ON THE SUBFAMILY XYLOPHAGAINAE (FAMILY PHOLADIDAE, BIVALVIA, MOLLUSCA)

RUTH D. TURNER[1]

CONTENTS

Editorial Note. Professor *Emerita* Ruth Dixon Turner died on 30 April 2000 and was for the last several months of her life severely disabled; in fact, her active work as a researcher was considerably foreshortened by medical problems beginning in about 1995. Among her *Nachgelassene Werke* was an important manuscript on the systematics of the deep-sea pholadid bivalve genera *Xylophaga, Xyloredo,* and *Xylopholas,* a manuscript that she had been preparing for a number of years and one that had the active support of the U.S. Department of Defense's, then, Office of Naval Research (ONR). Professor Turner was unquestionably a leading world authority on these taxa and had posted this document, in its preliminary draft form, on a Web site; after her retirement and the beginning of the illnesses that plagued her, the manuscript was removed from the Web site with the intent of readying it for formal publication. Two outside authorities, Dr. Jorgen Knudsen of the Zoologisk Museum, Københavns Universitet, København, Denmark, and Dr. K. Elaine Hoagland, then at the Association for Systematic Collections, Washington, D.C., were solicited to make criticisms, and these, along with my own, were incorporated into a more advanced revision of the text prepared by Ms. Helene Ferranti, a long time coworker and associate of Professor Turner. Ms. Ferranti agreed to revise this *Nachlass* in accordance with the comments of the reviewers and to update its content and organization. Having collaborated with Professor Turner on the subject of deep-sea bivalves, Ms. Ferranti is credited herein as the person responsible for the final completion and revision of this valuable text. The new species described, for which specimens are available for study in the Museum of Comparative Zoology (MCZ), and the taxonomic suggestions incorporated into the text are to be credited to Professor Turner.

Kenneth J. Boss
Editor

Abstract. The provisional grouping of the species of the bivalve genus *Xylophaga* suggested by Turner and Culliney is further elaborated, with 37 species assigned to six groups depending on characteristics of

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the mesoplax, siphons, muscle scars, and method of reproduction. Three cases of variation in species of *Xylophaga* are discussed: variation in response to different substrates, variation that possibly is genetic, and variation in a normal growth series. Some observations are made regarding the ecology of deep-sea wood borers based on experiments carried out with wood panels; these support the hypothesis that wood contributes to the growth and diversity of deep-sea organisms and that the Xylophagainae contribute significantly to the food chain by converting wood to a usable form. A section on systematics considers 19 species of *Xylophaga*, of which 7 are new, as well as the monospecific genus *Xylopholas* and three species of *Xyloredo*. Detailed descriptions are given of new species.

INTRODUCTION

The Xylophagainae, a subfamily of the Pholadidae, is composed of the genera *Xylophaga* Turton, 1822, *Xyloredo* Turner, 1972, and *Xylopholas* Turner, 1972. Species in the genus *Xylophaga* range in depth from just below low tide (*X. dorsalis* Turton) to depths of 7,000 m (*X. grevei* Knudson), whereas species in *Xyloredo* and *Xylopholas* are restricted to the deep sea (depths of 239 to more than 2,000 m). Species in *Xyloredo* range in depth from 1,737 to more than 2,000 m (*X. nooi* Turner, 1972) and species in *Xylopholas* range from 239 to 366 m (*X. altenai* Turner, 1972), with one lot dredged in 2,550 m off Port Victoria, São Tomé, Gulf of Guinea. However, the São Tomé specimens were boring in coconut shells and may not have been living at that depth.

The Xylophagainae are marine, cosmopolitan, and range from moderate to abyssal depths. All of the Xylophagainae, so far as known, are wood borers, and all are sublittoral. Only in high latitudes do they compete with shipworms (Teredinidae) in cold boreal waters. So far as known, the Xylophagainae do not occur intertidally, or in floating wood. Wood containing specimens of the Xylophagainae usually has been obtained by dredging. Occasionally, specimens may be obtained from waterlogged wood that has been brought up and thrown ashore during a storm after being on the bottom for some time.

Until recently, the Xylophagainae were considered to be deep-sea organisms of little or no economic importance. They were rare curiosities, of interest mostly in their role of recycling wood on the continental shelf and slope and in the abyss, largely beyond the depth range of the teredinids. The Xylophagainae often were referred to as shipworms and because of the ephemeral, patchy distribution of wood in the deep sea were thought to have little impact on ecological processes. With the extension of human activities into the deep sea for fishing (especially trap fishing for lobsters and crabs), as well as for archaeology, mining, monitoring currents, and other activities, these borers are now generally considered to be pests.

Species in the genus *Xylophaga* (*Xylo* = wood, *phaga* = eating) are restricted to wood, woody plants, and structures made of wood found in the deep sea. In common with the teredinids (shipworms), they have symbiotic bacteria in their gills (Waterbury et al., 1983). These bacteria are believed to have the ability to digest cellulose and probably to fix nitrogen. Collaborative work with Dr. Waterbury, microbiologist at Woods Hole Oceanographic Institute, was unable to culture cellulose-digesting bacteria from the gills of *X. atlantica,* but evidence was found of cellulose enzymes in the gill tissue.

The three genera of Xylophagainae may be briefly characterized as follows:

Genus *Xylophaga* Turton. Siphons relatively short, of equal length or with the excurrent siphon truncated, and often capable of retraction between the valves. Burrow seldom more than five times the length of the valves and often with a chimney of fecal pellets lining the posterior end of the burrow.

Genus *Xylopholas* Turner. Shell typical but with the animal extended and with lateral plates on the siphons.

Genus *Xyloredo* Turner. Shell typical but animal elongated and producing a teredinidlike burrow that is lined with a calcareous tube marked with distinct growth rings and margined anteriorly with a periostracal band.

The Xylophagainae are often confused with teredinids, but the gills and digestive and reproductive organs in the Xylophagainae do not extend posteriorly beyond the valves. In addition, the Xylophagainae do not have pallets to close the entrance to their burrows or apophyses for the attachment of the foot muscles. In common with the teredinids, but unlike species in the pholadid genera *Martesia* and *Lignopholas,* the only other genera of wood-boring pholadids, the Xylophagainae have a large wood-storing cecum and probably utilize the wood in which they bore as food. For details of anatomy, see Purchon (1941) for *Xylophaga dorsalis* Turton, and Turner (1955) for *X. atlantica.*

SPECIES GROUPS IN THE GENUS *XYLOPHAGA*

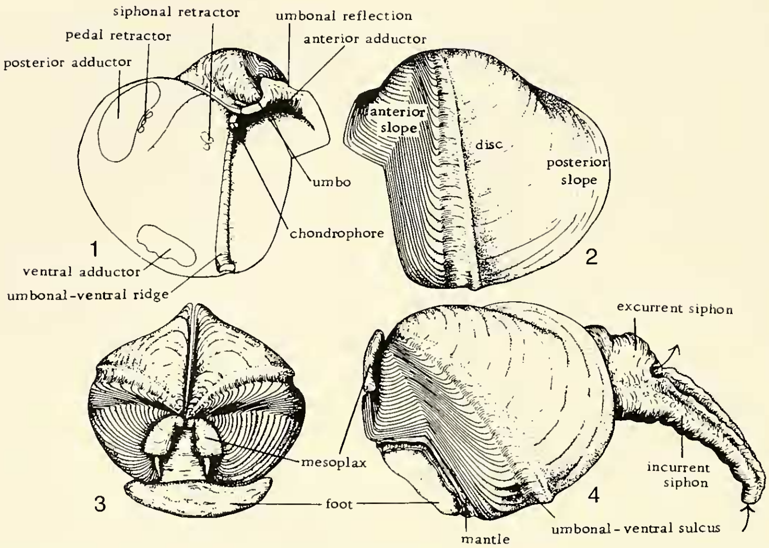
Genus *Xylophaga* Turton. *Xylophaga* Turton, 1822, Conchylia Insularum Britanicarum, p. 253 (type species, *Teredo dorsalis* Turton, 1819).

Species in this genus are characterized by teredolike shells that lack apophyses and have a divided mesoplax that is variable in shape and size. A chrondrophore and internal ligament are present. The siphons are variable, united for part or all of their length, with the excurrent siphon often truncated. The visceral mass and gills do not extend beyond the valves posteriorly. The wood-storing cecum is large.

In his discussion of the taxonomy of *Xylophaga,* Knudsen (1961) believed that the use of subgenera was not feasible and would only lead to the creation of a large number of monotypic subgenera that would be of limited value. This is still partially true but new species described in this report and the additional material now available concerning other species have made possible a provisional grouping of the species, as suggested by Turner and Culliney (1971). See also Hoagland and Turner (1981) and Hoagland (1983). This grouping is helpful when discussing relationships and geographic distribution. The characters used for grouping the species are those mainly of the mesoplax and siphons in conjunction with the muscle scars and methods of reproduction (see Text-Fig. 1). The mesoplax is a transverse plate, usually wider than long, that straddles the valves at the umbos and partially or completely covers the posterior end of the anterior adductor muscle. The mesoplax may be composed of one or two parts. The important character of the mesoplax is the presence or absence of a ventral portion and tubes; the more detailed characters, such as the presence of lobes, seem to be of specific value only. Siphonal characters include the relative length of the two siphons, the presence or absence of cirri at the apertures, and the type of siphonal folds, which may or may not have lappets or fringes.

Not all characters are known for all species and a few species seem to be transitional between groups. There is no question that more material is needed before definite statements can be made concerning the formal use of subgenera. However, the grouping of species as presented here does offer an opportunity to speculate on the possible origin and evolution of the genus and to focus attention on the types of information that should be considered in future studies. Comparative anatomical and molecular studies are greatly needed but it probably will be some time before these can be completed because well-preserved specimens of deep-sea *Xylophaga* are rare and difficult to obtain.

If we consider species with simple siphons of equal length and a mesoplax of two simple flat to slightly curved plates to be the basic type, it is possible to group the species in what appears to be a developmental series of six groups. This list does not include all nominal *Xylophaga.* The groups may be characterized as follows:



Text-Figure 1. Nomenclature of parts of *Xylophaga*. (1) Internal view of left valve showing relative position of muscle scars. (2) External view of left valve. (3) Dorsal view of animal with siphons retracted. (4) Lateral view of entire animal with siphons extended.

Group 1. Mesoplax composed of two simple flat or slightly curved plates located posterior to the anterior adductor muscle and standing erect. Siphons of equal length or with the excurrent siphon slightly shorter, cirri on one or both siphons present or absent. Group 1 includes *X. erecta* Knudsen, *X. concava* Knudsen, and *X. gerda* Turner n. sp.

Group 2. Mesoplax composed of two plates that may be curved, flat, sculptured, or smooth, set at an acute angle to each other, lack dorsal tubes and a ventral portion, but cover the anterior adductor muscle dorsally. Siphons of the same length or with the excurrent siphon slightly shorter and with large cirri on the sides of the excurrent siphon and small cirri at the incurrent siphon. Group 2 includes *X. grevei* Knudsen, *X. wolffi* Knudsen, *X. hadalis* Knudsen, *X. galatheae* Knudsen, *X. murrayi* Knudsen, *X. africana* Knudsen, *X. panamensis* Knudsen, and *X. clenchi* Turner and Culliney.

Group 3. Mesoplax composed of two nearly flat plates set at an acute angle to each other forming an inverted V, with tubes extending from the posterior dorsal surface or longitudinally folded with anterior lobes or pores. Mesoplax lacking a ventral portion and set in a tentlike fashion over the anterior adductor muscle. Siphons nearly the same length and usually with small cirri on both openings. Group 3 includes *X. supplicata* Taki and Habe, *X. lobata* Knudsen, *X. tubulata* Knudsen, *X. bruuni* Knudsen, *X. obtusata* Knudsen, *X. whoi* Turner n. sp., and *X. profunda* Turner n. sp.

Group 4. Mesoplax composed of two plates that have a small to large ventral portion, the dorsal portion being smooth, folded, or lobed. Siphons of the same length or with the excurrent siphon slightly shorter and with cirri or papillae at one or both openings. Group 4 includes *X. abyssorum* Dall, *X. duplicata* Knudsen, *X. muraokai* Turner n. sp., *X. foliata* Knudsen, and *X. atlantica* Richards.

Group 5. Mesoplax composed of two plates that are more or less triangular in outline, with a ventral portion ranging from very narrow to more than one half the width of the dorsal portion. The excurrent siphon may vary in length from one half to three quarters that of the incurrent siphon and have cirri, or it may be truncated just posterior to the valves and have dorsal lobes or folds extending from the truncation along the dorsal surface of the incurrent siphon for part or all of its length. Group 5 includes *X. washingtona* Bartsch, *X. rikuzenica* Taki and Habe, *X. aurita* Knudsen, *X. turnerae* Knudsen, and *X. praestans* E. A. Smith.

Group 6. Mesoplax composed of two more or less ear-shaped plates somewhat coiled posteriorly. Excurrent siphon truncated near the posterior end of the valves, continuing as lateral lobes extending from the truncation along the dorsal surface of the incurrent siphon. These lobes may vary in width but are always fringed. Group 6 includes *X. dorsalis* Turton, *X. depalmai* Turner n. sp., *X. guineensis* Knudsen, *X. mexicana* Dall, *X. tipperi* Turner n. sp., *X. bayeri* Turner n. sp., *X. globosa* Sowerby, *X. japonica* Taki and Habe, and *X. indica* Smith.

