly shifting successively backwards on the posterior segments. Pereon segments 6-7 bear 4 tubercles each, two submedian and two lateral with a bunch of long thin hairs. Composite pleon with 4 tubercles as in the pereon. Lateral parts with 3 oblique sutures. Telson somewhat triangular with the proximal part slightly bulged, four tubercles present, two submedian and two lateral; dorsal surface of telson pustulose the pustules being surmounted by hairs, apex rounded, slightly curved upwards with minute apical hairs (For details of appendages see Pillai 1961, Kensley, 1978).

Ecological notes : This is a true borer. It is mainly confined to the brackishwater areas. This is abundant in the backwaters of Kerala, ranging from the bar mouth where the salinity equals to that of the sea to the region of fresh water. However, it has never been reported from any water body unconnected with the sea. The damage caused by this species to all sorts of submerged timber is considerable. In many areas it causes considerable damage to living trees also. The attack has been observed to be more heavy in the intertidal regions. It is a continuous breeder and the female broods the eggs. The phenomenon of mixed brood is exhibited (Venkatakrishnan and Nair 1973).

Occurrence : It has been reported from almost all areas surveyed for marine borers along the Indian coasts. Reports are available from Andamans (Tewari *et.al.* 1980) off Puri, Orissa and Godavary Estuary (Ganapati and Rao 1961); Visakhapatnam and Madras (Purushotham and Rao 1971); Portonovo (Nair and Dharmaraj 1980a); Pamban (Nair 1965); Trivanandrum, Neendakarai and Anjengo (Pillai 1955, 1961; Dharmaraj and Nair 1981a); Cochin (Erlanson 1936; Pillai 1955, 1961; Cheriyan 1964; John 1964, 1968); Mangalore, Karwar and Panaji (Palekar and Bal 1957, Pillai 1961; Santhakumaran 1976, 1981, 1983; Santhakumaran and Pillai 1975; Dharmaraj and Nair 1981); Okha, Porbandar and Veraval (Santhakumaran 1976).

Distribution : Mediterranean, Africa, Congo, Mozambique, Zanzibar, Sri Lanka, Queensland, Florida, Brazil and India.

***Sphaeroma annandalei* Stebbing 1911**
(Plate X, Fig. 1)

- 1911. *Sphaeroma annandalei* Stebbing p. 181.
- 1936. *Sphaeroma annandalei* Barnard p. 178.
- 1940. *Sphaeroma annandalei* Baranard p. 405.
- 1954. *Sphaeroma annandalei* Pillai pp. 1-21.
- 1955. *Sphaeroma annandalei* Pillai p. 134.
- 1961. *Sphaeroma annandalei* Pillai p. 13.

Salient features : Body almost parallel sided, oblong; cephalon, anterior margin slightly bisinuate, with a small antero-median rostrum; eyes small, pereon segments subequal, pereon segments 2-4 with an indistinct submarginal transverse ridge in the posterior pereonite, this ridge gets cut up into transversely elongated tubercles which become progressively prominent posteriorly. Coxal plates fused with the respective pereonites, with a matting of minute setae on its lateral margins. Composite pleon with 3 oblique lateral sutures, bearing the submarginal tubercles dorsally. Proximal dorsal surface of telson slightly

bulged with two pairs of submedian tubercles arranged longitudinally followed by a median tubercle, this arrangement of tubercles is flanked by a longitudinal row of three tubercles on either side; apex semi circular (for details of appendages see Pillai, 1961).

Ecological notes : *S. annandalei* is very abundant in the backwater systems of Kerala and is a true timber borer causing considerable damage. This species though common in estuarine habitat, can be found in typically marine environment too. It is usually found along with *S. terebrans*. Attack is heaviest in the intertidal zone, the maximum intensity being at half tide level. Dharmaraj and Nair (1982) reported *S. annandalei* from laterite and hard clay embankment from the backwaters namely the Ashtamudy, Kadinamkulam, Anjengo, and Akathumury along the South-West coast of India.

It is a continuous breeder and mixed broods are a common phenomenon in this species (Venkatakrishnan and Nair 1973a).

Occurrence : It is a common crustacean borer of the backwaters along the coast of India. Report of occurrence from the Indian coast is as follows: Calcutta (Stebbing 1911); Orissa (Ganapati and Rao 1961); Visakhapatnam (Pillai 1961); Godavary Estuary (Purushotham and Rao (1971); Madras (Pillai 1961); Portonovo, Trivandrum, Anjengo and Mangalore (Nair and Dharmaraj 1980a; Dharmaraj and Nair 1981, 1981a); Neendakarai and Cochin (Pillai 1955, 1961; Erlanson 1936; Cherian 1964); Karwar and Panaji (Santhakumaran 1981, 1983; Santhakumaran and Jain 1981); Bombay Okha, Veraval and Kolak (Palekar and Bal 1957a; Joshi 1957; Santhakumaran 1976).

Distribution : Zululand and Natal (South Africa) and India.

***Sphaeroma triste* Heller 1868**
(Plate X, Fig. 3.)

- 1868. *Sphaeroma triste* Heller p. 142.
- 1902. *Sphaeroma felix* Lanchester p. 379.
- 1936. *Sphaeroma triste*, Barnard p. 177.
- 1961. *Sphaeroma triste* Heller Pillai p. 17.
- 1964. *Sphaeroma triste* Heller George p. 12.

Salient features : Slightly elongate oval body with the broadest part at the fifth pereon segment. There is an anterior submarginal groove and 3 small tubercles on the dorsal side. The first pereon segment produced antero-dorsally into prominent rounded lobes that overlaps the eyes; segments 2-5 equal but the 7th very short. Each pereon segment is with a prominent transverse ridge. Pleon with a pair of large conical submedian tubercles. Telson about one and a half times as broad as long, with a convex proximal median part and with two tubercles like that on the pleon. Distal half of telson triangular with a hairy border. Epistome triangular with a pointed apex.

Uropods with rami subequal in length, outer border of exopod bears 9 sharp teeth including the tooth-like apex. *S. triste* could easily be identified by the presence of 9 teeth on the outer border of the exopod of the uropod (Pillai 1961).

Ecological notes: *S. triste* occurs along the coast of Tamil Nadu, Andaman and Nicobar Islands and Lakshadweep Archipelago. It is a typical marine form.

Occurrence : Reported from Andaman Nicobar Islands (Heller 1868); Pamban (George 1963; Nair 1965); Tuticorin (Nair 1968); Lakshadweep (by the authors during a recent survey).

Distribution : India and Malaya Peninsula.

***Sphaeroma walkeri* Stebbing 1905**

- 1905. *Sphaeroma walkeri* Stebbing p. 31.
- 1920. *Sphaeroma walkeri* Barnard p. 360.
- 1928. *Sphaeroma walkeri* Baker p. 49.
- 1931. *Sphaeroma walkeri* Monod p. 36.
- 1933. *Sphaeroma walkeri* Monod p. 154.
- 1936. *Sphaeroma walkeri* Barnard p. 178.
- 1940. *Sphaeroma walkeri* Barnard p. 405.
- 1955. *Sphaeroma walkeri* Pillai p. 132.
- 1961. *Sphaeroma walkeri* Stebbing Pillai p. 8.

Salient features : Body has a warty appearance due to tubercles of various sizes on elongate oval body surface. The short cephalon bears a transverse row of 5-6 low tubercles. Each pereon segment is provided with a transverse ridge, bearing one or two transverse rows of large tubercles on all except the first segment. Posterior border of segments beaded. Posterior border of pleon with a row of large tubercles and two oblique lateral rows of smaller ones. Telson as wide as long, with a rounded, ridge-like and conspicuously raised posterior border that is continued on to the dorsal side at the middle of the lateral borders. There are 3 pairs of longitudinal rows of tubercles the median row not reaching the apex of the telson like other rows. The entire dorsal side is pustulose. (For details of appendages see Pillai 1961).

Ecological notes : *S. walkeri* is mainly seen in marine areas. They are only sparsely seen in estuarine regions, because they are not capable of tolerating low salinities. *S. walkeri* is seen in empty burrows of other crustacean borers, shells of barnacles, and also in the sand tubes of sabellid worms. Whether it actually bores into wood is doubtful (Pillai 1961).

Occurrence : Reports are available about the occurrence of *S. walkeri* along the coast of India. Visakhapatnam (Ganapathi and Nagabhushanam 1955; Pillai 1961); Madras, Pamban, and Tuticorin (Srinivasan, 1955; Pillai 1961; Nair 1965; Purushotham and Rao 1971); Quilon, Cochin, and Calicut (Pillai, 1955, 1961; Cheriyan 1964; Purushotham and Rao 1971).; Lakshadweep (Nair and Dharmaraj 1983); Bombay (Palekar and Bal 1957a; Joshi 1957; Santhakumaran 1976).

Distribution : South Africa, Suez, Egypt, Sri Lanka, New South Wales and India.

Family LIMNORIIDAE Harger

The family consists of two genera, namely *Paralimnoria* and *Limnoria*. The genus *Limnoria* may be distinguished from the genus *Paralimnoria* by the nature of the uropods. Both rami of the uropods of *Paralimnoria* bear terminal, sharply pointed claws, whereas only the outer ramus (exopodite) of the uropods of *Limnoria* has a terminal claw.

The first antennae of all species of *Limnoria* are about the same. The 2nd antennae have a 5-Jointed peduncle and a multiarticulate flagellum. The number of articles of the flagellum is useful in separating groups of species.

The mandibles of *Limnoria*, have a rasp and file arrangement on the incisive parts of the mandible, but lacking in *Phycolimnoria*, a subgenus of the genus *Limnoria*. Most species of the subgenus *Limnoria* have a triarticulate mandibular palp but varies in some.

The maxillipedal epipod is apically pointed and short in most species but is strap-like in others.

The arrangement of carinae and tuberculations on the surface of the pleotelson is also important. Thus tripunctata has three tubercles, quadripunctata four; platycauda none; multipunctata, many; unicornis, one etc. (Menzies 1957, 1959).