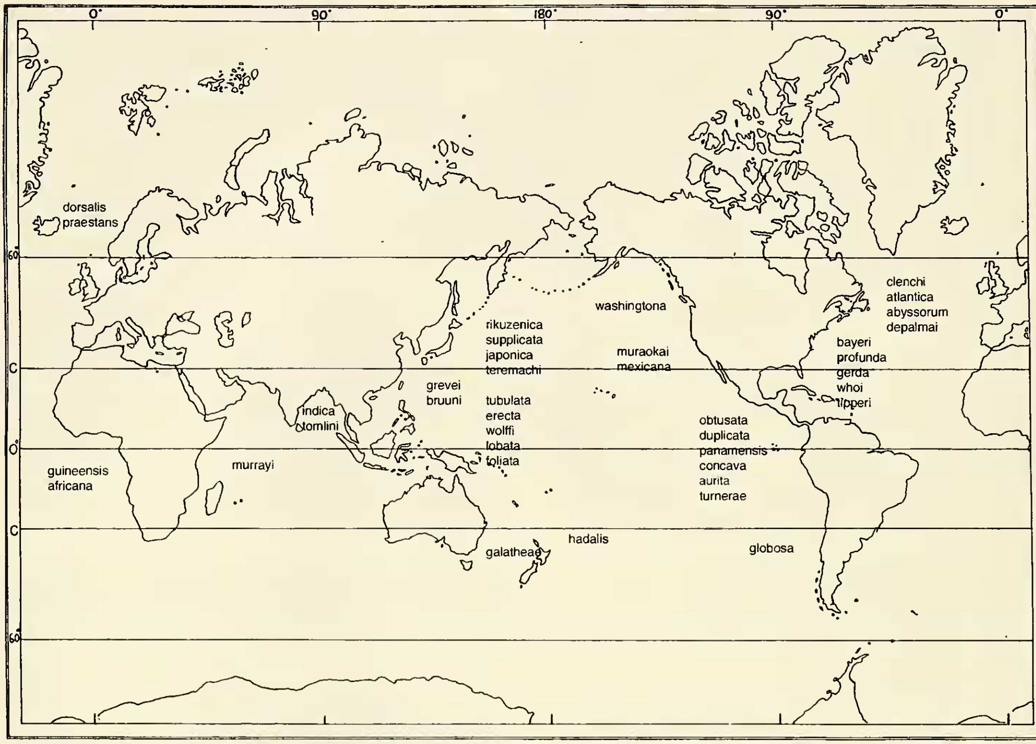
Most species are known only from the type series and these have all been studied by the author except *X. indica,* and the species described by Taki and Habe. However, paratype specimens received through the kindness of Dr. Habe are in the collection of the MCZ. They include *X. japonica, X. rikuzenica, X. teramachi,* and *X. supplicata,* although unfortunately all lack the mesoplax except the last. Two species, *X. teramachi* Taki and Habe (Taki and Habe, 1950) and *X. tomlini* Prashad (Prashad, 1932); are known only from the valves and remain unassigned. A map showing the distribution of species of *Xylophaga* is provided in Text-Figure 2.

Nineteen of the 37 species of *Xylophaga* listed in the groups above as well as the monospecific genus *Xylopholas* and the three species of *Xyloredo* are considered in the section on systematics. Some species are discussed more fully than others but the distinctive characters have been given for all. For example, *Xylophaga mexicana* Dall and *Xylophaga abyssorum* Dall are fully described because these names were based on valves only and were virtually *nomina dubia.* By matching the valves of the holotypes with complete specimens, it has been possible to fix the names of these species. If additional characters or records are given for a well-described species, a reference is made to the original description. Detailed descriptions are given for new species.

VARIATION

Knudsen (1961) aptly stated that very little was known about variation in species of *Xylophaga.* Unfortunately, large series of any one species seldom have been available for study because material usually is obtained from small pieces of wood or other plant material that has been dredged or occasionally thrown ashore as driftwood. Of the 30 species listed by Knudsen and the 7 species described as new in this paper, 24 are known from fewer than 10 specimens; only 7 species are known from series of more than 100 specimens. Most are known from only one or two localities and often all specimens are from a single piece of wood, and may all be of the same set, that is, have settled at the same time. Consequently, it is not surprising that all specimens in any one lot are quite similar. Only since the beginning of deep-sea testing and the use of the submersible DSV *Alvin* to place experimental wood islands at great depths has it been possible to obtain sufficient material to study intraspecific variation in this subfamily.

The earliest work of this sort was done by the U.S. Naval Civil Engineering Laboratory (USNCEL) and the Navy Oceanographic Office (NOO). Three cases of variation based on this material are re-



Text-Figure 2. Distribution map of species of *Xylophaga*.

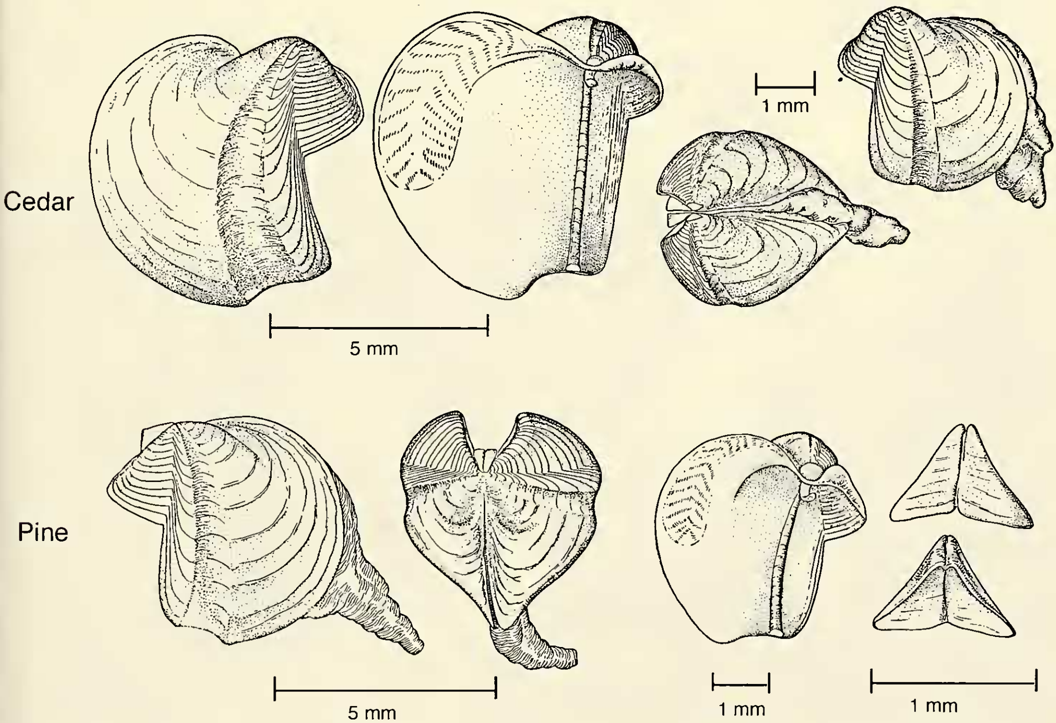
ported here. The first case involves variation in response to different substrata, the second case exhibits variation that possibly is genetic because the substrate and all other parameters were as nearly uniform as possible, and the third case illustrates variation in a normal growth series.

Variation Due to Different Substrates. Variation in *Xylophaga washingtona* in response to the substrate can be demonstrated with material from the USNCEL tests. A series of 10 panels of different types of wood were attached to a submersible test unit (STU) that was submerged from April 1965 to May 1966 off San Miguel Island, California (34°06′N, 120°42′W) at 2,370 ft (730 m) (see Table 1 and Text-Figs. 3–9). The 2 × 6 × 0.5-in (50.8 × 152.4 × 12.7-mm) wood panels were all attached to the same rack on the STU so that they would be resting just above the mudline. Consequently, all factors affecting the borers were as nearly identical as possible except the substrate (i.e., the species of wood) on which the borer larvae settled and into which they would bore. Text-Figures 3–8 illustrate typical specimens from each of the wood panels; Text-Figure 9 shows specimens from a phenolic laminated rod. It is interesting to note that the dorsal plates in all specimens are remarkably uniform, varying only slightly in length/width proportions. Even the specimens taken from the phenolic laminated rod could be identified by the dorsal plates.

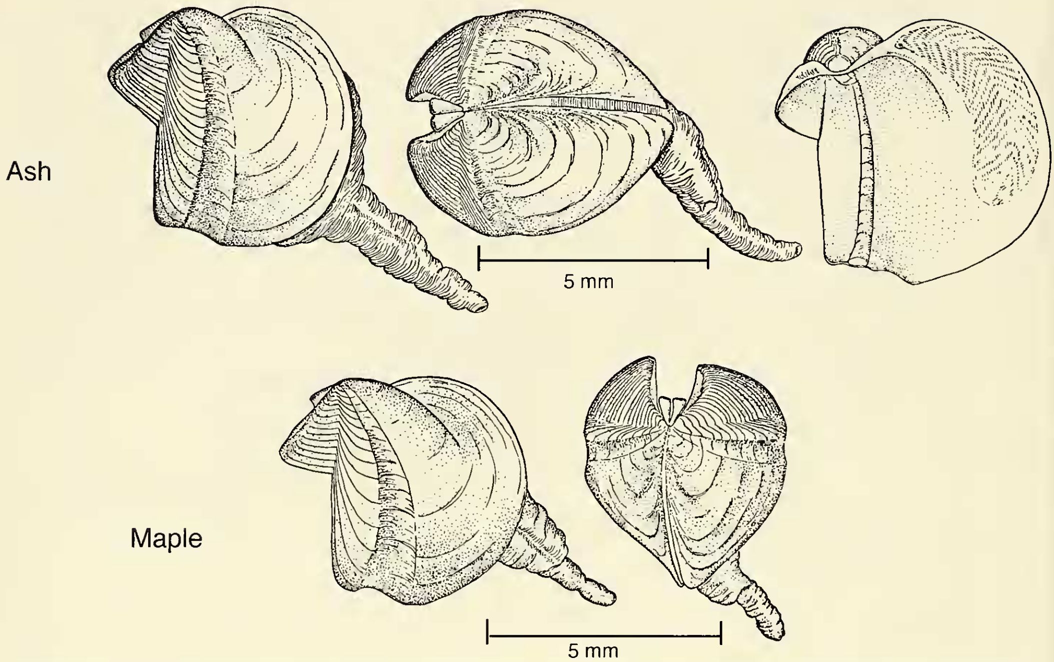
The general shape of the valves with the high posterior slope also remained rather constant except in the extremely stenomorphic (stunted) specimens from *Afambeau* and the phenolic laminated rod. It is difficult to explain the proportionate size of the larval valves on specimens boring into harder materials except that these specimens had not greatly increased in di-

TABLE 1. VARIATION OF *XYLOPHAGA WASHINGTONA* BURROWS IN DIFFERENT TYPES OF WOOD.

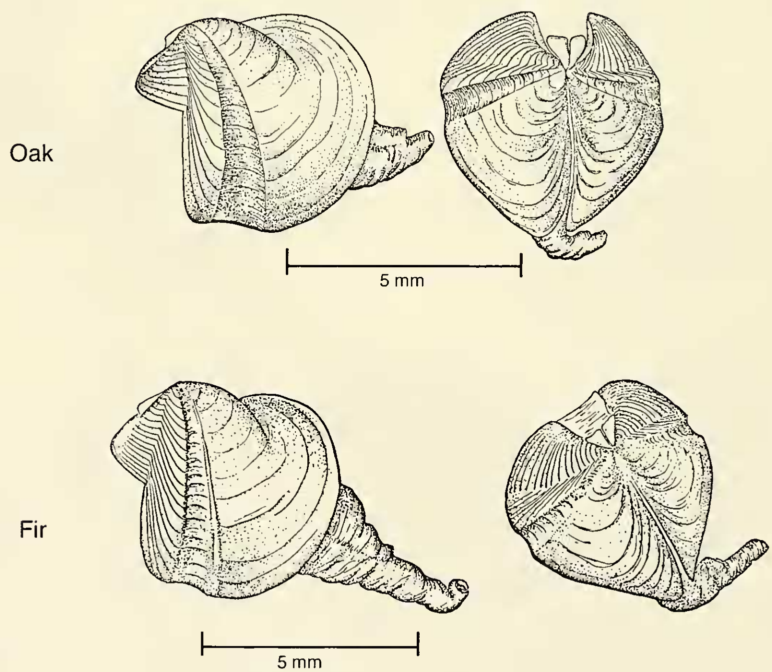
Wood	No. Specimens Examined	Burrow Length (mm)	Burrow Diameter (mm)	Remarks
Cedar	50	25.0	4.5	many dead, often three or four specimens in one enlarged cavity where burrows ran together. Heavily attacked, particularly at one end.
Ash	125	21.0	5.0	many dead, burrows running together, panel heavily attacked, particularly at one end.
Maple	75	11.0	5.5	well distributed, with a little more concentration around the hole at one end.
Pine	35	15.0	5.0	clustered at one end, newly settled to adult.
Oak	±50	15.0	6.0	evenly distributed, shells yellowish-green from wood.
Fir	46	12.0	4.5	many newly settled, often cut into burrows of other specimens.
Redwood	46	14.0	4.5	specimens stained dark red brown by wood.
Greenheart	75	2.75	1.75	concentrated around edges.
Afambeau	19	0.75	0.05	concentrated at one end, all very small, many in umbo stage veliger, 15 small depressions without animals.
Antidesma pulvinatum	150	0.10	0.05	many newly settled, just beginning metamorphosis.