Genus *Limnoria* Leach

- 1813. *Limnoria* Leach p. 433.
- 1957. *Limnoria* Pillai p. 149.
- 1958. *Limnoria* Becker and Kampf p.1.
- 1961. *Limnoria* Leach, Pillai p. 20.
- 1968. *Limnoria* Leach Kuhne p. 65-68.

Salient features : Flagellum of first antennae with four articles. Flagellum of 2nd antenna with three, four or five articles. Mandibular incisor with or without "rasp" and "file". Lacinioid setae of right mandible always flattened, never tubular, and with apex of variable structure. Exopod of uropod much shorter than endopod and with an apical claw; endopod elongate and without a claw. Fifth pair of pleopods lack marginal setae (Menzies 1957).

The genus *Limnoria* contains two subgenera *Limnoria* and *Phycolimnoria*

Sub-genus *Limnoria* Menzies

- 1957. *Limnoria* Menzies p. 122.
- 1961. *Limnoria* Menzies, p. 20.

Salient features : Species of this subgenus have a "rasp and "file" arrangement of scales and ridges on the incisive process of the mandibles. The species are all wood-borers (Menzies 1957).

About 9 species of *Limnoria* are known from the Andaman Nicobar and Lakshadweep Islands.

Limnoria (Limnoria) andamanensis (Rao & Ganapati) (Plate X, Rig. 5)

- 1969. *Limnoria (Limnoria) andamanensis* Lakshmana Rao and Ganapati p. 226.

Salient features : Rao and Ganapati (1969) described the species as follows :

"Flagellum of second antenna with 4 articles. Epipod of maxilliped slightly over reaches the articulation of the palp of the endopod, it is two and a half to three times longer than broad, and is broadest behind the apex. Mandibular palp 3-segmented. Dorsal surface of pleotelson with prominent tubercles, fifth pleon segment with two submedian curved ridges. The lateral crests are well raised, with a row of thick long hairs. Lacinioid seta has the apex pointed and smooth and curved in the form of a beak. The epipod of the uropod is slightly longer than the peduncle, the exopod unguiform, about as long as the endopod"

Ecological notes : This species has been reported from an infested log of wood from the Andaman Island by Rao and Ganapati (1969). This is known only from the type locality.

Occurrence and Distribution : Andamans, India.

***Limnoria (Limnoria) bombayensis* Pillai 1961**
(Plate X, Fig.6)

1961. *Limnoria (Limnoria) bombayensis* Pillai p. 29.

Salient features : Body elongated and almost parallel sided, head transversely oblong. Pereonites 2-7 with a row of setae at the posterior border. Pleon segments with an oblique setose lateral ridge, that on the fifth segment prominent with tubercles. Telson almost circular with tubercular lateral crests but absent on the dorsal surface. Border of telson sparsely setose but devoid of spine-like bristles, but with a row of tubercles on the distal border.

According to Pillai (1961) flagellum of 2nd antenna 5-segmented; mandibular palp 3-segmented; incisor process with file-like ridges and teeth; lacinioid seta, small, apically curved and feebly spiny, setal row formed of a bundle of 8 feebly barbed setae. Maxilliped slender and long.

Propodus of first paraeopod with 2 barbed spines. Secondary unguis bifid, lower border of ischium, merus and carpus tubercular.

Peduncle of uropod slightly longer than endopod, endopod about twice the length of exopod, exopod with a claw.

Ecological notes : The occurrence of this species was first reported by Palekar and Bal (1957a) from Bombay harbour. Careful examination by Pillai (1961) distinguished it as a new species *L. bombayensis*.

Occurrence : Reported from Bombay by Palekar and Bal (1957a) Pillai (1961) and Santhakumaran (1976). It has also been recently collected by the present authors from Lakshadweep.

Distribution : Known from India only.

***Limnoria (Limnoria) indica* Becker and Kampf**
(Plate X, Fig. 7) (Plate X, Fig. 8.)

1958. *Limnoria indica* Becker and Kampf p.1.

1961. *Limnoria (Limnoria) indica* (Becker and Kampf) Pillai p. 23.

Salient features : There is marked sexual dimorphism in this species. Body elongated and parallel sided in female, but elongate oblong in male. The coxal plates more projecting in the male than in the female. First pereon segment twice as long as second with 2 indistinct lateral oblique grooves, pereonites 2-4 subequal, 7th only twice as long as first pleon segment. Fifth pleonite slightly longer than the first 4 combined and with a pair of subparallel longitudinal carinae on the dorsal surface and an oblique setose ridge laterally.

Telson with a pair of lateral setose ridges. Dorsal surface in male with 3 pairs of tubercles, 2 submedian, the 2nd slightly larger, and a lateral pair of smaller ones. Each with a setae by its side. Tubercles are absent in the female except for a row of oblong tubercles towards the border. Telson with stiff spinules on the dorsal side and short spine setae on the distal border (For more details see Pillai 1961).

Ecological notes: It was Becker who for the first time reported this species from a collection of *Limnoria* from the trunk of a palm tree from Mandapam. Later the same species was found in Madras Harbour in untreated test panels of various timber species used for test with wood preservatives. Recently the authors collected this from jetty piles in the different atolls of Lakshadweep islands.

Occurrence : Andaman Islands (Ganapathi and Rao 1960; Karande 1978); Madras, Pamban and Bombay (Becker and Kampf 1958, 1959; Nair 1965). Lakshadweep

Distribution : Known only from Indian Waters.

***Limnoria (Limnoria) insulae* (Menzies)**
(Plate X Fig. 9)

1957. *Limnoria (Limnoria) insulae* Menzies p. 178.

Salient features : Body elongate and nearly parallel sided, fifth pleonite with a conspicuous hump on midline near distal border. In female the hump is markedly reduced to only a mid-longitudinal carina; Pleotelson lacking ornamentation but the lateral crests of the male are much elevated and extend outward over the cupshaped part of the pleotelson. Posterior margin tuberculate.

Flagellum of second antenna with 4 articles. Epipod of maxilliped spatulate, widest near middle, mandibular palp with three articles. Lacinioid seta of right mandible with two apical spines. Peduncle of uropods markedly compressed and tuberculations are spine-like (Menzies 19587)

Occurrence : Reported from Andaman islands only (Ganapati and Rao 1960).

Distribution : South Pacific Ocean. Reports are available from Serua, Fiji Island, Guam Island, Palmyra island, Caroline island and India.

***Limnoria (Limnoria) pfefferi* Stebbing**
(Plate X, Fig. 10)

1904. *Limnoria pfefferi* Stebbing p.714.

1914. *Limnoria pfefferi* Chilton p.382.
 1957. *Limnoria pfefferi* Menzies and Becker p. 87.
 1957. *Limnoria (Limnoria) pfefferi* Menzies p. 135.
 1961. *Limnoria (Limnoria) pfefferi* (Stebbing) Pillai p. 25.

Salient features : Body elongate with a globular head which is narrower than the rest of the body. The first pereonite longest with a V-shaped groove. The 5th pleonite which is equal to the other 4 segments bears a yoke-shaped carina dorsally and a pair of oblique setose lateral ridges. Telson with a pair of lateral carinae and a pair of submedian parallel ridges; border of telson with short setae mixed with long ones.

Flagellum of 2nd antenna with 4 articles, epipod of maxilliped clavate and widest near distal end. Mandibular palp with 3 articles. Lacinioid seta of right mandible short with 5-6 apical denticles. Propodus of first pereopod with 2 spines. Merus of 7th leg externally produced into a long spine- fringed process. Peduncle of uropod twice as long as endopod, latter nearly twice as long as exopod (Menzies 1957, Pillai 1961).

Ecological notes : Stebbing (1905) collected this species from Minicoy Atoll in rotten wood. This has also been collected from Miami beach by Mr. Leonard in the year 1950. In India Purushotham and Rao (1971) reported it from Madras and Ganapati and Rao (1960) from Andaman islands.

Occurrence : Andamans, Madras and Lakshadweep.

Distribution : Indian ocean and the Atlantic (Miami, Florida).

***Limnoria (Limnoria) platycauda* Menzies**
 (Plate X, Fig. 11)

1957. *Limnoria (Limnoria) platycauda* Menzies p. 139.

Salient features : Fifth pleonite with a median longitudinal ridge dorsally, pleotelson lacking ridges or rugosities : posterior margin tuberculate, with a few setae and no spike-like bristles. Lateral crests with tubercles.

Flagellum of second antenna with four articles; epipod of maxilliped, semispatulate, narrowest at distal end, about 3 times as long as wide. Mandibular palp with 3 articles. Lacinioid seta of right mandible elongated, bent at distal end bearing a cup-shaped serrated apex (Menzies 1957).

Remarks : The species differs from all others noticeably in the lack of ridges, rugosities or tuberculations on the dorsal surface of its pleotelson.

Occurrence : Ganapati and Rao (1960) reported it from Andaman islands.

Distribution : Besides India, reports are available from Caribbean, Puerto Rico to Curacao, Dutch, West Indies (Menzies 1957).

***Limnoria (Limnoria) septima* Barard**
(Plate X, Fig. 12)

1936. *Limnoria septima* Barnard p. 174.
1957. *Limnoria (Limnoria) septima* Menzies p. 168.
1961. *Limnoria (Limnoria) septima* Barnard, Pillai p. 27.

Salient features : Body elongate with a short cephalon, first pereonite longer than others, pereonites 2-7 granular and pubescent along the posterior border. Each pleonite with a lateral oblique ridge, more conspicuous on the posterior ones. Fifth pleonite medially with a distal horseshoe-shaped carina facing a similar one proximally between which is an unornamented sulcus.

Telson nearly circular, strongly raised margin and is setose. Dorso-median part with a pair of submedian and pair of lateral tubercles, each followed by a strong ridge, with 2 pairs of smaller ridges in between; the tubercles joined by arched carinae.

Flagellum of 2nd antenna with 5 articles. Epipod of maxilliped semi-triangular, narrowing distally to a point and widest at base. Mandibular palp with 3 articles.

First paraeopod with 6-7 large tubercles on 3rd segment, 1 on fourth, propodus with 2 spines, secondary unguis bifid (Menzies 1957; Pillai 1961).