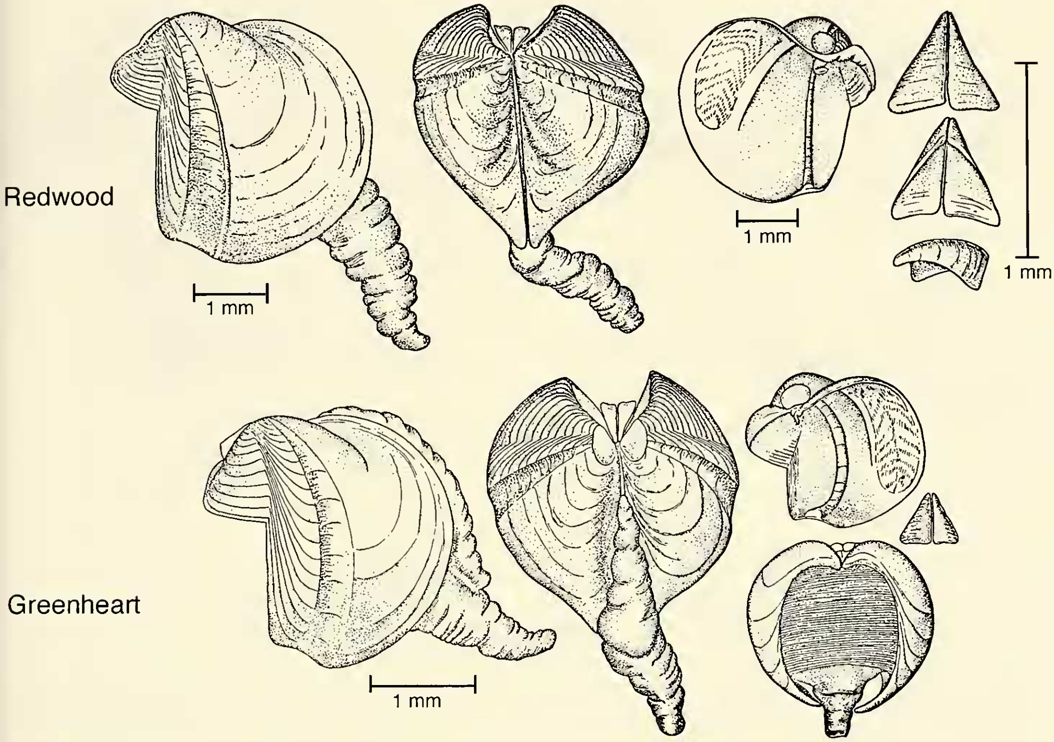
Text-Figure 3. Typical specimens of *Xylophaga washingtona* collected from submerged cedar (top) and pine (bottom).



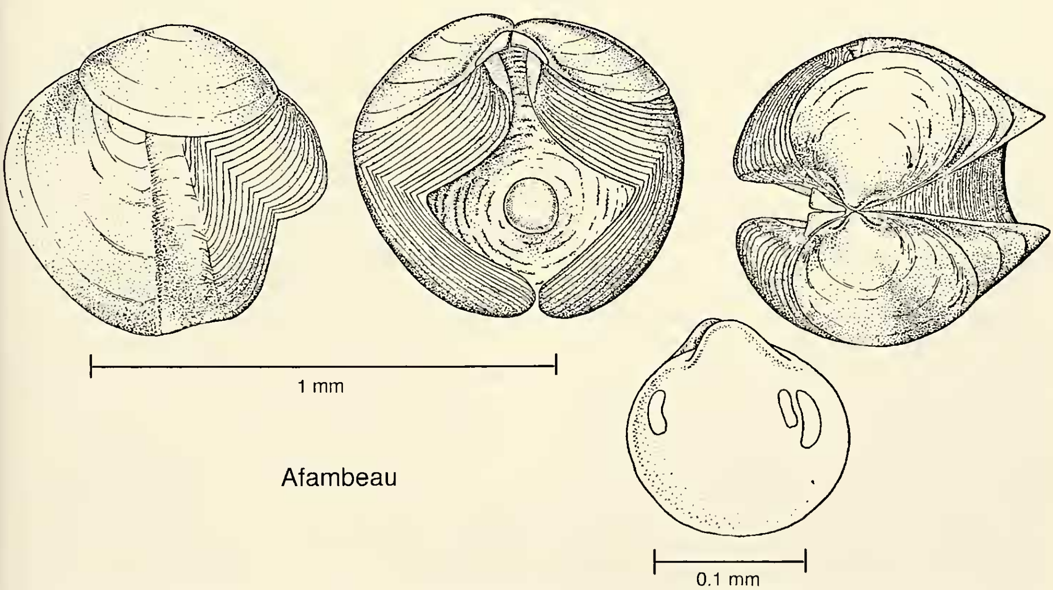
Text-Figure 4. Typical specimens of *Xylophaga washingtona* collected from submerged ash (top) and maple (bottom).



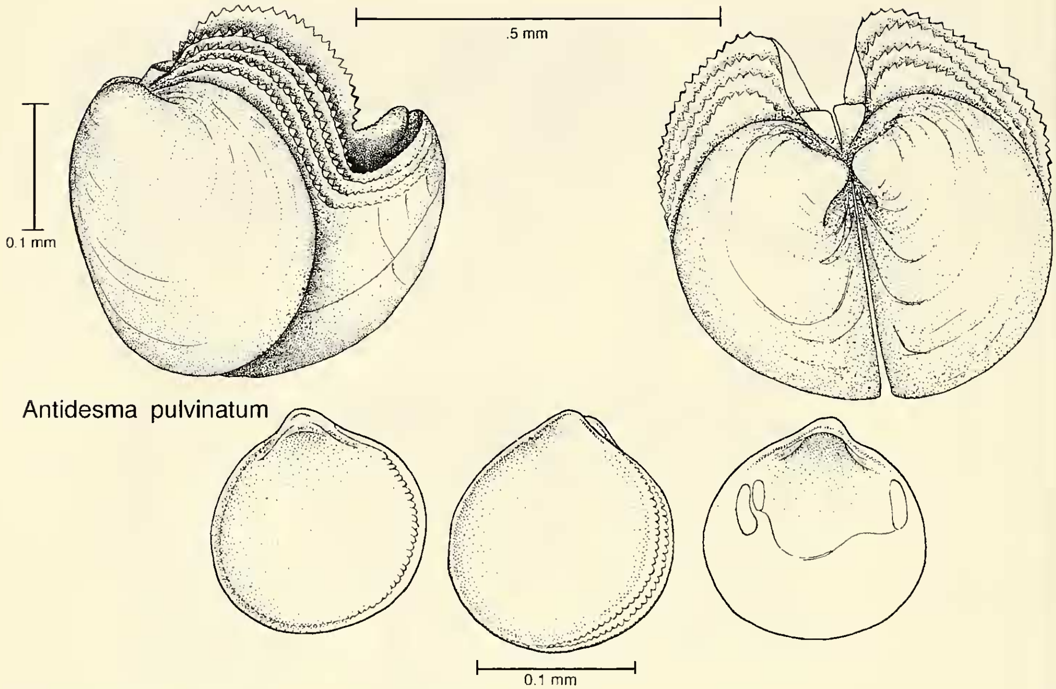
Text-Figure 5. Typical specimens of *Xylophaga washingtona* collected from submerged oak (top) and fir (bottom).



Text-Figure 6. Typical specimens of *Xylophaga washingtona* collected from submerged redwood (top) and greenheart (bottom).



Text-Figure 7. Typical specimens of *Xylophaga washingtona* collected from a submerged panel of *Afambeau*.

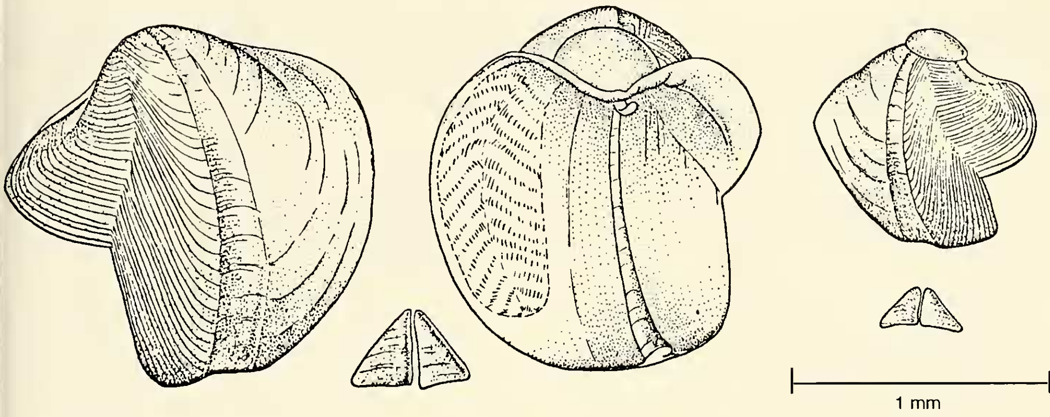


Text-Figure 8. Typical specimens of *Xylophaga washingtona* collected from a submerged panel of *Antidesma pulvinatum*.

ameter as they bored so that the larval valves were not inturned with the growth of the umbos. Evidently little or no attrition had occurred at the umbonal area or the embryonic valves would have been worn away.

The most variable characters in this series are the size of the valves and the number of denticulated ridges on the anterior slope in relation to the length of the valves. Specimens from cedar, pine, ash, maple, oak, and fir (Text-Figs. 3–5) all were drawn to the same scale, as shown by the 5-mm scale bar, and are arranged in order of decreasing size. The number of denticulated ridges on the anterior slope of these specimens varies from 12 to 20. Specimens from redwood, greenheart, *Afambeau,* and *Antidesma pulvinatum* (Text-Figs. 6–8) were drawn to their own scales and, although these specimens are much smaller, they have as many or more ridges on the anterior slope. The specimen removed from the phenolic laminated rod (Text-Fig. 9) has 44 denticulated ridges. Correlated with the increased hardness of the substrate and the additional denticulated ridges is a proportional increase in the size of the posterior adductor muscle and its scar. This suggests the enlargement of the posterior adductor muscle in response to increased activity of boring. The general shape and sculpturing of the muscle scar was similar in all specimens. No noticeable variation was found in the siphons, except size, regardless of the substrate. However, specimens that were able to bore deeply into the wood usually formed a chimney composed of compacted fecal material lining the posterior end of the burrow.

Two periods of settlement apparently occurred on some of the panels, because specimens of two age groups could be found. However, it is impossible to say whether the specimens removed from the *Antidesma* were of the second set or if



Text-Figure 9. Typical specimens of *Xylophaga washingtona* collected from a submerged phenolic rod.

they had simply been unable to increase in size because of the hardness, chemical composition, or both of the wood. Because the specimens apparently were alive at the time the wood was removed from the water and because only a few rows of denticulated ridges were present, the inference was made that these specimens probably belonged to a second set. Certainly the larval shells shown in Text-Figure 8 must be from a second set. The number of specimens examined and the maximum length and diameter of the burrows for each type of wood are given in Table 1.

Variation in the Mesoplax of Xylophaga depalmai *Turner* n. sp. Approximately 300 specimens of *X. depalmai* n. sp. were obtained from tests conducted by the NOO about 2–3 miles east of Fort Lauderdale, Florida (26°04′N, 80°04′W) in depths from 100 to 500 ft (30.5 to 152.5 m) (see Table 14 under the description of *X. depalmai* n. sp. for information giving panel numbers, depth, and dates of exposure). In this species, the general shape of the valves, the siphons, and the muscle scars show little variation but the mesoplax is extremely variable. The mesoplax is typically bilaterally symmetrical, ear-shaped, longer than wide, with the two halves coiled inward at the posterior end, and with a long medial line where the two halves meet (Plate 24, Figs. 16, 17). In numerous specimens, the mesoplax was not bilaterally symmetrical, but one half was considerably shorter than the other and often appeared malformed (Plate 24, Figs. 11–15). In several specimens, the ventral surface of the two halves of the mesoplax was fused by the periostracal covering, although the dorsal surface still appeared divided. In other specimens, the mesoplax was elongated, the coiled posterior ends, instead of curling inward toward each other, remained nearly straight or curled slightly outward, with the ventral surface being completely fused (Plate 24, Figs. 1–5). In two specimens, the two halves of the mesoplax had completely fused dorsally and ventrally, although the lines of fusion remained clearly visible. The tapered posterior end of this cornucopialike mesoplax coiled slightly ventral and to the left.

Such variation is in marked contrast to the uniformity seen in the mesoplax of *X. washingtona* Bartsch. It is impossible to say whether this variation is genetic or ecologic but we are able to say that all types of the mesoplax of *X. depalmai* were found in a single panel retrieved from a depth of approximately 300 ft (91.44 m). Variation in the mesoplax is a factor that must be taken into consideration when evaluating species in this genus.

Variation Exhibited in Growth Series. In most species of *Xylophaga*, the dorsal plate is quite simple and the mesoplax of the young is similar to that of the adult, as seen for *X. washingtona.* Dons (1929a,b) described briefly and illustrated a similar situation in *X. praestans* Smith and *X. dorsalis* Turton.