Occurrence and Distribution : known only from the type locality, Andaman Islands.

***Limnoria (Limnoria) unicornis* Menzies**
(Plate X, Fig. 13).

1957. *Limnoria (Limnoria) unicornis* Menzies p. 173.

Salient features : Body elongate nearly parallel sided. Fifth pleonite with an anteriorly located, depressed, triangular area on mid-line followed by a mid-longitudinal carina. Pleotelson with a large, elevated, median tubercle at proximal end. Posterior margin devoid of tubercles but with spike-like setae. Lateral crests also lack tubercles.

Flagellum of second antenna with 4 articles. Epipod of maxilliped short, semi-triangular, 3 times as long as wide with acute apex. Mandibular palp with one article. Lacinioid seta of right mandible simple, apically spinulate (Menzies 1957).

Occurrence : Ganapati and Rao (1960) collected *L. unicornis* from Andaman islands.

Distribution : Besides India it has also been reported from Ponape and Caroline islands.

The nature of distribution of timber borers along the coasts of India

The nature of distribution of timber borers along the coasts of India presents an interesting picture. The pattern of distribution of wood borers along the coasts of India and in the Indian ocean islands is shown

in Table 1. This is not a complete list of species since virtually nothing is known regarding their occurrence from many areas along the coast.

Of the 14 genera of shipworms of the family Teredinidae 13 are represented in Indian waters. A total of 38 species have so far been reported from our coasts. Not less than 50 species of pholads are known as timber destroyers in the world oceans (Jones *et al.* 1976). Species of obligate woodborers of the family pholadidae known from India are only 4, one as yet undescribed of the genus *Lignopholas* and three of the genus *Martesia* of which one is still to be described. Species of *Barnea*, *Pholas* and *Zirfaea* are not obligate wood borers though records are available from India (Nair and Dharmaraj 1983). Among the crustacean borers 5 species and one variety of pill bugs (sphaeromatids) and not less than 9 species of gribbles, (limnoriids) have so far been reported from the coasts of India.

At least 7 species of shipworms are known to occur in West Bengal. It is certain that this does not represent the actual number that exists in that area because the extensive mangrove forests that occur there should certainly be harbouring a much greater number than is known at present. More extensive collections would bring to light the real nature of the fauna of W. Bengal. From the mangrove forests of Sunderbans, *B. thoracites* has been reported as a serious pest infesting both living and dead trees. (Roonwal 1954, 1954a), *D. manni*, *N. dunlopei*, *B. campanellata*, *B. nordi* and *B. rochi* are the other species reported as active in W. Bengal.

13 species have so far been collected from the Mahanadi Estuary in Orissa and these include all the species reported from W. Bengal except *B. nordi*.

The marine wood-borers of Andhra Pradesh have been studied in detail by Nagabhushanam (1955, 1960), Ganapati and Rao (1959). A total of 20 species of wood-borers are reported from this area. Of the 16 species of shipworms in the region *T. furcifera*, *L. pedicellatus* and *B. campanellata* are the most destructive in the area especially in the Vishakhapatnam Harbour. *M. striata* is the only species of pholad reported from this area. Of the crustacean wood borers there is a record of 3 species of sphaeromatids from this area.

No other region in India has been subjected to such detailed and extensive surveys as Tamil Nadu coast. Since 1953 as many as 36 species have been collected, identified and described from this area covering the southeastern part of India. Of the 24 species of shipworms so far reported from this area the most destructive are *T. furcifera*, *L. pedicellatus*, *B. carinata* and *U. rehderi*. *M. striata* is the most destructive among the 4 species of pholads reported from the area. Of the 8 species of crustacean borers sphaeromatids are highly destructive (see Daniel 1958; Nair 1954, 1955, 1956, 1962, 1965; Nair and Dharmaraj 1979; 1980; Nair and Gurumani 1957; Nair and Saraswathy 1971; Radhakrishnan *et al.* 1983; Srinivasan and Chandramohan 1973).

The Andaman and Nicobar Islands commonly known as the Bay islands occupy a unique position zoogeographically. Recent studies have brought to light the existence of 25 species of borers. (Das and Dev Roy 1980; Ganapathi and Rao 1960; Karandae 1978; Tewari *et al.* 1980).

From Kerala, southwest coast of India 22 species of molluscan and 4 species of crustacean borers have been reported. (Nair & Dharmaraj 1983; Nair *et al.* 1987). In Cochin harbour a typical tropical estuary, the most destructive species are the estuarine *N. hedleyi* and *T. furcifera* (Nair and Saraswathy 1971).

Recent surveys along the extensive backwaters of Kerala have brought to light the existence of a few interesting species such as *N. globosa*, *N. oahuensis* and *L. triste*.

The Lakshadweep Archipelago situated off the S.W. coast of India harbour at least 22 species of molluscan and 5 species of crustacean borers. The shipworms are the most destructive in this area followed by limnoriids. Species highly destructive are *T. fulleri*, *T. clappi* and *L. massa* (Nair and Dharmaraj 1983).

The northwest coast of India representing the region north of Goa has also been subjected to detailed surveys by Santhakumaran (1973, 1976, 1985, 1986). These along with earlier records show that 21 species of marine borers occur north of Goa in the Indian waters. Of these 13 species belonging to Teredinidae are the most destructive.

Thus, there is a marked difference in the occurrence and distribution of different boring organisms along the east and west coasts of India. Panikkar (1969) has tried to explain the differences in the nature and composition of the fauna along these coasts. According to him there is a partial or complete destruction of fauna of the estuaries and to some extent of the shore of the west coast of India during the southwest monsoon and that this is followed by an annual repopulation of the estuaries and backwaters after the monsoon months.

Ecological factors

The intensity and distribution of the wood borers depend on several environmental factors. These are the physico-chemical variables of sea-water, such as temperature, salinity, oxygen tension, turbidity and pollutants. Other factors such as the presence and intensity of fouling organisms, the nature of wood; the period of exposure of wood in water; the presence or absence or the nature of preservatives used; location of wood in relation to tidal changes; the interaction of the species of woodboring animals present in the area; the presence or absence of predators and parasites. The occurrence, the abundance and the intensity of attack in any locality is dependent on these factors, which vary widely from year to year (Nair 1984). Probably there are several more, but these factors are the most important.

Temperature is a major factor influencing the activities and distribution of many borers particularly the shipworms and limnoriids. The temperature of the coastal waters of India varies from 24 to 33° C. In estuaries, the water being generally shallow, temperature goes up to 35°C during the hot season. This may go up to 40° C in some isolated areas. There is a correlation between the biological effects of temperature and salinity, the former can modify the effects of the latter and change the salinity range of an organism. Depending on the temperature tolerance some species are restricted to cold waters of high latitudes, some are inhabitants of subtropical areas while the majority are inhabitants of the tropical regions. Thus, along the coasts of Norway 3 species of shipworms occur (Nair 1959), 5 species in the Mediterranean, 7 in Hawaii and Midway islands, 16 species in the Phillippine islands and as many as 38 species in India (Nair 1984). Uniformly high temperature hastens metabolic activities and accelerate growth rates, leading to early sexual maturity, many breed continuously producing several generations in rapid succession within a year. This probably accounts for the richness of fauna in the tropics.

Among the crustacean wood borers limnoriids are more sensitive to temperature changes (Smme 1940; Pillai 1961). Temperature below and above a certain limit has marked effect on the breeding capacity

of *Limnoria* (Menzies 1957). In Indian waters the average temperature is generally high and hence Becker (1959) considered that *Limnoria* could not grow abundantly and become a pest. The presence of *Limnoria* in 4 major Indian harbours and in Andaman and Lakshadweep islands reveals that heat resistant races of *Limnoria* do occur in Indian waters (Karande 1978).

In case of sphaeromatids, they can tolerate wide variations of temperature (Pillai 1961). Reports are available about the occurrence of these pests from temperate, subtropical and tropical waters of the world (Barnacle *et.al.* 1886.)

The uniformly high temperature of the tropics can stimulate sexual activity, accelerate development of the gonad, hasten maturity and shorten the free swimming larval period. These contribute towards the production of several spawning in a single year leading to an almost continuous settlement of borers which bring about speedy destruction of timber. Similarly the period of free swimming of larvae and growth rates may also be influenced by temperature.

Salinity is another important factor controlling the distribution and abundance of organisms by influencing the density of the medium. In tropics, in the estuaries and in other similar localities salinity varies between almost fresh water to 35ppt. During the dry months the water in the estuaries is as saline as that of sea whereas during the monsoon period salinity falls to almost freshwater condition. This restricts the occurrence of stenohaline species in these estuaries. Diverse responses are exhibited by the various groups of borers to this changing environment.

The reactions of molluscan borers to different salinities vary widely. Some species can tolerate only high salinities, others can tolerate a fairly wide range of salinities while a few are capable of enduring very low salinities. Further, the salinity tolerance of the same species may vary according to the geographical location depending on the prevailing temperature and may even vary in the same locality during the different seasons of the year. This is due to the existence of a complex correlation between the biological effects of temperature and salinity, the former having the ability to modify the effects of the latter and change the salinity range of an organism (Kinne 1963).

Nagabhushanam (1962) reported that *B. campanellata* occurs in Visakhapatnam in areas where the salinity ranges between 21 and 34ppt., with a decreasing trend in decreasing salinity. The genus *Nausitora* is generally confined to brackish water with stray occurrence in marine habitats (Nagabhushanam 1960, Nair 1954). In *N. hedleyi* a majority of adults are typically euryhaline capable of enduring a wide range of salinities (0.65-33.68ppt.) but the breeding is apparently restricted to the low saline period (Nair and Saraswathy 1971). In the case of *M. striata*, the adults and larvae can tolerate a fairly wide range of salinity 9ppt. to 30ppt. (Nagabhushanam 1961). Most species of shipworms require normal marine conditions for successful spawning but the adults may withstand unfavourable conditions by closing the burrow with the pallets. They are also able to utilize the stored glycogen under anaerobic conditions.

The responses of sphaeromatids and limnoriids also vary to different salinities. In the case of *S. terebrans* and *S. annandalei* they are abundant all over the backwaters from the bar mouth to the region of almost fresh water area. *S. triste* has so far been collected only in the open sea. *S. walkeri* is predominantly marine but stray occurrence of it has been reported from estuaries. No species of sphaeromatids have, however, been collected from any water mass totally unconnected with the sea (Pillai 1961; Dharmaraj and Nair 1979, 1981a).

Limnoriid borers are found only in marine habitat because low salinity appears to be an important factor governing their distribution (Menzies 1957).

The rate of water flowing over them is of considerable significance in the distribution of sessile invertebrates. The effects of water currents upon the rate of settling of *T. furcifera*, *B. campanellata* and *Martesia striata* have been studied by Nagabhushanam (1961a) at Visakhapatnam Harbour. He found that all these borers require some water current velocity for settling on timber, and that the settlement is more rapid in the flowing waters than in the still waters.

The turbidity of the water medium also affects the activity of the borers. Nair (1962a) has reported that both crustacean and molluscan borers are much less active where the water is highly turbid.

Pollution of the water medium can affect the organisms directly or they may influence the water, for instance its oxygen content. Waters with heavy sewage pollution or which are influenced by hydrogen sulphide as in some backwaters of Kerala are comparatively free from wood-borers. Experiments were conducted by Cheriyan (1967) using timber test panels of mango immersed in retting ground water as well as in an area free from the influence of retting. Panels immersed at the retting ground remained unattacked by borers for 16 months whereas those in the other area were totally destroyed within 3 months. Smell of hydrogen sulphide is noticed in the retting grounds. A detailed study of the ingredients of the retting grounds would perhaps help to protect the under water wooden structures from wood-borers. The pollution of harbour waters is unfavourable for borer activity. This is evident from the observations of Nair (1962a) who found that the activity of mat-forming fouling organisms over timber structures in areas with sewage pollution is beneficial since these organisms form a protective cover against the settlement and penetration of borers.

Dense fouling accumulations over under water surfaces can effectively inhibit the attack by both crustacean and molluscan borers. Of the different groups of fouling organisms, the barnacles and other mat-forming organisms are the most effective agents hindering attachment of borer larvae (Nair and Saraswathy 1971). Nagabhushanam (1960a) found that fouling has profound effect on the attack of marine borers, fouled blocks showing as low as one ninth of the attack noticed on clean blocks.

Conclusion

The occurrence, abundance and activity of the borers show remarkable variations and fluctuations in the different harbours of India, each having its own assemblage of marine fouling and wood-boring forms. It is well known that reactions of closely allied species may be different and even individuals of the same species may vary according to the peculiar hydrographic conditions prevailing in an area. It is noteworthy that each species has its characteristic preferences, distinctive life history and seasons of settlement. Generalisations should, therefore be made with great caution and a scheme evolved after elaborate study and experimentation for one locality may prove inapplicable for another. Species density has fluctuated over long periods and within the same period their attacks have differed considerably in various locations along the same stretch of coast (Becker 1958). So the problem varies with the species occurring in any locality and also with climatic and hydrographic conditions. The vagaries and discriminations of these pests are such that most of the conclusions drawn from any investigation must usually be considered as purely of local application and the experience gained from one locality cannot necessarily be applied to another. Each harbour or geographical location needs a special set of conservative measures owing to the difference in the species of borers prevalent, the condition of the water, degree of pollution etc.

TABLE 1
The nature of distribution of shipworms along the coasts of India

Sl. No.	Name of species	West Bengal	Orissa	Andhra Pradesh	Tamil Nadu	Andaman & Nicobar Islands	Lakshadweep	Kerala	Karnataka and Goa	Maharashtra	Gujarat
1.	<i>Bactronophorus thoracites</i> (Gould)	+	+	+	+	+	-	-	+	+	-
2.	<i>Neoteredo reynei</i> (Bartsch)	-	-	-	-	+	-	-	-	-	-
3.	<i>Dicyathifer manni</i> (Wright)	+	+	+	+	+	-	+	+	+	+
4.	<i>Teredothyra excavata</i> (jeffreys)	-	-	-	+	-	+	-	+	-	-
5.	<i>Teredothyra matocotana</i> (Bartsch)	-	-	-	-	-	-	-	-	-	+
6.	<i>Teredothyra smithi</i> (Bartsch)	-	-	-	+	-	+	+	+	-	+
7.	<i>Teredora palauensis</i> (Edmondson)	-	-	-	-	-	+	-	-	-	-
8.	<i>Teredora princesae</i> (Sivickis)	-	+	-	+	-	+	+	+	-	-
9.	<i>Uperotus clavus</i> (Gmelin)	-	-	+	+		+	-	-	-	-
10.	<i>Uperotus rehderi</i> (Nair)	-	-	-	+	+	+	-	-	-	-
11.	<i>Psiloteredo senegalensis</i> (Blainville)	-	-	-	-	-	+	-	-	-	-
12.	<i>Teredo aegypos</i> Moll	-	-	-	-	-	+	-	-	-	-
13.	<i>Teredo clappi</i> Bartsch	-	+	+	+	-	+	+	-	+	+
14.	<i>Teredo bartschi</i> Clapp (<i>T. fragilis</i> Tate)	-	-	+	+	-	-	-	-	-	-
15.	<i>Teredo fulleri</i> Clapp	-	-	-	+	-	+	+		+	+
16.	<i>Teredo furcifera</i> Martens	-	-	+	+	+	+	+	+	+	+
17.	<i>Teredo somersi</i> Clapp	-	-	-	-	-	+	-	-	-	-
18.	<i>Teredo triangularis</i> Edmondson	-	-	+	+	-	+	-	-	-	-
19.	<i>Teredo mindanensis</i> bartsch	-	-	-	-	-	+	-	-	-	-

20. <i>Teredo portoricensis?</i> Clapp.	-	-	-	-	-	+	-	-	-	-
21. <i>Lyrodus triste</i> (Iredale)	-	-	-	+	-	-	+	+	-	-
22. <i>Lyrodus mediolobata</i> (Roch)	-	-	-	-	-	-	-	-	-	+
23. <i>Lyrodus affinis</i> (Deshayes)	-	-	+	+	-	-	-	-	-	-
24. <i>Lyrodus massa</i> (Lamy)	-	-	+	+	-	+	+	+	-	-
25. <i>Lyrodus pedicellatus</i> (Quatrefages)	-	+	+	+	+	+	+	+	+	+
26. <i>Nototeredo edax</i> (Hedley)	-	-	+	+	+	-	-	-	+	+
27. <i>Nototeredo knoxi</i> (Bartsch)	-	+	-	-	-	-	-	-	-	-
28. <i>Spathoteredo obtusa</i> (Sivickis)	-	-	-	-	+	-	+	-	-	-
29. <i>Nausitora globosa</i> (Sivickis)	-	-	-	-	-	-	+	-	-	-
30. <i>Nausitora dunlopei</i> wright	+	+	+	+	+	-	+	+	-	-
31. <i>Nausitora fusticula</i> (Jeffreys)	-	+	-	-	-	-	-	-	-	-
32. <i>Nausitora hedleyi</i> Schepman	-	+	-	+	+	-	+	+	+	+
33. <i>Nausitora oahuensis</i> (Edmondson)	-	-	-	-	-	-	+	-	-	-
34. <i>Bankia bipalmulata</i> (Lamarck)	-	-	-	+	+	-	-	-	-	-
35. <i>Bankia bipennata</i> (Turton)	-	-	+	+	+	-	-	-	-	-
36. <i>Bankia campanellata</i> Moll and Roch	+	+	+	+	+	+	+	+	+	+
37. <i>Bankia carinata</i> (Gray)	+	+	+	+	-	+	+	+	+	+
38. <i>Bankia fimbriatula</i> Moll and Roch	-	+	-	-	-	-	-	-	-	-
39. <i>Bankia nordi</i> Moll	+	-	-	+	-	-	-	-	+	-
40. <i>Bankia rochi</i> Moll	+	+	+	-	+	-	+	+	+	-

+ present

- not recorded

TABLE 2
Distribution of wood boring pholads along the coasts of India

Name of species	West Bengal	Orissa	Andhra Pradesh	Tamil Nadu	Andaman & Nicobar Islands	Laksha- dweep	Kerala	Karnataka and Goa	Mahara- shtra	Gujarat
<i>Martesia striata</i> (Linnaeus)	+	+	+	+	+	+	+	+	+	+
<i>Martesia fragilis</i> Verrill and Bush	-	-	-	+	+	+	+	-	-	-
<i>Martesia (Particoma) nairi</i> Turner & Santhakumar	-	-	-	+	-	-	+	+	-	-
<i>Pholas chiloensis</i> Molina	-	-	-	-	-	+	-	-	-	-
<i>Barnea birmanica</i> Philippi	-	-	-	+	-	-	-	-	-	-
<i>Barnea manillensis</i> Philippi	-	-	-	-	-	-	+	-	-	-
<i>Xylophaga</i> sp.	-	+	-	-	-	-	-	-	-	-
<i>Lignopholas fluminalis</i> (Blanford)	-	-	-	-	-	-	+	-	-	-

+ present - not recorded

TABLE 3
Distribution of crustacean woodborers along the coasts of the various maritime states in India

Name of Species	West Bengal	Orissa	Andhra Pradesh	Tamil Nadu	Andaman & Nicobar Islands	Laksha- dweep	Kerala	Karnataka and Goa	Mahara- shtra	Gujarat
<i>Sphaeroma terebrans</i> Bate	-	-	+	+	+	-	+	+	+	+
<i>Sphaeroma annandalei</i> Stebbing	-	-	+	+	-	-	+	+	+	+
<i>Sphaeroma annandalei travencorensis</i> Pillai	-	-	-	-	-	-	+	+	-	-
<i>Sphaeroma tuberculatum</i> George	-	-	-	+	-	-	-	-	-	-
<i>Sphaeroma walkeri</i> Stebbing	-	-	+	+	-	+	+	-	+	-
<i>Sphaeroma triste</i> Heller	-	-	-	+	+	+	-	-	-	-
<i>Limnoria indica</i> Becker and Kampf	-	-	-	+	+	+	-	-	+	-
<i>Limnoria septima</i> Barnard	-	-	-	-	+	-	-	-	-	-
<i>Limnoria tripunctata</i> Menzies	-	-	-	+	-	-	-	-	-	-
<i>Limnoria bombayensis</i> Pillai	-	-	-	-	-	+	-	-	+	-
<i>Limnoria pfefferi</i> Stebbing	-	-	-	+	+	+	-	-	-	-
<i>Limnoria unicornis</i> Menzies	-	-	-	-	+	-	-	-	-	-
<i>Limnoria platycauda</i> Menzies	-	-	-	-	+	-	-	-	-	-
<i>Limnoria andamanesis</i> Rao and Ganapathi	-	-	-	-	+	-	-	-	-	-
<i>Limnoria insulae</i> Menzies	-	-	-	-	+	-	-	-	-	-