Some species have more elaborate dorsal plates and for some of these (i.e., *X. muraokai* Turner n. sp., *X. bayeri* Turner n. sp., and *X. abyssorum* Dall), it is possible to build up what appears to be growth series. All begin with a simple posterior covering to the anterior adductor muscle that is difficult to differentiate among the species in the young stage. As calcification of the periostrascal covering progresses, the adult form gradually appears. In the three species mentioned, the characters of the valves and the siphons of the young agree with those of the adult specimens. Therefore, although living material has not been available and developmental studies have not been possible, it seems reasonable to consider these as growth series. *Xylophaga muraokai* (Plate 19, Fig. 3) is relatively simple, with the dorsal portion becoming thickened and joining laterally with the basal portion while the ventral flanges enlarge. In *X. bayeri* (Plate 31, Fig. 3), the broad transverse dorsal portion becomes very conspicuous and in *X. abyssorum* (Plate 15, Figs. 4, 5), the dorsal incurving of the lateral arms produce an elaborately lobed mesoplax. Nothing is known of the allometric changes that take place during growth of the peculiar dorsal plates of *X. tubulata* Knudsen, *X. bruuni* Knudsen, *X. obtusata* Knudsen, and *X. whoi* Turner n. sp.

Detailed studies of these growth series will have to await improved techniques for handling living material under deep-sea conditions, and the ability to rear deep-sea species in the laboratory. In the meantime, it seems best to consider these forms as members of growth series rather than different species, particularly because the series in each case was built up from material taken from a single piece of wood.

PRELIMINARY REPORT ON THE RESULTS OF EXPERIMENTS ON THE ECOLOGY OF DEEP-SEA WOOD BORERS AND THE ROLE OF WOOD IN THE DEEP SEA

The results of the first exposures of wood panels at the Woods Hole Oceanographic Institution (WHOI)–*Alvin* permanent bottom station south of Woods Hole (39°46′N, 70°41′W, in 1,830 m) were reported in 1973 (Turner, 1973). At that time, the Xylophagainae were postulated to be the most important deep-sea organisms involved in converting woody plant material to an available food source for other organisms.

Pursuing this theory and to continue the studies of the ecology and life history of the Xylophagainae, wood panels were exposed at the *Alvin* permanent station in the Tongue of the Ocean, Bahama Islands, on 19–22 January 1974 (*Alvin* dives 492, 493, 494, and 495) at a depth of 2,032 m. The first of these panels was picked up on 7 March 1974, frozen immediately, and returned to Woods Hole where it was examined. Newly settled larvae and metamorphosing *Xylophaga* with one to two rows of denticulated ridges were removed from the panel. The specimens were approximately 300 μm in length and the greatest penetration was about twice the depth of the shell. The debris rings surrounding the burrows were much coarser than those made by teredinids. The distribution of the entrance holes was somewhat patchy and varied from 5 to 20 cm^2. The specimens were too young to identify because none of the dorsal plates had been formed but examination with scanning electron microscopy showed a well-developed distinctive sculpture on the larval shell.

This first panel from the Tongue of the Ocean established that *Xylophaga* were just beginning to settle on the wood a maximum of 48 days after it was implanted in the bottom and that settlement of larvae could occur in early March, at least at this site.

Three more panels were removed from the Tongue of the Ocean station (Tower 1—west arm) on 19 April 1975 during *Alvin* dive 552. I was an observer on this dive and as we approached the panels I noticed an increase in the number of shrimp and galatheid crabs. The panels had numerous crabs crawling all over them. Some of the crabs had crawled under the plastic mesh bags covering the panels and had grown so large they could not escape. (Note: After the near loss of the panels at the northern station because of the heavy attack of borers, the decision was made to put the panels in plastic mesh bags so that the pieces could be retrieved if they began to disintegrate.) The specimens inside the bag were carried to the surface with the panels. When the panel was disturbed, the specimens on the outside of the mesh fell off. The largest of the 12 crabs was 43 mm in length. The diamond-shaped opening of the mesh was 5 × 10 mm. The smallest crab measured 8 mm in length; others measured 40, 33, 32, 30, and 24 mm. It is obvious that the crabs were finding sufficient food either in or on the wood to grow at a fairly rapid rate.

The first young crabs to find the wood may have fed on the newly settled *Xylophaga* larvae and this might explain the patchy distribution of the borers in the panels. However, the larger crabs would not have stayed on the wood unless there was something for them to eat. The crabs had to be under 10 mm in length to get under the mesh and if the larvae were not settling until early March it would be at least early May before the borers had grown sufficiently to be a good food source for the crabs. Therefore, I think we can postulate that the largest crab measured grew at least 33 mm in a period of 10 months.

Examination of the panels showed a rather heavy attack of three species of Xylophagainae. These included *Xyloredo nooi* Turner and two *Xylophaga* species, *Xylophaga clenchi* Turner and Culliney and *X. profunda* Turner n. sp. The *X. nooi* were typical with valves that reached 5 mm in length and burrows that were 18–22 mm in length. The calcareous lining of the burrow of the largest specimen was 13 mm long and 2.5 mm in diameter at its anterior end. The smaller species of *Xylophaga, X. clenchi* Turner and Culliney, also had been obtained previously from wood exposed in the Tongue of the Ocean by John DePalma of the NOO. This is a fairly small species. The valves were 8–10 mm in length and several of the specimens were carrying larvae on the umbonal area of the valves. The larvae measured 0.2 mm in length. The large species of *Xylophaga, X. profunda* Turner n. sp., had not been seen before. The valves were 14 mm in length, and one specimen measured 40 mm to the tip of the siphons. The burrows were 45–50 mm in length. Both *X. clenchi* and *X. profunda* lined the posterior end of their burrows with consolidated fecal pellets and the burrows of all dead specimens contained one or more specimens of capitellid worms that were feeding on the pellets as well as the remains of the *Xylophaga.* Often the spaces between the valves of the borers were filled with the smaller fecal pellets of the worms. Breaking these balls of pellets apart, I always found one or two capitellid worms. In the *Xylophaga* burrows and on the surface of the wood, I also found two other polychaete worms. One belonged to the family Chrysopetalidae and the other to a family of polynoid worms.

A preliminary examination of the stomach contents of a broken specimen of a galatheid showed that the crab had ingested some fine chips of wood because identifiable cells remained in the material. Consequently, we can postulate that the crabs were feeding on the *Xylophaga,* probably dead ones. The tissues of the *Xylophaga* are so soft that they are unrecognizable in such a preliminary examination. The crab's stomach also contained setae of the chrysopetalid worms, a small nematode, and some sponge spicules. The chrysopetalids probably were feeding on the capitellid worms.

I think five points are worthy of notice: 1) *Xylophaga* in the Tongue of the Ocean as well as at the northern *Alvin* station are growing much faster than one would expect. 2) The larvae of *X. profunda* n. sp. were settling in early March. 3) *Xylophaga clenchi* broods its young and was carrying young in mid-April. 4) Probably the crabs and worms were also growing faster than normal for the deep sea. 5) A food chain based on wood and *Xylophaga* was being developed.

This lends support to my hypothesis that wood is an important source of enrichment in the deep sea, that it contributes to both the diversity of organisms in a given area and to their rate of growth, and that the Xylophagainae are the most important organisms involved in converting the wood to a usable form. To my knowledge, this is the first documented food chain for invertebrates in the deep sea. On the basis of these simple experiments, it now seems conceivable that the slow growth rates usually attributed to deep-sea animals may be due to lack of food, at least for epifaunal forms, rather than being an inherent characteristic of the species involved.

SYSTEMATIC ACCOUNT

GENUS *XYLOPHAGA* TURTON 1822

Xylophaga concava Knudsen
Plate 1

Xylophaga concava Knudsen, 1961, *Galathea* Report, 5: 167–169, figs. 4, 5 (*Galathea*, station 726, Gulf of Panama [5°49′N, 78°52′W] in 3,270–3,672 m). Holotype, Zoological Museum, University of Copenhagen; paratype, MCZ 235796.

Distinctive Characters. Posterior slope of valves concave when viewed dorsally. Mesoplax composed of two rather wide, erect, curved plates that extend above the umbos. Siphons nearly the same length, excurrent slightly shorter with a few large cirri, incurrent siphon with many small cirri (Plate 1, Figs. 2, 3). Chimney apparently lacking, not mentioned by Knudsen and not found with the single specimen reported here.

Remarks. At the time Knudsen described this species he had 4 specimens from *Galathea* station 726 and 25 specimens from *Galathea* station 739. Both of these stations were given as in Gulf of Panama. However, station 726 is about 95 miles west of the Gulf of Tibuga, Colombia, whereas station 739 is about 90 miles west of Ensenada Guayabo, Panama. A single specimen of *X. concava* was taken by the R/V *Pillsbury* at station 526. This locality is about midway between the two *Galathea* stations.

The *Pillsbury* specimen agrees closely with the description and figures given by Knudsen (1961) except that the incurrent siphon has a double row of about 25 small cirri around the aperture and the excurrent siphon has 6 large cirri (Plate 1, figs. 2, 3). Concerning the siphons, Knudsen stated that "both openings are at the distal end, close together, and around them 15–16 small cirri are present." In Knudsen's illustration, the distal ends of the siphons appear to be contracted; neither the two openings nor the cirri are apparent. The contracted condition of Knudsen's specimens probably accounts for the differences noted here.

Xylophaga concava is closely related to *Xylophaga gerda* Turner n. sp. but differs in the size of the mesoplax, the type of siphonal openings, and the chimney. (See Remarks under *x. gerda.*) *Xylophaga concava* also is related to *X. erecta* Knudsen (1961) from the Sulu Sea. Knudsen (1961) reported that no cirri were visible on the siphons of *X. erecta,* that the posterior adductor scar was much broader in *X. concava,* and that the posterior slope of the valve viewed dorsally was convex in *X. erecta* rather than concave. Knudsen's description of *X. erecta* was based on 20 specimens and unfortunately no further records have been obtained.

Range. From off Ensenada Guayabo, Panama, south to off the Gulf of Tibuga, Colombia, in depths from about 915 to 3,670 m.

Specimens Examined. COLOMBIA: *Galathea*, station 739, Gulf of Panama, about 90 miles W of Ensenada Guayabo (7°22′N, 79°32′W) in 915–975 m (dried specimens); *Pillsbury*, station 526, about 110 miles W of Cabo Marzo (6°53′N, 79°27′W) in 3,193–3,211 m; *Galathea*, station 726, Gulf of Panama (5°49′N, 78°52′W) in 3,270–3,670 m.

Xylophaga gerda[2] Turner new species
Plates 2, 3

Holotype. MCZ 328378. Paratypes, MCZ 316741, 316742.

Type Locality. Gerda, station 499, about 3 miles off Southwest Point, Great Bahama Island, Bahama Islands (26°37′N, 78°56′W) in 155 fathoms (283.96 m).

Distinctive Characters. Posterior slope of valves concave when viewed dorsally. Mesoplax composed of two narrow, erect curved plates at the posterior end of the anterior adductor muscle. Siphons of equal length, with a periostracal sheath and four or five cirri surrounding the apertures. Chimney composed of fecal material agglutinized to a periostracal base (Plate 2, Fig. 7).

Description. Shell globose, fragile, reaching 3.0 mm in length and 2.8 mm in height, umbos inflated. Pedal angle 110–115°. Anterior slope with up to 45 rather evenly spaced denticulated ridges. Umbonal–ventral sulcus narrow and only slightly depressed. Disc and posterior slope sculptured with fine, incised growth lines. Posterior slope high, flaring, and somewhat ear-shaped.

Inner surface of valves smooth and glistening. Umbonal–ventral ridge low and indistinct except near the wide, low ventral condyle. Chondrophore and internal ligament small. Posterior adductor muscle scar large with faint transverse impressions, which are best seen externally on an entire specimen. Disc separated from posterior slope by a shelflike ridge (Plate 3, figs. 2–5). Pedal and siphonal retractor scars not visible.

Mesoplax composed of two erect, narrow, curved, slightly calcified plates, located just posterior to the anterior adductor muscle and not extending above the umbos.

Siphons long, probably not capable of retraction between the valves, of equal length, united nearly to the tip, with a thin periostracal sheath. Siphonal apertures of about equal size, each with four or five comparatively large cirri, which appear as a common ring of cirri when the siphons are retracted. A brown periostracal cylinder containing fecal material may extend nearly one half the length of the excurrent siphon (Plate 2, Figs. 1–4). Chimney built in sections, composed of fine fecal material agglutinized on a periostracal lining with "leaves" of periostracum extending to the outer surface (Plate 2, Figs. 6, 7). Arrangement of the gills and labial palps typical for the genus, foot large but not muscular, cecum very large and showing through the foot (Plate 2, Fig. 5). Pedal and siphonal retractor muscles weak, their arrangement typical for the genus.

Measurements. See Table 2.

Remarks. On the basis of the shell and the mesoplax, this species is closely related to *X. concava* Knudsen from the Gulf of Panama. It differs in being much smaller

TABLE 2. MEASUREMENTS OF *XYLOPHAGA GERDA*.

Length (mm)	Height (mm)	Location
1.1	1.0	*Gerda,* station 266
1.5	1.4	*Gerda,* station 266
1.8	2.0	*Gerda,* station 266
2.5	2.3	paratype
3.0	2.5	holotype
3.0	2.8	*Pillsbury,* station 328
3.3	3.0	*Pillsbury,* station 944
3.8	3.5	*Pillsbury,* station 944

[2] Named for R/V *Gerda,* Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, Florida, whose station 499 is the type locality.

(none of the 19 specimens reached 4 mm in length, whereas Knudsen gives 8.6 mm for *X. concava*) and in having a narrow mesoplax that does not extend above the umbos. In addition, the excurrent and incurrent siphons of *X. gerda* are the same length, are separate at the tip, and the apertures of both siphons have four or five relatively large cirri. In *X. concava*, the siphons are joined for their entire length and the excurrent siphon is slightly shorter. The type of chimney produced by *X. gerda* is unlike any other known to date in this genus.