+ present - not recorded

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P L A T E S

PLATE I

A. *Bactronophorus thoracites* (Gould)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

(From Turner 1966)

B. *Neoteredo reynel* (Bartsch)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

(From Turner 1966)

C. *Dicyathifer manni* (Wright)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

D. *Teredothyra excavata* (Jeffreys)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

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PLATE I

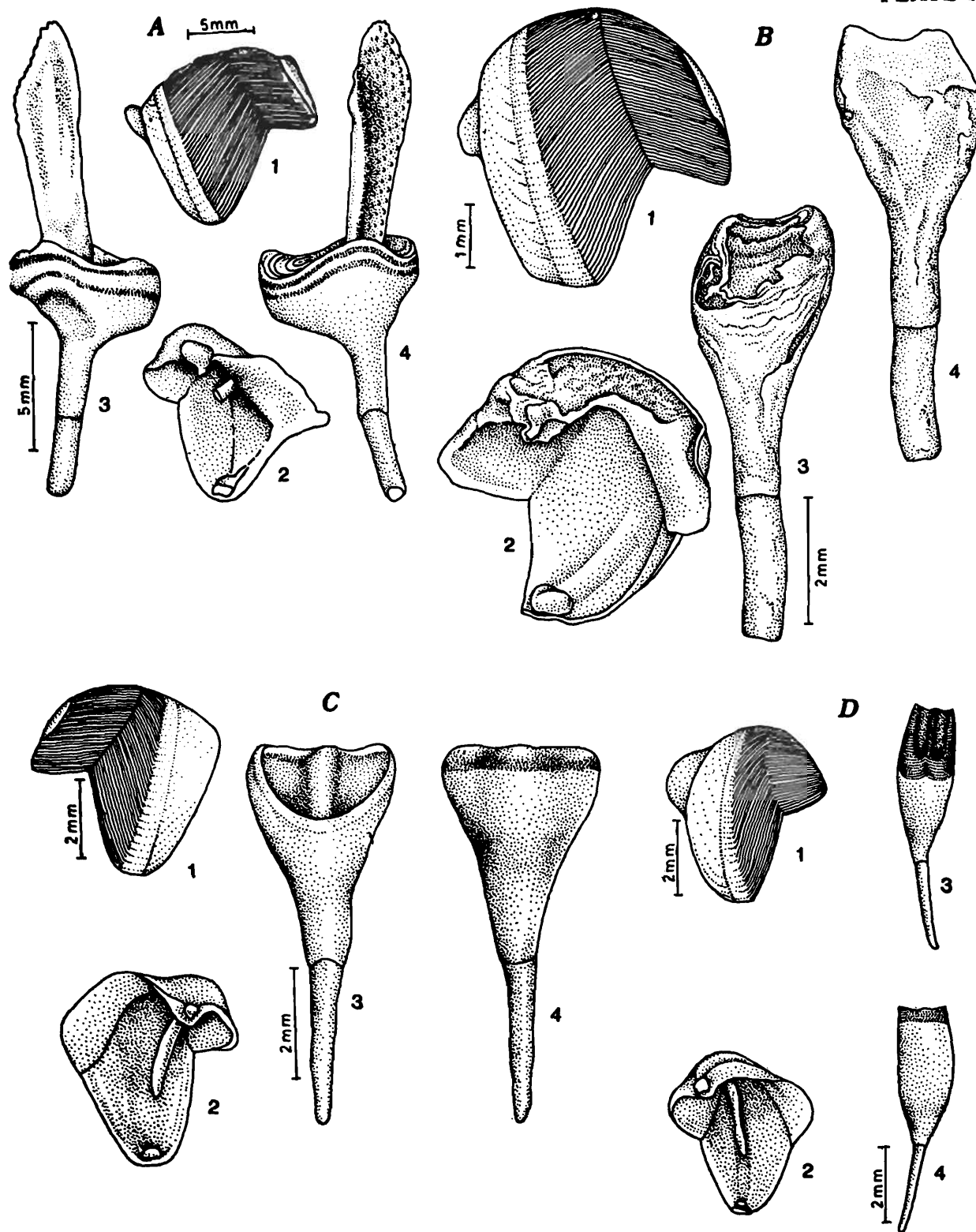


PLATE II

A. *Teredothyra smithi* (Bartsch)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

B. *Teredora palauensis* (Edmondson)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

C. *Teredora prineesae* (Siviekis)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

D. *Uperotus clavus* (Gmelin)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

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PLATE II

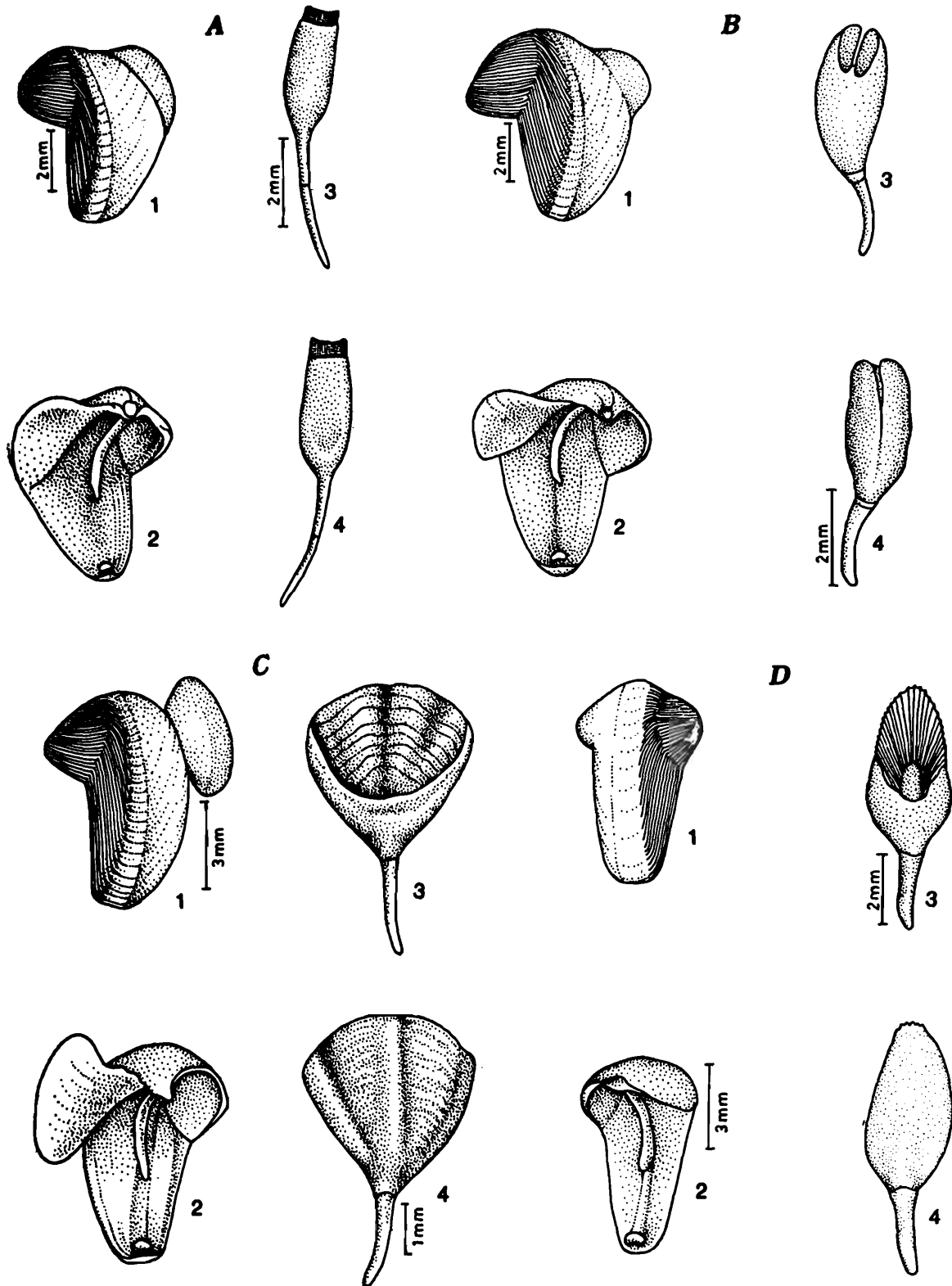


PLATE III

A. *Uperotus rehderi* (Nair)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

B. *Psiloteredo senegalensis* (Blainville)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

C. *Teredo aegypos* Moll

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

D. *Teredo bartschi* Clapp

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

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PLATE III

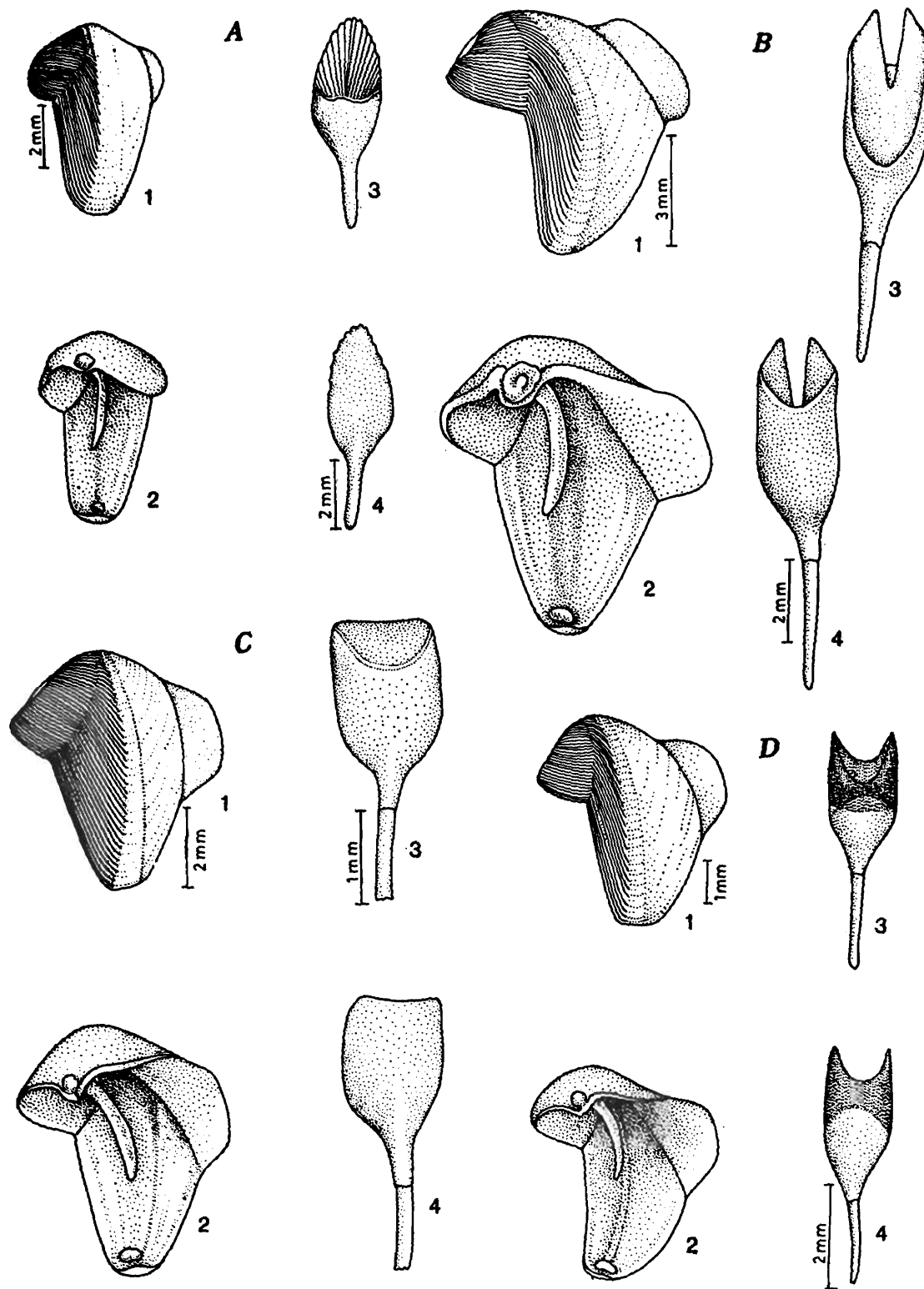


PLATE IV

A. *Teredo clappi* Bartsch

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

B. *Teredo fulleri* Clapp

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

C. *Teredo furcifera* von Martens

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

D. *Teredo mindanensis* Bartsch

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

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PLATE IV

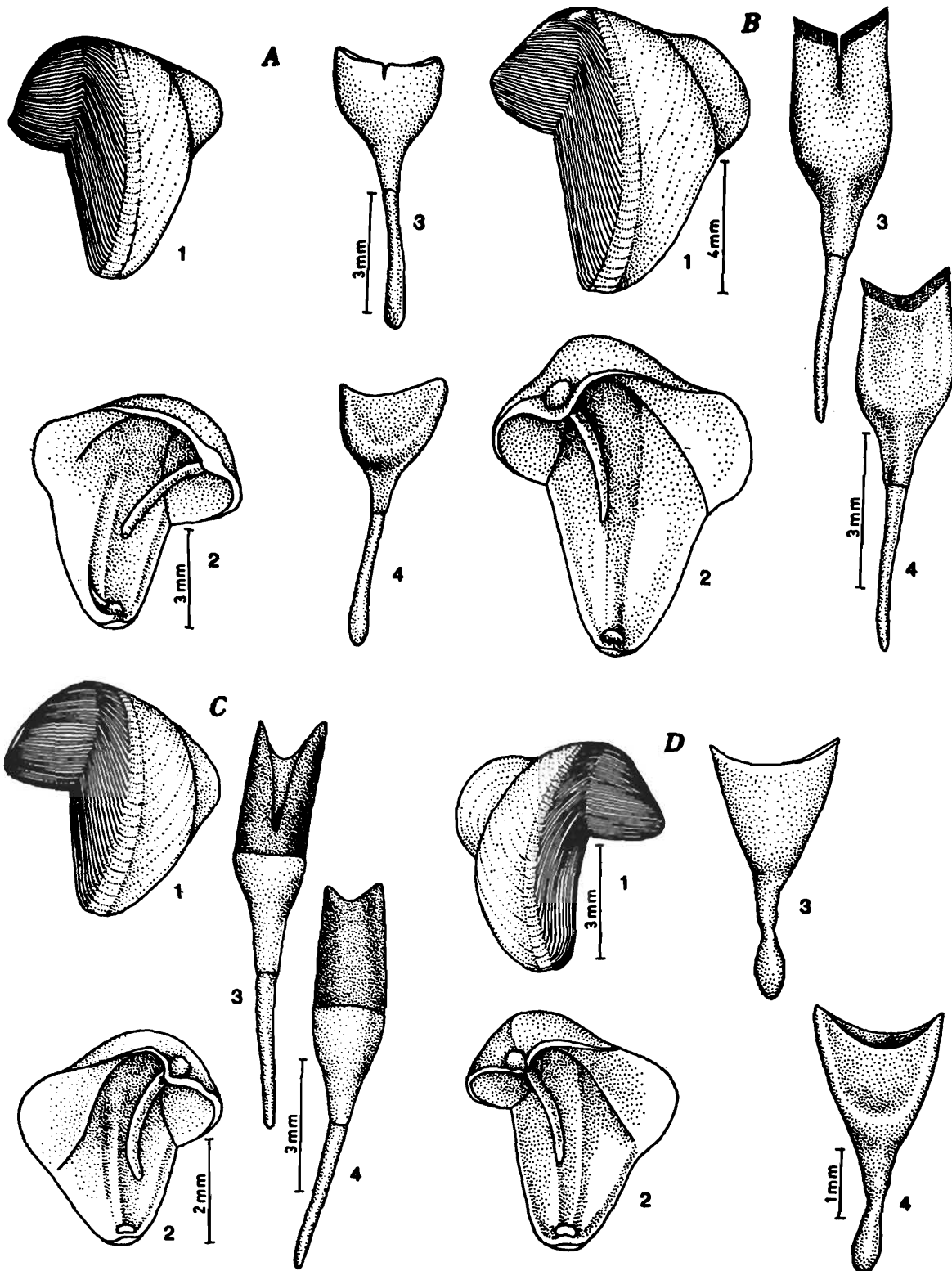


PLATE V

A. *Teredo portoricensis* Clapp

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

B. *Teredo triangularis* Edmondson

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

C. *Teredo somersi* Clapp

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

D. *Lyrodus massa* (Lany)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

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PLATE V

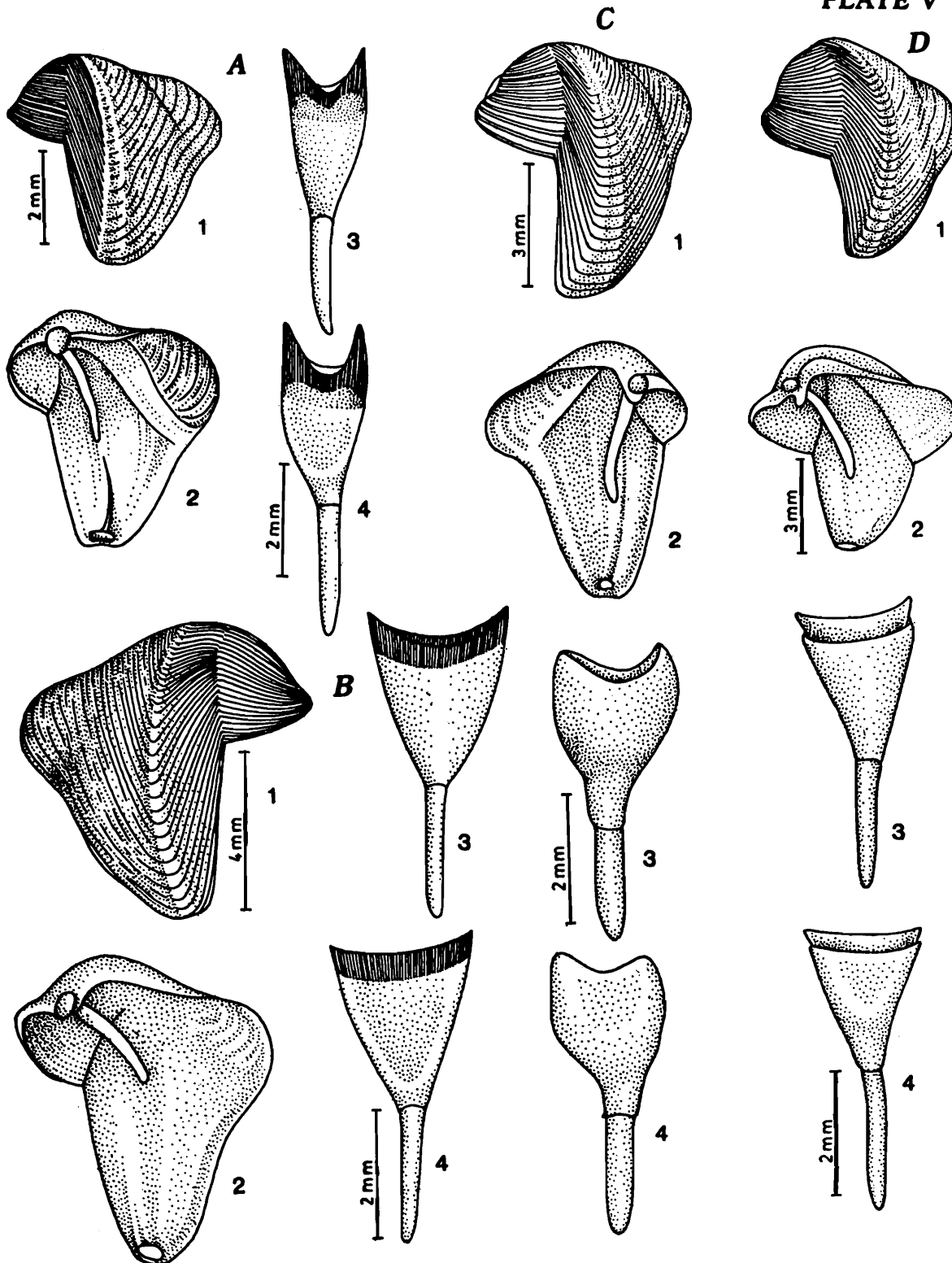


PLATE VI

A. *Lyrodus pedicallatus* (Quatrefages)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

B. *Nototeredo edax* (Hedley)

- Fig. 1 Outer view of shell
 - Fig. 2 Inner view of shell
 - Fig. 3 Outer face of pallet
 - Fig. 4 Inner face of pallet
- (From Turner 1966)