Unfortunately, all the specimens of *X. gerda* are small, extremely fragile, and rather poorly preserved. Consequently, it has been impossible to do anatomical work beyond that mentioned in the description. One specimen from which the valves were removed appeared to have an accessory genital organ similar to that described by Purchon (1941).

Range. Probably throughout the Caribbean in depths from about 283 to 2,072 m.

Specimens Examined. BAHAMA ISLANDS: *Gerda*, station 499, about 3 miles off Southwest Point, Great Bahama Island (26°37′N, 78°56′W) in 155 fathoms (283 m). UNITED STATES, FLORIDA: *Gerda*, station 266, off Fowey Rocks, Florida Keys (25°39′N, 79°58′W) in 185–187 fathoms (338–342 m). LESSER ANTILLES: *Pillsbury*, station 944, 45 miles N of Port Louis, Guadeloupe Island (16°32.2′N, 61°36.8′W) in 364–421 m. PANAMA: *Pillsbury*, station 328, about 25 miles N of Punta San Blas, Gulf of San Blas (9°55.8′N, 78°59.8′W) in 2,069–2,072 m.

Xylophaga grevei Knudsen
Plate 4

Xylophaga grevei Knudsen, 1961, *Galathea* Report, 5: 176, figs. 16–18 (*Galathea*, station 495, Banda Trench, south of Ceram [5°26′S, 130°58′E] in 7,250–7,290 m). Holotype, Zoological Museum, University of Copenhagen.

Distinctive Characters. Mesoplax composed of two triangular plates that are flat dorsally, in contact the length of their median edge, bent downward on their outer edge to meet the umbonal reflection, and lack a ventral portion. Posterior adductor muscle scar with oblique radiating impressions. Siphons nearly the same length, the aperture of the excurrent siphon much smaller in diameter than the incurrent siphon and with about 6 cirri; incurrent siphon with about 35 small cirri. Young carried on the umbonal area of the adult.

Table 3. Measurements of *Xylophaga grevei*.

Length (mm)	Height (mm)	Location
1.9	1.6	*Galathea*, station 444
12.5	11.0	holotype

Measurements. See Table 3.

Remarks. Through the kindness of Jorgen Knudsen, it was possible to borrow the preserved dredged wood from the Zoological Museum, University of Copenhagen. In a small piece taken by the *Galathea* at station 444, I found several additional specimens of *X. grevei*. They are much smaller than that figured by Knudsen, the anterior slope is much narrower, and the denticulated ridges are more widely spaced. However, they appear to be young but sexually mature specimens of that species. From one to five rather large young were attached posterior to the umbos on the dorsal surface of the parent shells.

Xylophaga wolffi Knudsen, based on only two specimens, also was from *Galathea*, station 444. It has valves, muscle scars, and siphons similar to those of *X. grevei*. The outstanding difference between these species is the flat plates of the mesoplax of *X. wolffi*, which are set in tentlike fashion at an acute angle to each other. It has not been possible to compare the type of *X. wolffi* with this new material from *Galathea*, station 444, but it appears that these two forms (i.e., *X. grevei* and *X. wolffi*) may be equivalent to the condition found in *X. clenchi* Turner and Culliney, where occasional specimens have a bent, flat-topped mesoplax (Plate 4, Figs. 5, 6). Further collecting may show *X. grevei* and *X. wolffi* to be forms of a single species. The denticles on the ventral edge of the mesoplax of *X. wolffi* described by Knudsen may be an age factor but more material is needed to prove this.

Range. Mindanao Sea south to the Banda Trench, Banda Sea in depths from about 545 to 7,290 m.

Specimens Examined. PHILIPPINE ISLANDS: *Galathea*, station 444, Sulu Sea, W of Basilan Island (7°54′N, 121°30′E) in 5,050 m.

Xylophaga clenchi[3] Turner and Culliney
Plates 5–8

Xylophaga clenchi Turner and Culliney, 1971, American Malacological Union Annual Report for 1970, p. 66 (U.S. NOO test site, Tongue of the Ocean, about 4 miles off northeastern tip of Andros Island, Bahama Islands [24°54′N, 77°49′W] in 1,737 m). Holotype, MCZ 316743; paratypes, MCZ 316744, 316745.

Distinctive Characters. Mesoplax small, composed of triangular, nearly flat plates lacking a basal portion; the two plates usually meeting at an acute angle in frontal view. Burrow lined with a chimney of coarse, loosely consolidated fecal pellets. Young held on posterior dorsal surface of the adult. Excurrent siphon shorter than incurrent siphon and with two large papillae on either side.

Description. Shell globose, reaching 14 mm in length and 13.5 mm in height, thin, fragile, with a thin, light brown periostracum that is thickened along the dorsal and posterior margin of the valves. Umbos prominent and strongly incurved. Pedal gape angle about 108°. Beaked portion of the anterior slope sculptured with numerous denticulated ridges that are widely spaced in the young, becoming increasingly compacted toward the ventral margin in older specimens. Specimens 5 mm in length have up to 25 ridges. Posterior portion of the anterior slope rather narrow. Umbonal–ventral sulcus moderately to deeply impressed becoming shallower with age and bounded posteriorly by a broad, low, rounded ridge. Disc and posterior slope sculptured with uniform, rather pronounced growth ridges that are particularly prominent in young specimens.

Inner surface of valves smooth and glistening. Umbonal–ventral ridge prominent, distinctly segmented, and with a large ventral condyle. Chondrophore and internal ligament well developed. Posterior adductor muscle scar kidney-shaped in outline and with irregular transverse, often anastomosing impressions that become more numerous with age. Pedal retractor scar more or less oval in outline and located just anterior to the embayment in the posterior adductor scar. Siphonal retractor scars small, not impressed, located just posterior to the umbonal–ventral ridge about midway between the umbo and the ventral condyle.

Mesoplax small, composed of two flat to slightly arched triangular plates lacking a ventral portion, set in a tentlike fashion and held in place by the periostracum and the anterior adductor muscle. Plates usually meet dorsally at 90° (Plate 5, Fig. 3), occasionally at an obtuse angle. They are rarely bent longitudinally (Plate 8, Fig. 3). Outer surface of plates sculptured with ridges paralleling the anterior margin and lining up with the denticulated ridges of the valves where they come in contact.

Siphons short, extending only about one third the length of the valves. Excurrent siphon about one half the diameter of and slightly shorter than the incurrent siphon, with a well-developed sphincter muscle surrounding the aperture and two large papillae on each side (Plate 7, Fig. 3). Incurrent siphon has minute cirri surrounding the aperture and a second set of larger cirri anterior to them within the siphon (Plate 6, Fig. 4).

Posterior end of burrow lined with coarse, loosely compacted fecal pellets. Young held by byssus threads on the posterior dorsal surface of the adult shell (Plate 7, Figs. 1, 2).

Measurements. See Table 4.

Remarks. This species is most closely related to *X. africana* Knudsen from the

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[3] Named for Dr. William J. Clench, Curator of Mollusks, 1926–1966, Museum of Comparative Zoology, Harvard University.

TABLE 4. MEASUREMENTS OF *XYLOPHAGA CLENCHI.*

Length (mm)	Height (mm)	Location
2.3	2.1	*Ingolf,* station 67
3.2	2.0	*Atlantis II,* station 124
3.5	3.5	holotype
4.0	3.5	Tongue of the Ocean
5.0	4.8	Tongue of the Ocean
10.0	9.5	Tongue of the Ocean
10.0	10.0	*Pillsbury,* station 104
14.0	13.5	*Pillsbury,* station 394

Gulf of Guinea, West Africa (1°42′N, 7°51′E in 2,550 m), but the mesoplax differs in having a longer median line where the two plates meet, a weaker sculpture, and in lacking the rounded nodule on the ventral surface. Unfortunately, the valves of the two known specimens of *X. africana* were too fragmentary to allow comparisons on this basis. The siphons of these two species are similar but *X. clenchi* differs in having only two rather than three large cirri on either side of the excurrent siphon and in having two rings of small cirri bordering the aperture of the incurrent siphon. The incurrent siphon of *X. africana* lacks cirri, according to Knudsen (1961). Two other species, *X. wolffi* Knudsen from the Sulu Sea and *X. murrayi* Knudsen from off Zanzibar, also have similar dorsal plates. The former differs from *X. clenchi* in having denticles on the basal margin of the mesoplax with corresponding denticles on the umbonal reflection. In addition, on each side of the excurrent siphon of *X. wolffi* there are "7 finger-like tentacles on a common base and somewhat larger tentacle dorsally." The siphons of *X. murrayi* differ in having a circle of about 35 "short tentacles" surrounding both openings. Knudsen (1961) compared *X. wolffi* with *X. supplicata* Taki and Habe but examination of paratypes of *X. supplicata* received from Habe showed that species to have tubules on the mesoplax. (See also under *X. supplicata* Taki and Habe.)

Xylophaga clenchi Turner and Culliney also appears to be closely related to *X. panamensis* Knudsen but the latter differs in having the plates of the mesoplax smooth. The posterior adductor muscle scar of *X. panamensis* is oval and irregularly lobed anteriorly, the weak umbonal–ventral ridge is bounded posteriorly by a groove, and the condyles are lacking. The siphons of *X. panamensis* are unknown.

The variation in the mesoplax of *X. clenchi* is interesting and presents some problems. In most specimens, the plates are flat or nearly so and none has a ventral portion or cavity of any kind. The angle at which the plates meet dorsally is typically acute; however, specimens from shallower waters (i.e., less than 900 m) occasionally have plates that meet at an obtuse angle. Two of the five specimens from *Atlantis II,* station 124, have the dorsal plate bent longitudinally at a right angle (Plate 8, Fig. 3), whereas others are typical. Because the shell characteristics of these specimens fit within the range of variation of the typical forms, they are considered to be ecologic variants. Unfortunately, none of the specimens from shallower water has extended siphons, so comparisons cannot be made on that basis.

Although the holotype of *X. clenchi* is small, it was selected because it was the most nearly perfect and the only specimen for which dorsal plates, young, siphons, and chimney all were present. The large specimen from R/V *Pillsbury,* station 394, and the two from *Pillsbury,* station 104, were dead when collected. At least one specimen from all other localities was alive at the time of collection. The specimens from the Tongue of the Ocean were from test panels submerged by the NOO from 4 April 1962 to 17 February 1965. For a description of the test site see DePalma (1969). One specimen taken by the R/V *Atlantis II* at station 119 and three specimens taken at station 131 were from epibenthic sled hauls in which no wood or plant material was found. The specimens were alive and apparently normal although they were badly crushed, for they were minute and very delicate. This raises the question as to whether or not at least some species of *Xylophaga* can survive in a firm muddy bottom if wood is not available. So far as known, these are the only living specimens of *Xylophaga* not taken from wood or other plant material, except those that were boring in plastic at the navy test site off California and possibly those specimens of *Xylophaga foliata* Knudsen that came from a station in Macassar Strait from which it was reported that no wood was taken. The specimens from off Iceland were removed from wood dredged by the *Ingolf* Expedition in 1896. All specimens were small, the largest being 2.5 mm in length. Many had from 1 to 10 large young attached to the valves in the umbonal area (Plate 7, Fig. 2). This record extends the range of the species far to the north but it has been impossible to find any characters to distinguish these specimens from those occurring to the south.

The difference in the size of the young attached to the dorsal surface of the specimens figured in Plate 5, Figures 1 and 2, and Plate 7, Figures 1 and 2, reflects the age of the larvae, with those in the latter plate having well-developed umbos and appearing fully mature. It is interesting to note the position of the larvae on the two adults and to speculate that perhaps the larvae move gradually toward the umbos as they mature.

Range. From off Iceland south to Venezuela in depths ranging from 35 to 4,862 m.

Specimens Examined. ICELAND: *Ingolf,* station 67, S of Eyrabakki (61°30′N, 22°30′W) in 1,836 m. UNITED STATES, NEW JERSEY: *Albatross,* station 2550, about 160 miles E of Barnegat Bay (39°44′N, 70°30′W) in 1,977 m. VIRGINIA: *Albatross,* station 2731, off Cape Henry (36°45′N, 74°28′W) in 1,428 m. NORTH CAROLINA: *Atlantis II,* station 131, about 420 miles E of Currituck Sound (36°28.9′N, 67°58.2′W) in 2,178 m; off Cape Hatteras (35°44′N, 75°15′W) in 35 m. GEORGIA: *Pillsbury,* station 104, about 80 miles SE of Brunswick (31°00′N, 79°50′W) in 247 m. BAHAMA ISLANDS: Tongue of the Ocean, about 4 miles off NE tip of Andros Island (24°54′N, 77°49′W) in 1,737 m; Tongue of the Ocean (24°53.2′N, 77°40.2′W) in 2,066 m. BERMUDA: *Atlantis II,* station 124, about 750 miles E of Cape Charles (due N of Bermuda) (37°26′N, 63°59′W) in 4,862 m; *Atlantis II,* station 119, just S of Bermuda (32°15′N, 64°32′W) in 2,095–2,223 m. PANAMA: *Pillsbury,* station 328, about 25 miles off Punta San Blas, Gulfo San Blas (9°55.8′N, 78°59.8′W) in 420–640 m. VENEZUELA: *Pillsbury,* station 719, about 100 miles N of Pertigalete Bay (11°35′N, 64°35.4′W) in 770–890 m.