C. *Spathoteredo obtusa* (Siviekis)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

D. *Nausitora dunlopei* Wright

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

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PLATE VI

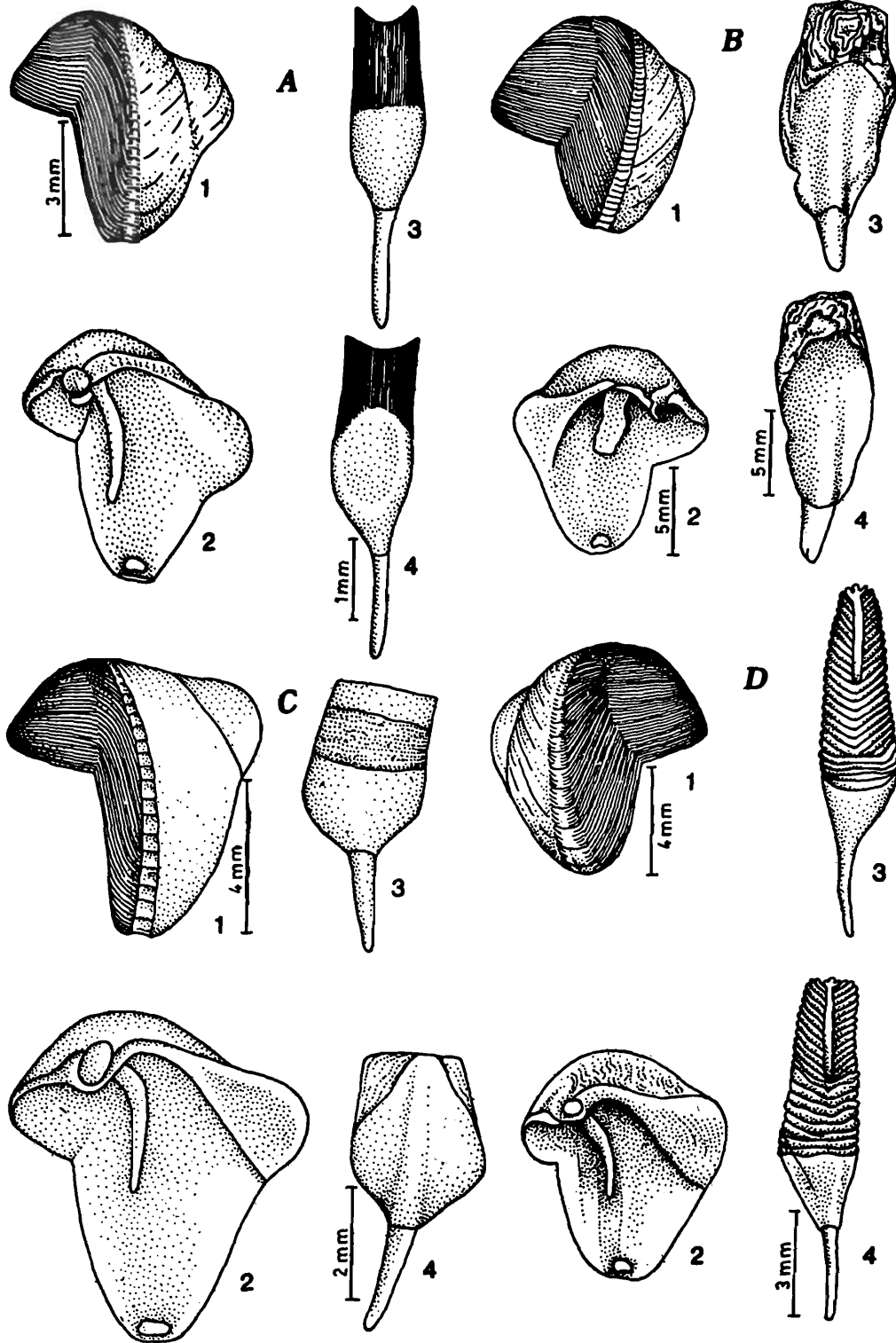


PLATE VII

A *Nausltora hedleyi* Schepman

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

B. *Bankia bipalmulata* (Lamarck)

- Fig. 1 Outer face of pallet
- Fig. 2 Inner face of pallet
(From Turner 1966)

C. *Bankia bipennata* (Turton)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Inner face of pallet
- Fig. 4 Inner face of cones enlarged
- Fig. 5 Outer view of cones enlarged
(From Nair 1955)

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PLATE VII

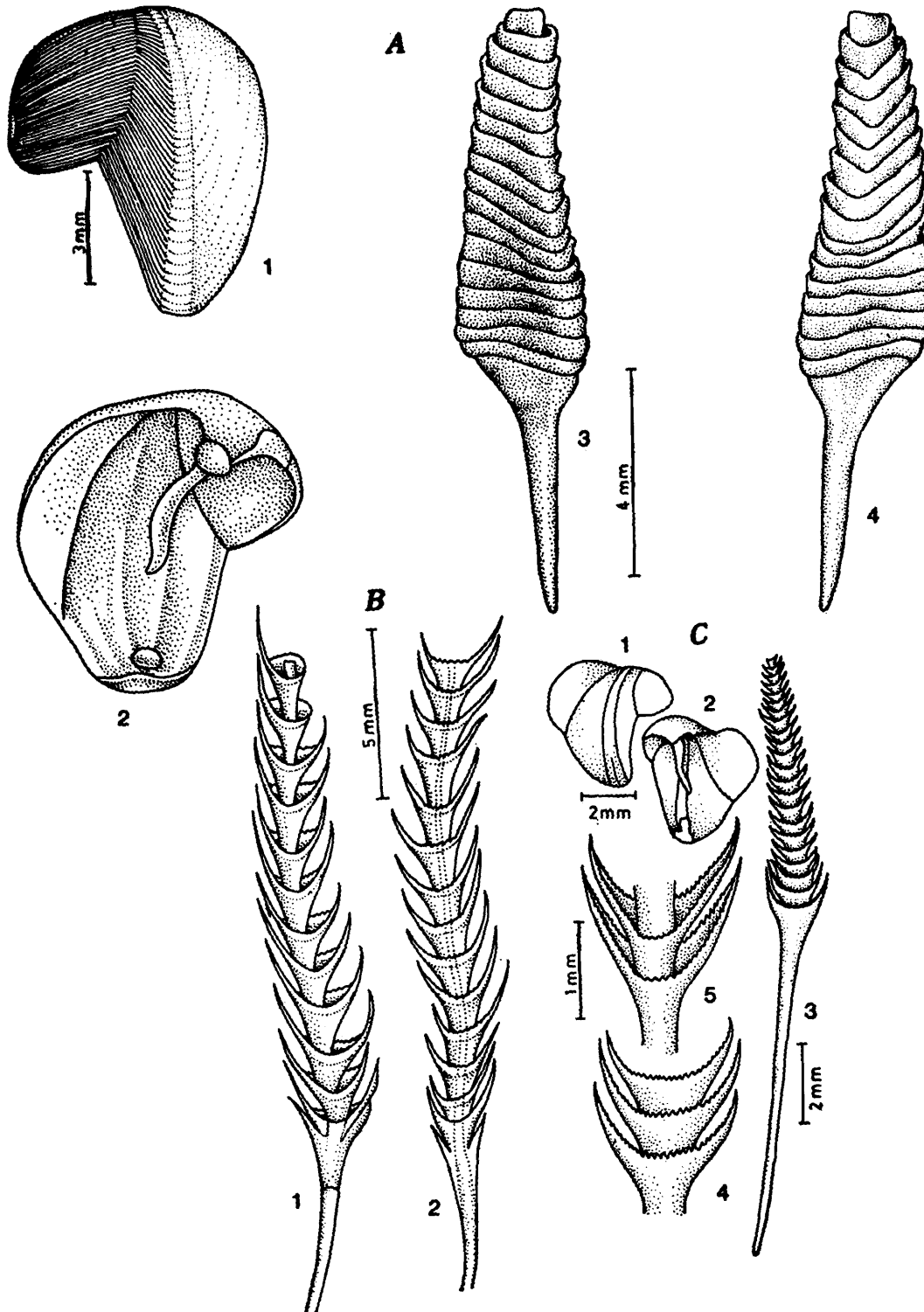


PLATE VIII

A. *Bankia campanellata* Moll and Roch

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

B. *Bankia carinata* (Gray)

- Fig. 1 Outer view of shell
- Fig. 2 Inner view of shell
- Fig. 3 Outer face of pallet
- Fig. 4 Inner face of pallet

C. *Bankia rochi* Moll

- Fig. 1 Outer view of shell
 - Fig. 2 Inner view of shell
 - Fig. 3 Outer face of pallet
 - Fig. 4 Inner face of conc enlarged
 - Fig. 5 Outer face of a conc enlarged
- (From Turner 1966)

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PLATE VIII

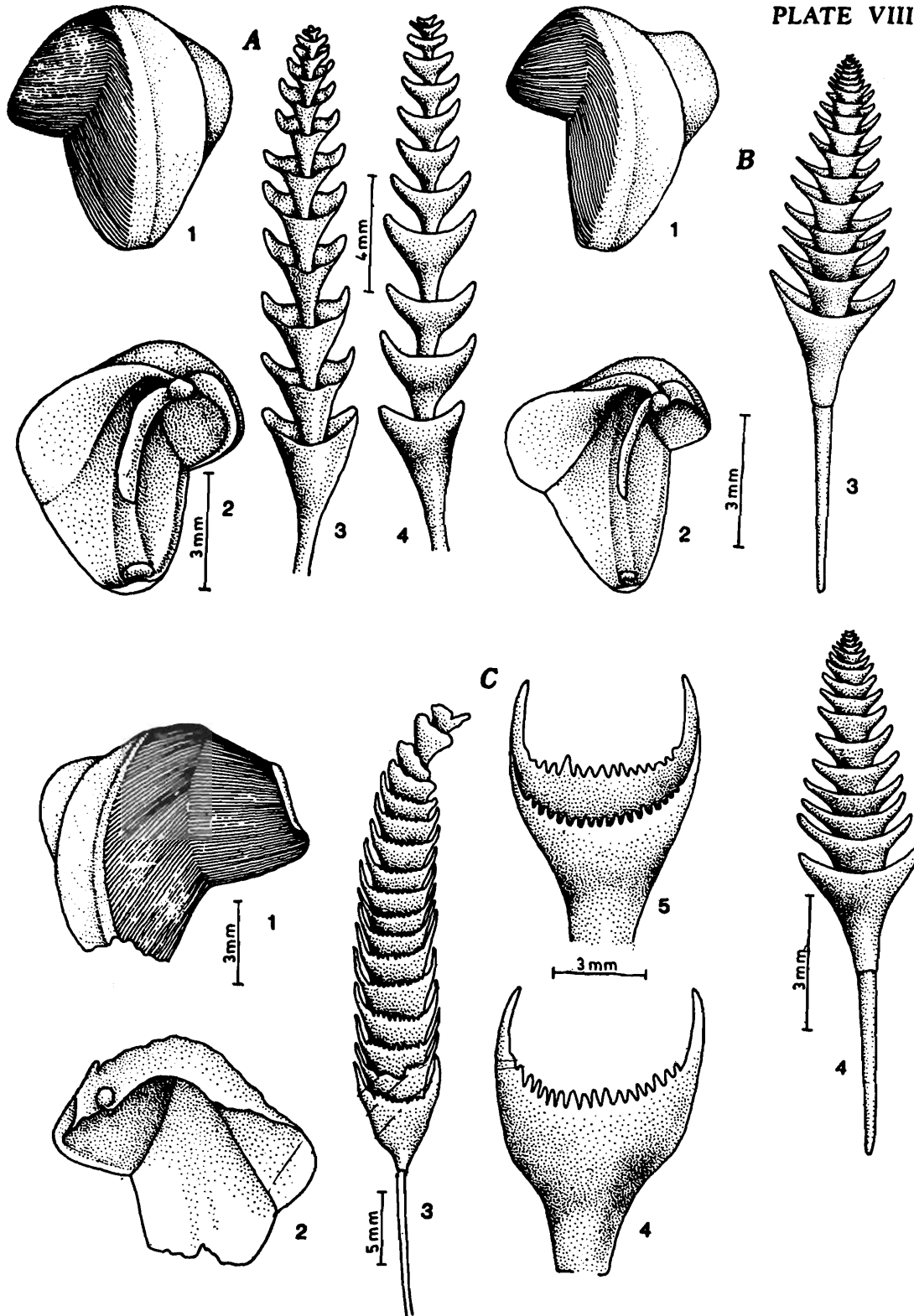


PLATE IX

A. *Pholas chiloensis* Molina

- Fig. 1 Outer view of left shell valve
- Fig. 2 Inner view of right shell view
- Fig. 3 Dorsal view of protoplax
- Fig. 4 Dorsal view of mesoplax
- Fig. 5 Dorsal view of metaplax

B. *Martesia fragilis* Verrill and Bush

- Fig. 1 Dorsal view of an entire specimen
- Fig. 2 Lateral view
- Fig. 3 Dorsal view of mesoplax
- Fig. 4 Ventral view of mesoplax
- Fig. 5 Lateral view of mesoplax

C. *Martesia striata* (Linnaeus)

- Fig. 1 Dorsal view of entire specimen
- Fig. 2 Lateral view of entire specimen
- Fig. 3 Dorsal view of mesoplax
- Fig. 4 Ventral view of mesoplax
- Fig. 5 Lateral view of mesoplax

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PLATE IX

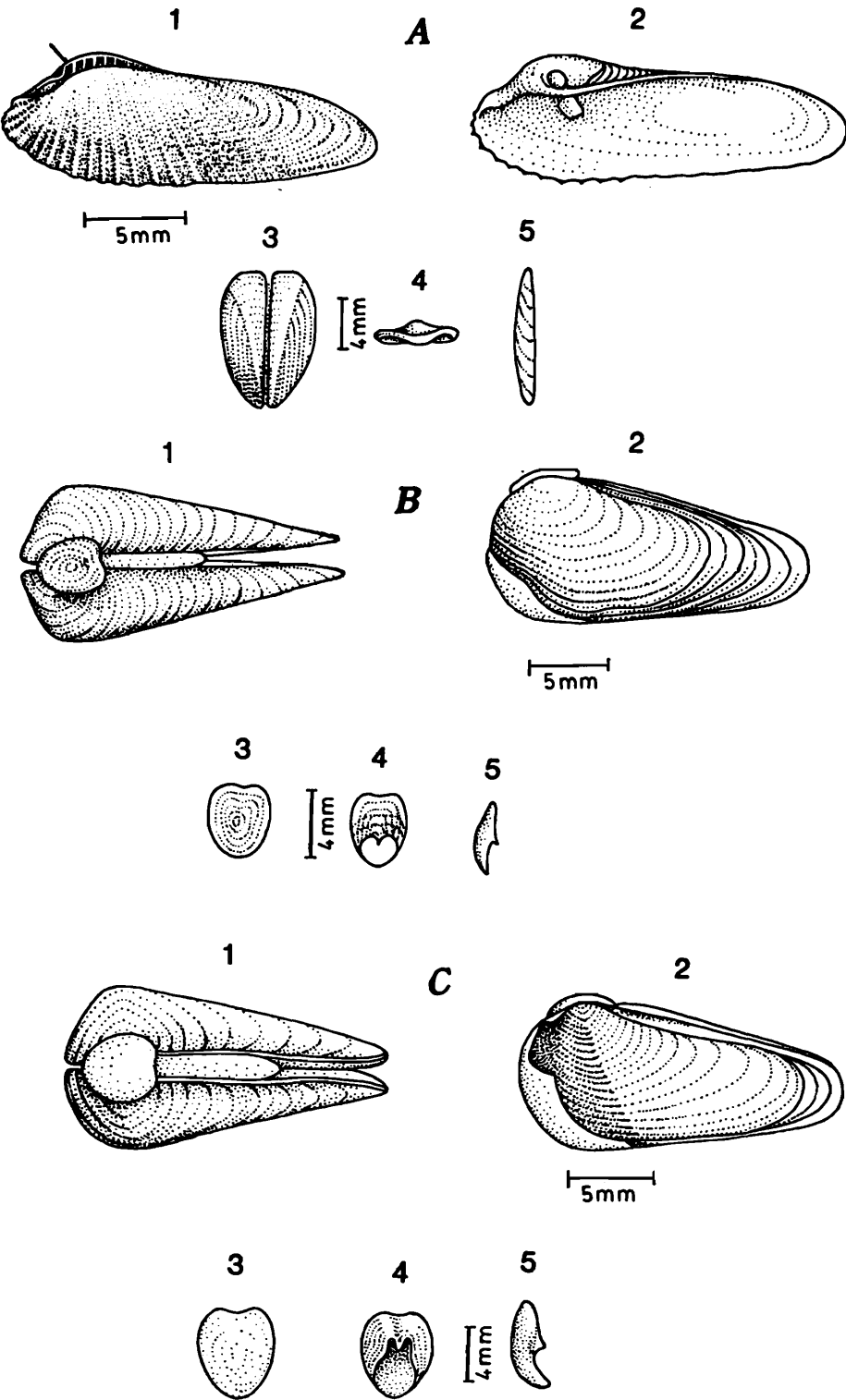


PLATE X

- Fig. 1 *Sphaeroma annandalci* Stebbing—dorsal view of pleotelson.
- Fig. 2 *Sphaeroma terebrans* Bate—dorsal view of pleotelson.
- Fig. 3 *Sphaeroma triste* Heller—dorsal view of pleotelson.
- Fig. 4 *Sphaeroma walkeri* Stebbing—dorsal view of pleotelson.
- Fig. 5 *Limnoria andamanensis* Rao and Ganapati—dorsal view of pleotelson (From Rao & Ganapathi 1969).
- Fig. 6 *Limnoria bombayensis* Pillai—dorsal view of pleotelson.
- Fig. 7 *Limnoria indica* Becker and Kampf—dorsal view of pleotelson of female.
- Fig. 8 *Limnoria indica* Becker and Kampf—dorsal view of pleotelson of male.
- Fig. 9 *Limnoria insulae* Menzies—dorsal view of pleotelson.
- Fig. 10 *Limnoria pfefferi* Stebbing—dorsal view of pleotelson.
- Fig. 11 *Limnoria platyeuda* Menzies—dorsal view of pleotelson.
- Fig. 12 *Limnoria septima* Barnard—dorsal view of pleotelson.
- Fig. 13 *Limnoria unicornis* Menzies—dorsal view of pleotelson.

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PLATE X