TABLE 5. MEASUREMENTS OF *XYLOPHAGA SUPPLICATA.*

Length (mm)	Height (mm)	Location
8.5	8.8	paratype MCZ 194820

Xylophaga supplicata Taki and Habe Plate 9

Metaxylophaga supplicata Taki and Habe, 1950, Illustrated Catalogue of Japanese Shells No. 7, p. 47, text-figs. 1, 2 (Tosa Bay, Shikoku, Japan, in 100 fathoms). Holotype, T. Habe Collection; paratype, MCZ 194820; Knudsen 1961, *Galathea* Report, 5: 188.

Distinctive Characters. Mesoplax composed of two flat triangular plates set at a sharp angle to each other, dorsal margin more than one half the total length, and with minute tubules at the posterior end. The tubules sit deep within the cavity formed by the umbos and cannot be seen when the shell is viewed anteriorly. Chondrophore of left valve with a large tooth (Plate 9, Figs. 5, 6).

Measurements. See Table 5.

Remarks. Taki and Habe (1950) described the dorsal plate of *X. supplicata* simply as a “small triangular protoplax [=mesoplax]” that is attached vertically. A paratype received from Dr. Habe has small tubes on the dorsal posterior end of the mesoplax.

Xylophaga bruuni Knudsen, 1961, from the Mindanao Sea is very close to if not synonymous with *X. supplicata.* Unfortunately, Taki and Habe did not mention the tubes in their original description and Knudsen did not see the types. Also, unfortunately, Knudsen had only a single specimen; hence, it will be necessary to obtain more material before a definite statement can be made concerning the status of *X. bruuni*. (See also Remarks under *Xylophaga whoi* Turner n. sp.)

Specimens Examined. JAPAN: Tosa Bay, Shikoku, in 100 fathoms (183 m).

Xylophaga whoi[4] Turner new species
Plates 10, 11

Holotype. MCZ 275015.

Type Locality. R/V *Atlantis*, station 3471, off Cardenas, Matanzas Province, Cuba (23°21′N, 80°56′W) in 500 fathoms (914 m).

Distinctive Characters. Mesoplax composed of two flat triangular plates with a short median line, set at a sharp angle to each other and with a large hollow tube extending outward from the posterior dorsal surface of each plate.

Description. Shell globose, reaching 7 mm in length and 6.2 mm in height, thin, fragile, and with a very thin, light tan periostracum. Pedal gape angle about 95°. Beaked portion of the anterior slope sculptured with numerous low denticulated ridges; the posterior portion with fine indistinct ridges. Umbonal–ventral sulcus only slightly impressed and irregularly sculptured. Sculpture on the disc and posterior slope consisting of pronounced growth ridges. Umbonal reflection narrow, closely impressed near the umbos, free and vertical anteriorly.

Inner surface of valves smooth and shining. Umbonal–ventral ridge becoming evident only near the ventral margin but rapidly increasing in size to a large ventral condyle. Chondrophore and internal ligament well developed; chondrophore of the left valve with a small tooth on the posterior upper margin. Posterior adductor muscle scar large, elongate, oval in outline, irregularly sculptured, set high on the posterior slope and well in from the posterior margin. Pedal retractor scar rather large, elongate, somewhat irregular, and located just anterior to the posterior adductor scar. Siphonal retractor scar not impressed.

Mesoplax composed of two triangular plates that are set at an acute angle to each other dorsally and have two large, hollow, tubular projections extending from the posterior dorsal margin (Plate 10, Figs. 3–10). Length of dorsal margin less than one half the length of the plate, outer surface sculptured with distinct ridges paralleling the anterior margin; inner surface smooth, with a small internal opening into the tube (Plate 10, Figs. 11, 12).

Siphons short, of about equal length, and probably not capable of extending more than one half the length of the shell. Aperture of incurrent siphon large and apparently lacking cirri, that of the excurrent siphon small and with a few fine cirri on each side ventrally.

Measurements. See Table 6.

Table 6. Measurements of *Xylophaga whoi*.

Length (mm)	Height (mm)	Location
2.5	2.3	*Gerda*, station 266
3.1	3.0	*Gerda*, station 266
6.9	6.2	holotype
7.0	6.8	*Pillsbury*, station 394
7.2	7.0	*Pillsbury*, station 944
9.5	9.0	*Pillsbury*, station 944
12.5	11.5	*Pillsbury*, station 944
13.8	13.1	*Pillsbury*, station 944
14.9	14.0	*Pillsbury*, station 944

Remarks. Knudsen (1961) described three species of *Xylophaga* with tubulate mesoplaxes, and studies for this report have shown that *X. supplicata* Taki and Habe also is tubulate. Three of these species are from the western Pacific (*X. tubulata* Knudsen from Macassar Strait, *X. bruuni* Knudsen from the Mindanao Sea, and *X. supplicata* Taki and Habe from Japan), and one from the eastern Pacific (*X. obtusata* Knudsen from the Gulf of Panama). *Xylophaga whoi* Turner n. sp. is the first tubulate species reported from the Atlantic. It is most closely related to *X. bruuni* Knudsen from the Mindanao Sea but differs in that the mesoplax has a propor-

[4] An acronym for Woods Hole Oceanographic Institution, whose research vessel *Atlantis* collected the holotype.

tionately shorter dorsal margin and larger tubes. In addition, the posterior adductor muscle scar is set well in from the posterior margin and the umbonal–ventral ridge is evident only near the ventral margin of the shell but increases rapidly to a large condyle. *Xylophaga whoi* Turner n. sp. differs from *X. obtusata* Knudsen in the position of the posterior adductor scar, the shape of the mesoplax, the larger tubes on the mesoplax, the narrower anterior slope, and smaller umbonal reflection. The third tubulate species described by Knudsen, *X. tubulata* from Macassar Strait, differs from *X. whoi* in having very large tubules that extend to the anterior margin of the mesoplax and in having the plates bent longitudinally at a right angle so they are flat dorsally rather than meeting at an acute angle. Examination of a paratype specimen of *X. supplicata* Taki and Habe, 1950, from Japan shows that this species has minute tubes on the mesoplax similiar to those in *X. bruuni* and it may be synonymous with that species. (See also under *X. supplicata* Taki and Habe.)

The specimen of *X. whoi* Turner n. sp. taken by the R/V *Pillsbury* from off Punta Piedras, Colombia, had 13 young attached to the umbonal area (Plate 11, Fig. 2). Among the other species in this group (Group 3), Knudsen (1961) reported that the type of *X. obtusata* had two young and the type of *X. bruuni* had four young on the dorsal surface of the adult shell, whereas *X. tubulata* had five young at the ventral base of the siphons in a depression of the mantle tissue. The young at the base of the siphons of *X. tubulata* were very small, about one half the size of those on *X. bruuni*. They possibly had only recently been extruded from the excurrent siphon of the adult and had not yet crawled to the dorsal surface of the adult. It has not been proven that the juveniles clinging to the mantle and shells of adult *Xylophaga* are definitely the young of the specimen to which they are attached, and this has been questioned by some workers. However, until the species concerned are cultured in the laboratory, it is the only assumption that can be made safely. The only way the young of another specimen or species could get into the burrow would be via the incurrent siphon. For the veliger larvae of another specimen to get to the umbonal area, they either would have to pass through the gills into the epibranchial chamber and then out the excurrent siphon, or go through the digestive tract to the excurrent siphon. Neither of these alternatives seems likely. It is, of course, possible that the young of *X. tubulata* complete their development at the base of the siphons of the parent.

Range. From off southern Florida to Colombia in depths from about 336 to 910 m.

Specimens Examined. UNITED STATES, FLORIDA: *Gerda*, station 266, off Fowey Rocks (25°39′N, 79°58′W) in 185–187 fathoms (338–345 m). CUBA: *Atlantis*, station 3471, off Cardenas, Matanzas Province (23°21′N, 80°56′W) in 500 fathoms (914 m). LESSER ANTILLES: *Pillsbury*, station 944, 45 miles N of Port Louis, Guadeloupe Island (16°32.2′N, 61°36.8′W) in 364–421 m. COLOMBIA: *Pillsbury*, station 394, off Punta Piedras (9°28′N, 76°26′W) in 230–350 fathoms (419–640 m).

Xylophaga profunda Turner new species
Plates 12, 13

Holotype. MCZ 316751.

Type Locality. Tongue of the Ocean, off NE tip of Andros Island, Bahama Islands (25°54′N, 77°49′W) in 1,722 m. From test panel submerged from 26 July 1962 to 17 February 1965.

Distinctive Characters. Valves with a well-impressed umbonal–ventral sulcus, bounded posteriorly by a low broadly rounded ridge. Posterior slope sculptured with narrow, concentric grooves. Mesoplax of two triangular plates, lacking a basal portion, set at an acute angle to each other, folded longitudinally with the anterior margin bent inward and with a small pore in each anteriorly. Umbonal–ventral ridge on inner surface of valves narrow, high, and strongly segmented.

Description. Shell globose, reaching about 11 mm in length, thin, fragile, and

Table 7. Measurements of *Xylophaga profunda*.

Length (mm)	Height (mm)	Location
5.9	5.6	holotype
8.0	7.9	Tongue of the Ocean, off NE tip of Andros Island, Bahama Islands
9.5	8.8	Tongue of the Ocean, off NE tip of Andros Island, Bahama Islands
10.0	9.8	Tongue of the Ocean, off NE tip of Andros Island, Bahama Islands
10.9	10.8	Tongue of the Ocean, off NE tip of Andros Island, Bahama Islands

with a relatively heavy, light brown periostracum. Pedal gape angle about 95°. Beaked portion of anterior slope sculptured with numerous strong, denticulated ridges that are more closely spaced toward the ventral margin in adults. Umbonal–ventral sulcus narrow, deep, bounded posteriorly by a low, broad, rounded ridge. Posterior slope sculptured with widely spaced, incised grooves. Umbonal reflection narrow, high, and strongly segmented. Incised grooves of posterior slope expressed internally as faint ridges just posterior to the umbonal–ventral ridge giving a "back bone and ribs effect." Posterior adductor muscle scar broadly oval, set high on the posterior slope, and lightly marked with irregularly anastomosing depressions. Pedal retractor scar lightly impressed, dumbell-shaped, and located just anterior to the midportion of the posterior adductor. Siphonal retractor scar large, elongate, lightly impressed, and located about midway between the posterior adductor and the umbonal–ventral ridge. Chondrophore large, that of the left valve with two small teeth on the posterior edge.

Mesoplax composed of two triangular plates lacking a basal portion, set at an acute angle to each other, folded longitudinally with the anterior margin bent inward and with a small pore in each anteriorly at the outer edge of the fold.

Measurements. See Table 7.

Remarks. This species is superficially similar to *X. abyssorum* Dall but differs in having a low, broad, rounded ridge posterior to the umbonal–ventral sulcus, in lacking the deep groove posterior to the umbonal–ventral ridge on the inner surface, in having a pronounced sculpture on the posterior slope, and in being larger. In addition, the mesoplax of *X. profunda* lacks a ventral portion, has only a single pore in each plate, does not produce tubes, and appears narrow when viewed anteriorly.

Xylophaga profunda Turner n. sp. is probably most closely related to *X. lobata* Knudsen from the Sulu Sea. *Xylophaga profunda* differs in having a mesoplax that is much longer than wide, whereas in *X. lobata* the structure is wider than long. Both species have a strongly segmented umbonal–ventral ridge and a similarly marked posterior adductor scar, although in *X. profunda* the markings are more extensive and elaborate. Knudsen (1961) compared his *X. galatheae* from the Tasman Sea with *X. lobata,* noting differences in the mesoplax and muscle scars. Unfortunately, he had only a single complete specimen of *X. galatheae,* so he could not determine range of variation. *Xylophaga galatheae* possibly is a young *X. lobata* but more material from intervening areas is needed to ascertain this.

On the basis of the general shape and attachment of the dorsal plates, *X. profunda,* along with *X. lobata* and *X. galatheae,* appear to belong in species Group 3, although *X. profunda* is not closely related to any species in the group and is placed here tentatively. The major differences include the sculpturing of the posterior adductor muscle scar, the presence of anterior pores, and the lack of posterior tubes on the mesoplax. The chondrophore of the left valve of *X. profunda* has two small teeth, a character that relates it to *X. whoi* and *X. supplicata,* both of which have a single large tooth. Unfortunately, Knudsen did not mention the presence of teeth in the three tubulate species he described. Consequently, it cannot be stated definitely that this is characteristic of the group.

The siphons of *X. profunda* are short,

probably of the same length and capable of complete retraction within the valves. Unfortunately, none of the specimens was sufficiently well preserved for anatomical work. Four specimens carried young on the umbonal area, the smallest had 5 and the largest had 75. The young have pronounced umbos, distinct concentric sculpture, and measure about 0.30 mm in length.

Xylophaga profunda Turner n. sp. is known from five specimens taken from one panel submerged in the Tongue of the Ocean at 25°54′N, 77°49′W, and from 14 specimens taken from an asbestos-backed panel submerged at 24°53.2′N, 77°40.2′W.

Specimens Examined. BAHAMA ISLANDS: Tongue of the Ocean, off NE tip of Andros Island (25°54′N, 77°49′W) in 1,722 m; Tongue of the Ocean, Tower 3 (24°53.2′N, 77°40.2′W) in 2,066 m.

Xylophaga abyssorum Dall
Plates 14–16

Xylophaga abyssorum Dall, 1886, Bulletin Museum of Comparative Zoology, 12: 317, pl. 9, fig. 7, 7a (*Blake*, station 215, off St. Lucia, Lesser Antilles [13°51′N, 61°03′W] in 226 fathoms). Holotype, MCZ 8135; Turner, 1955, Johnsonia, 3(34): 156, pl. 93.

Distinctive Characters. Valves with a prominent ridge just posterior to the umbonal–ventral sulcus and with a slightly to strongly concave profile posterior to the ridge when viewed dorsally. Umbonal–ventral ridge on the inner surface developed only near the ventral condyle and bounded posteriorly by a deep groove. Mesoplax composed of two more or less triangular plates having a ventral portion and a variously lobed dorsal portion; lobes varying with age and coalescing to form pores or tubes (Plate 15, Figs. 4, 5).

Description. Shell globose but appearing constricted posteriorly when viewed dorsally, reaching 5.5 mm in length, thin, fragile, and with a thin, light brown periostracum. Pedal gape angle about 95°. Beaked portion of the anterior slope sculptured with fine, denticulated ridges, widely spaced in young specimens but compacted toward the ventral margin in older specimens. Umbonal–ventral sulcus narrow, rather shallow, and with a narrow prominent ridge just posterior to it. Profile of valves concave posterior to the ridge when viewed dorsally. Posterior slope sculptured with faint concentric growth lines, umbonal reflection erect, the ventral margin of the mesoplax meeting it and attached by a periostracal fold. Umbos inflated, particularly in young specimens.

Inner surface of valves white and glazed. Muscle scars well marked. Posterior adductor scars somewhat pear-shaped, set well in from the posterior margin, and marked with irregular, elongate depressions extending inward from the posterior margin. Anterior adductor scar covering most of the umbonal reflection. Pedal retractor scar nearly circular and located just anterior to the widest position of the posterior adductor scar. Siphonal retractor scar small, elongate, lightly impressed, and located anterior and ventral to the pedal retractor. Umbonal–ventral ridge not well developed except near the ventral condyle but bounded posteriorly by a deep groove that is a reflection of the external ridge. Chondrophore well developed, internal ligament strong.

Mesoplax variable, with a well-developed, more or less triangular basal portion, occasionally with lateral notches in young specimens. Dorsal portion developing and varying with age; in young specimens, consisting of lobes extending anteriorly from the posterior ends of the plates (Plate 14, Fig. 2) followed by lobed lateral folds (Plate 14, Figs. 3–5, 7), which grow and eventually coalesce to form pores or short tubes (Plate 15, Figs. 4, 5, and Plate 16, Figs. 4, 5). Aperture of the tubes in living specimens covered by a periostracal membrane.

Siphons short, about equal in length, and capable of complete retraction within the valves. Diameter of the incurrent siphonal aperture about twice that of the excurrent siphon. The margins of both appear to have cirri.

TABLE 8. MEASUREMENTS OF *XYLOPHAGA ABYSSORUM.*

Length (mm)	Height (mm)	Location
3.0	2.6	*Pillsbury,* station 944
3.0	2.9	Tongue of the Ocean, off NE tip of Andros Island, Bahama Islands
3.3	3.0	*Pillsbury,* station 944
3.9	3.2	*Pillsbury,* station 944
4.0	3.5	holotype
4.0	3.6	*Gerda,* station 266
5.4	4.5	*Pillsbury,* station 944

Measurements. See Table 8.

Remarks. Dall based his description of *X. abyssorum* on two isolated valves of a dead specimen, with the main distinguishing character being the pronounced ridge posterior to the umbonal–ventral sulcus. All specimens that have been assigned to this species since that time have been so named on the basis of this ridge. Among the specimens taken from boards submerged in the Tongue of the Ocean off Andros Island, Bahama Islands, by the U.S. NOO (DePalma, 1969), was a single specimen the valves of which coincided with those of the holotype. Two specimens were taken from wood dredged off Guadeloupe Island, Lesser Antilles. All of these specimens have a pronounced ridge, concave posterior slope, and lobed mesoplax. With this new material, it has been possible to redescribe *X. abyssorum* giving the characters of the mesoplax and a range of variation. Plate 14, Figure 6, illustrates the dorsal view of the right valve of the holotype of *X. abyssorum*; Figure 3 illustrates the dorsal view of the right valve of the specimen from the Tongue of the Ocean. These two valves so closely resemble each other that, except for a slight difference in size, they could be from the same specimen. Variations in the valves and dorsal plates of specimens from Florida and Guadeloupe Island are illustrated on Plates 14–16. Plate 15, Figure 5, illustrates the position in which the young are carried on the adult. The largest number of young on any one specimen was five; the average measurement of the young was 0.3 mm in length.

Xylophaga abyssorum has a small shell but is a distinctive species, particularly in the adult stage. It is probably most closely related to *X. lobata* Knudsen from the Sulu Sea but differs in having a sharp ridge posterior to the umbonal–ventral sulcus and a far more elaborately lobed mesoplax in the adult. From *X. profunda* Turner n. sp., the only other species with lobes on the dorsal portion of the mesoplax, *X. abyssorum* differs in having broad dorsal plates with two or more pores or tubes in each. In addition, *X. profunda* is a much larger species, the umbonal–ventral ridge on the outer surface of the valves is broad and rounded, and the deep groove on the inner surface is lacking. The posterior adductor muscle scars of *X. profunda* are lightly and irregularly marked, whereas the muscle scars of *X. abyssorum* are well marked. In the young stage, the mesoplax of *X. abyssorum* is similar to that of *X. bayeri* Turner n. sp. and *X. profunda,* but the valves of these species do not have a pronounced ridge. The shape of the valves of *X. abyssorum* somewhat resembles those of *X. japonica* Taki and Habe but the mesoplax of that species is ear-shaped and not lobed. (See under *X. japonica.*)

Range. Based on the valves of dead specimens lacking a mesoplax, the range of this species extends from off Atlantic City, New Jersey, south to St. Lucia, Lesser Antilles (Turner, 1955: 157). Living specimens are known only from Florida, the Bahamas, and Guadeloupe Island, Lesser Antilles, in depths ranging from 342 to 1,722 m.

Specimens Examined. UNITED STATES, FLORIDA: *Gerda,* station 266, off Fowey Rocks (25°38′N, 79°58′W) in 185–187 fathoms (338.3–342 m). BAHAMA ISLANDS: Tongue of the Ocean, about 4 miles off NE tip of Andros Island (24°54′N, 77°47′W) in 1,722 m. LESSER ANTILLES: *Pillsbury,* station 944, 4.5 miles N of Port Louis, Guadeloupe Island (16°32.2′N, 61°36.8′W) in 360–420 m.

TABLE 9. MEASUREMENTS OF *XYLOPHAGA DUPLICATA*.

Length (mm)	Height (mm)	Location
3.7	3.5	holotype
5.2	5.0	Gulf of Tehuantepec, Mexico
5.5	5.0	Gulf of Tehuantepec, Mexico

Xylophaga duplicata Knudsen
Plate 17

Xylophaga duplicata Knudsen, 1961, *Galathea* Report, 5: 175, figs. 14, 15 (*Galathea*, station 745, Gulf of Panama [7°15′N, 79°25′W] in 915 m). Holotype, Zoological Museum, University of Copenhagen.

Distinctive Characters. Plates of the mesoplax elongate oval, with a large ventral portion, somewhat inflated, diverging anteriorly, and standing off from the surface of the valves. Anterior adductor muscle extending into the cavity of the mesoplax. Anterior slope sculptured with numerous exceedingly fine, closely set denticulated ridges. Umbonal reflection narrow and erect. Umbonal–ventral sulcus narrow, slightly impressed, and bounded posteriorly by a faint, rounded ridge. Posterior adductor muscle scar oval and smooth. Umbonal–ventral ridge narrow, high, and segmented; ventral condyle small. Siphons of equal length, united except at the tip, the posterior three-fourths covered with a brown periostracal sheath; siphonal openings (apertures set on two short tubes) each with six to eight cirri.

Measurements. See Table 9.

Remarks. At the time Knudsen described this species he had only two specimens from the Gulf of Panama. Two additional specimens received from D. Shasky were taken by the San Juan Expedition at station N-12 from a sunken log dredged in 60 fathoms (109 m) in the Gulf of Tehuantepec, Mexico (15°08′N, 93°28′W). Although the specimens were in rather poor condition, the valves and siphons agree with those described by Knudsen. The mesoplax stands off from the surface of the shell and, as stated by Knudsen, is double, that is, has a basal portion, and the anterior muscle extends into the cavity of the mesoplax. The siphons are the same length, combined in a common sheath except at the tip, and are covered with a thin, brown periostracum. The white spots mentioned by Knudsen are not evident, but the few cirri surrounding the siphonal openings are similar.

Range. This record extends the geographic range of the species about 500 miles to the north. The depth range is from 109 to 915 m.

Xylophaga muraokai[5] Turner new species
Plates 18, 19

Holotype. MCZ 316746; paratypes, MCZ 316747, 316748, 316749, 316750.

Type Locality. U.S. Naval Civil Engineering Laboratory Test Site I, about 81 miles SW of Port Hueneme, California, or about 25 miles S of San Miguel Island, Santa Barbara Islands (33°44′N, 120°45′W) in 5,640 ft (1,720 m). The holotype was taken from a panel exposed on STU I-2 from October 1963 to October 1965.

Distinctive Characters. Plates of the mesoplax wedge-shaped, the basal portion large and the small dorsal portion covering only the posterior part of the muscle. Siphons smooth, of unequal length, the excurrent slightly shorter and with 8–10 prominent cirri.

Description. Shell globose, valves reaching 14 mm in length and 13 mm in height; the width of apposed valves about 12 mm. Valves thin but strong, white, with a thin clear, transparent to bright yellow periostracum. Angle of the pedal gape about 115°. Anterior slope sculptured with narrow, finely denticulated ridges that are widely spaced during early growth, becoming more closely spaced toward the ventral margin in older specimens. Holotype with 17 ridges on the anterior slope. Umbonal–ventral sulcus rather narrow, only slightly

[5] Named for James Muraoka, Biologist, U.S. Naval Engineering Laboratory, Port Hueneme, California.

depressed and sculptured with fine growth lines. Disc and posterior slope sculptured with growth lines only.

Inner surface of valves smooth and shining. Umbonal–ventral ridge narrow and marked with distinct transverse ridges that appear knobby in some specimens. Chondrophore and internal ligament well developed. Posterior adductor muscle scar large, elliptical, covering most of the posterior slope, and marked with irregular, faint depressions that generally cross the short axis of the scar. Pedal retractor muscle scar broadly oval in outline and located just anterior to and about midway on the posterior adductor scar. In some specimens, the two scars appear to be adjacent. Siphonal retractor muscle scars not clearly defined but located just posterior to the umbonal–ventral ridge about midway dorsoventrally. Ventral adductor muscle scar long, narrow, and traversing the ventral end of the umbonal–ventral ridge. Anterior adductor muscle scar covering the umbonal reflection and the ventral flange of the mesoplax.

Mesoplax small and divided. The ventral portion is a large, curved, wedge-shaped shield, fitting closely against the surface of the valves. Posteriorly, the mesoplax curves upward and forward covering the posterior portion of the anterior adductor muscle (Plate 18, Figs. 3–6).

Siphons smooth, united, and capable of extending over three times the length of the valves. Excurrent siphon only slightly shorter than the incurrent siphon. Aperture of the incurrent siphon bordered by 18–22 long, slender cirri that, in preserved specimens, curl inward and are not easily seen. At the base of these are numerous small cirri and, anterior to them on the inner wall of the siphon, 8–10 broad, branched cirri. Distal margin of excurrent siphon with two broad, short cirri on each side adjacent to the incurrent siphon, and 8–10 long, slender cirri, the longest located middorsally, with those on either side becoming progressively shorter.

The anterior adductor muscle inserts both on the anterior reflection and on the basal portion of the mesoplax. Siphonal retractor muscles straplike, extending anteriorly from the base of the siphons along the midportion and over the outer surface of the visceral mass to insert on the valves just posterior to the umbonal–ventral ridge. Ventral adductor muscle, formed as a thickened area of the fused mantle margin, inserts over and to each side of the ventral condyles. Pedal retractor muscles pass through the visceral mass and insert just anterior to the posterior adductor muscle.

TABLE 10. MEASUREMENTS OF *XYLOPHAGA MURAOKAI*.

Length (mm)	Height (mm)	Location
6.5	6.2	paratype
8.5	8.0	paratype
11.8	12.0	paratype
12.0	11.5	paratype
12.0	11.9	paratype
12.8	12.8	holotype
14.0	13.0	paratype

Measurements. See Table 10.

Remarks. The young of *X. muraokai* Turner n. sp. superficially resemble those of *X. concava* Knudsen, found in the Gulf of Panama, but differ in having a mesoplax with a large ventral portion, in having the excurrent siphon slightly shorter than the incurrent siphon, and in having a few large cirri on the excurrent siphon. From *X. duplicata* Knudsen, also from the Gulf of Panama, *X. muraokai* differs in lacking the brown periostracal sheath covering the siphons, in having an elongate rather than nearly circular posterior adductor scar, and in having the dorsal portion of the mesoplax reduced, covering only the posterior portion of the anterior adductor muscle.

As with all *Xylophaga* known to date, specimens of *X. muraokai* show considerable variation in size and sculpture depending on the type of wood in which they are boring. A specimen boring in greenheart with valves only 6 mm in length had 45 closely spaced denticulated ridges on the anterior slope, whereas a specimen of the same size in white pine had only 7 ridges. Although it is impossible to tell the exact age of these specimens, we know that the greenheart panel was exposed for 35 months and the white pine panels were exposed for 24 months. Other specimens in a white pine panel (exposed on the same rack for the same length of time as the greenheart panel) reached 12 mm in length and had only 24 ridges.

Large numbers of *X. muraokai* were taken from panels submerged for 2 years at 5,640 ft (1,720 m). The openings of the burrows averaged about 1 mm in diameter and increased rapidly. When specimens were uncrowded, the anterior end of burrows that had reached 15 mm in length averaged 12 mm in diameter; burrows 55 mm long averaged about 15 mm in diameter anteriorly. The tunnels often ran together and frequently two to six specimens occupied a large irregular cavity. Apparently, several specimens occasionally used a single opening to the surface.

Xylophaga muraokai Turner n. sp. is known only from the USNCEL Test Site I. It has never been taken from panels submerged at Test Site II, which is just north of San Miguel Island in about 2,370 ft (722 m). Differences in temperature, dissolved oxygen content of the water, and hydrostatic pressure between the two sites are probably the responsible factors. It is impossible to say whether or not they are all of equal importance.

Xylophaga washingtona Bartsch, a species of wide geographic and depth range, has been taken from wood exposed at Test Site I. It is the only species found at Test Site II, where it is abundant. For a comparison of the test sites, see Table 11. For a description of the test sites, see Muraoka (1964, 1965, 1966a, 1966b, 1966c, 1967).

Range. Known only from USNCEL Test Site I.

Specimens Examined. UNITED STATES, CALIFORNIA: USNCEL Test Site I (33°44′N, 120°45′W) about 81 nautical miles SW of Port Hueneme (about 25 miles S of San Miguel Island, Santa Barbara Islands); STU I-1 at 5,300 ft (1615.4 m) exposed March 1962–February 1965; STU I-2 at 5,640 ft (1,720 m) exposed October 1963–October 1965; STU I-4 at 6,800 ft (2,072.6 m) exposed June 1964–7 July 1965; STU I-5 at 6,000 ft (1,828.8 m) exposed 25 August 1965–12 February 1966.

Table 11. Comparison of the U.S. Naval Civil Engineering Laboratory test sites (average values taken from Muraoka, 1967).

Locality	Depth (ft)	Temperature (°C)	Dissolved Oxygen (ml/L)	Hydrostatic Pressure (psi)
Test Site I	5,640	2.5	1.26	2,482
Test Site II	2,370	5.0	.30	1,043

Xylophaga atlantica Richards
Plate 20

Xylophaga atlantica Richards, 1942, Nautilus, 56: 68, pl. 6, fig. 4 (east coast of the United States). Holotype, Academy of Natural Sciences Philadelphia 178741; Turner 1955, Johnsonia, 3(34): 152–154, pl. 91, figs. 1–6 (type locality, Mount Desert Island, Maine). (See Turner, 1955: 153.) [Not Turner, 1954, Johnsonia, 3(33): 5–6, pl. 4 = *X. clenchi* Turner and Culliney; see below.]

Distinctive Characters. Mesoplax small, anterior to and between the umbos, composed of two triangular plates that are in contact the length of the dorsal margin and meet at a broadly obtuse angle. Ventral portion of the mesoplax narrow, forming a small posterior cavity into which the posterior end of the anterior adductor muscle extends. Umbonal–ventral sulcus shallow with a median threadlike groove. Posterior adductor muscle scar elongate and irregularly marked. Excurrent siphon slightly shorter than the incurrent, the excurrent aperture with 15–20 large papillae, incurrent aperture with a double row of numerous minute papillae (Plate 20, Fig. 3).

Remarks. Between 16 June 1964 and 16 July 16 1965, the U.S. NOO submerged test panels off Mark Island, Penobscot Bay, Maine, in water 200 ft in depth. The panels were set in a vertical array at depths of 50, 100, 150, and 195 ft. Dissection of these panels showed that the bottom one had 85 specimens of *X. atlantica*, the one at 150 ft had six specimens, and the one at 100 ft had only one specimen. This suggests that, like *X. washingtona* Bartsch, *X. muraokai* Turner n. sp., *X. depalmai* Turner n. sp., and probably all *Xylophaga*, the larvae of this species do not rise very high in the water column and that the greatest decrease in attack occurs within a few feet of the bottom. Probably a panel touching or partially submerged in the substrate at this locality would have been heavily attacked. These tests also showed that the valves of *X. atlantica* may reach a length of at least 10.5 mm in a year. Several specimens removed from wood dredged off Ipswich, Massachusetts, in about 80 m averaged 14 mm in length. The maximum length for *X. atlantica* appears to be 15 mm.

The Ipswich specimens were well preserved and allow a more detailed description of the siphons than that given in the paper by Turner (1955) cited above. The siphons can be extended 1.5–2 times the length of the valves. The excurrent siphon is slightly shorter than the incurrent siphon and is combined with it for most of its length. The excurrent aperture is surrounded by 15–20 relatively large papillae that on the dorsal surface appear to be grouped in two lobes. The incurrent siphon is surrounded by an outer rim of small papillae and an inner one of slightly larger, stouter papillae (Plate 20, Figs. 1, 2).

Xylophaga atlantica is oviparous and does not brood its young. The reproduction and larval development of *X. atlantica* are fully discussed by Culliney and Turner (1976); they detail methods of laboratory culture and illustrate the various larval and growth stages. A reexamination of the specimen reported by Turner (1954: 5–6, pl. 4) has shown it to be *X. clenchi* Turner and Culliney, a species that usually is found with young attached to the parent. The adult of *X. clenchi* differs from that of *X. atlantica* in having a mesoplax that lacks a ventral portion, in the shape and type of marking on the posterior adductor muscle scar, in having a broad, rounded ridge posterior to the umbonal–ventral sulcus, and in the arrangement of the papillae on the siphons.

On the basis of the material then available, I formerly considered this species most closely related to *X. washingtona* Bartsch (Turner, 1956). It is now evident that these species belong to two different species groups. In *X. atlantica*, the excurrent siphon is only slightly shorter than the incurrent siphon and cirri surround the aperture of both siphons (Plate 20, Figs. 1–3). In addition, the posterior adductor scar is irregularly marked, whereas that of *X. washingtona* has regular herringbone markings.

Range. From Newfoundland south to Cape Henry, Virginia, in depths ranging from about 15 to 1,242 m.

Specimens Examined (New Records Since Turner, 1955). CANADA, NEWFOUNDLAND: ½ miles off Argentia in 18.3 m (test panel). NOVA SCOTIA: North Bay, Cape Breton Island (46°20′N, 61°50′W) in 128 m. UNITED STATES, MAINE: off Mark Island, Penobscot Bay, in 15.2 m, 30.5 m, 45.7 m, and 59.5 m (test panels). MASSACHUSETTS: 15 miles off Ipswich in 73 m; NE of Cape Cod Light off Truro in 40 m; E of Nantucket Island (41°23′N, 68°46′W).

Xylophaga washingtona Bartsch
Plate 21

Xylophaga washingtona Bartsch, 1921, Proceedings of the Biological Society of Washington, 34: 32 (San Juan Island, Washington). Holotype, U.S. National Museum (USNM) 334478; Turner, 1955, Johnsonia, 3(34): 154, pl. 92; Turner, 1956, Nautilus, 70: 10; Tipper, 1968, Ecological Aspects of Two Wood-Boring Molluscs from the Continental Terrace Off Oregon, Thesis, Department of Oceanography, Oregon State University, pp. 8–13, 64–118.

Distinctive Characters. Mesoplax small, anterior to and between the umbos, composed of two triangular plates that are in contact for the length of the dorsal margin and are set at a moderately obtuse angle to each other. Ventral portion of the mesoplax usually greater than one half the width of the dorsal portion and keeled. Umbonal–ventral sulcus broad and shallow. Posterior adductor muscle scar elongate oval in outline with regular herring-

TABLE 12. PENETRATION INTO WOOD OF *XYLOPHAGA WASHINGTONA* AT VARIOUS DEPTHS AND EXPOSURE TIMES.

Locality	Depth (m)	Exposure	Reference
3 miles off Oceanside, California	109	4 months	Turner, 1956
STU* II (1 and 2), California	722	6.5, 13.4 months	Muraoka, 1965, 1967
STU* I (1–4), California	1,615–2,066	4, 13, 25, and 35 months	Muraoka, 1964, 1966a, 1966b, 1966c
19 miles off Depoe Bay, Oregon	200	38 and 72 days	Tipper, 1968
25 miles off Depoe Bay, Oregon	500	2 months	Tipper, 1968
40 miles off Depoe Bay, Oregon	1,000	2 months	Tipper, 1968

* STU, submersible test unit.

bone markings. Proximal end of the combined siphons usually having a thin periostracal sheath. Excurrent siphon one third to one half the length of the incurrent siphon, truncated, and having a narrow ridge extending from each side for a short distance along the dorsal surface of the incurrent siphon. Excurrent siphonal opening small, located at the end of a short tube extending between the lateral ridges, and apparently lacking papillae (Plate 21, Figs. 2, 3). Incurrent siphonal opening margined by 15 inwardly extending papillae (Plate 21, Fig. 4).

Remarks. In recent years a great deal has been added to our knowledge of the distribution of *X. washingtona,* and interesting observations have been made concerning its ecology and variation. The many specimens taken from the STU panels exposed by the USNCEL off San Miguel Island, California, have shown that a great deal of variation exists in the shape and sculpture of the valves as well as the size of the posterior adductor muscle in response to the hardness of the substrate in which they are boring. This is discussed in the section on Variation. From these tests we have also learned that larval and adult *X. washingtona* can tolerate a wide range in dissolved oxygen concentration. They were the only borers taken from the STU II test site where the concentration was 0.30 ml/L. The temperature at this site was 5.0° C (Muraoka, 1965). Based on adults dissected from new wood exposed at various sites with known dates and depth of submergence, it has been possible to determine the depth at which the larvae can successfully penetrate. These data are summarized in Table 12.

A single large specimen was taken in 18.3 m from wood that had been removed from old street cars and used to make Hermosa Reef, ½ mile west of Hermosa Beach, Santa Monica Bay, California. This is the shallowest record known for the settlement of larvae. The apparent scarcity of specimens suggests that this is the upper limit of the depth range. Living specimens have been taken from a fir log dredged from 73 m off Vancouver Island, British Colombia. Although no testing has been done in this area, it is likely that, in these colder waters, *X. washingtona* could occur at shallower depths.

Muraoka (1966c) found that "wood specimens which were exposed near the sediment were damaged considerably more severely than those specimens which were exposed about 3 feet above the sediment." This, he said, "indicates that the deep sea borers are very active in large numbers immediately above the sediment layer and that their numbers tend to decrease in seawater as the distance from the sediment layer increases." Tipper (1968) showed that the settlement of larvae of *X. washingtona* off Depoe Bay, Oregon, was densest in proximity to the sea–sediment interface and that the drop in borer penetration usually occurred within the first 6 cm upward from the interface. He also showed that, from the initial penetration very close to the sea–sediment interface, the attack progressed upward with increasing time of exposure. Analyses of these data suggest that 1) the free-swimming larvae of *X. washingtona* probably do not rise more than 10–25 ft above the sea floor; 2) as the attack increases, competition occurs for space; and 3) the second crop of larvae, prevented from settling on the lower levels because of the activity of the siphons of specimens already in the wood, are kept swimming and eventually settle on surfaces higher up in the water column.

Tipper (1968) also pointed out that the depth of penetration decreased with increased density of the wood. Cedar, pine, fir, and oak panels exposed for 50 days at a depth of 200 m showed an average penetration of 3.8 mm in cedar, 3 mm in pine, 1.5 mm in fir, and 0.5 mm in oak. Decrease in depth of penetration also is related to increase in depth of exposure. This, he postulated, may be correlated with lower temperatures resulting in slower growth rates or with the increased density of the wood from compression at great depth.

These observations agree with those obtained from the tests off southern California (see section on Variation in the Introduction). From the STU samples we found that the softer the wood (except balsa), the deeper the *Xylophaga* penetrated and the greater was the development of the chimney of fecal pellets. In a cedar panel exposed on STU I-5 for 6 months, two sets of *X. washingtona* were found; the earlier set had tunnels averaging 10–12 mm in length, and the second set had tunnels averaging 5 mm in length. Another panel on STU I-1 exposed for 35 months had specimens with tunnels reaching 35 mm in length. These tunnels averaged 10 mm in diameter at the anterior end; a chimney of rather coarse fecal pellets lined the posterior 15 mm of the burrow. Considering the greater depth of the STU panels and realizing that the rate of growth decreases with age, these growth rates agree with those reported by Tipper (1968).

Based on data gathered to date from test panels, it would appear that *X. washingtona* probably breeds throughout the year and that the entire larval life is spent in the sea. Young specimens have never been found attached to the shells of the hundreds of adults examined.

Range. From Vancouver Island, British Columbia, south to the Santa Barbara Islands, California, in depths ranging from 20 to 2,000 m.

Specimens Examined (New Records Since Turner, 1955). CANADA, BRITISH COLOMBIA: Satellite Channel, between Saltspring and Vancouver Islands in 93 m (C. Carl). UNITED STATES, OREGON: about 30 miles W of Seaside (46°00′N, 124°48′W) in 464.5 m; about 50 miles W of Tillamookhead (45°54′N, 125°09′W) in 1,554.4 m; about 40 miles W of Silver Point (45°52′N, 124°54′W) in 822.9 m (all Oregon State University); 19 miles W of Depoe Bay (44°52′N, 124°54′W) in 200 m; 25 miles W of Depoe Bay (44°52′N, 124°36′W) in 500 m; 40 miles W of Depoe Bay (44°52′N, 125°01′W) in 1,000 m (all R. Tipper). CALIFORNIA: Hermosa Reef, ½ mile off Hermosa Beach in 18.3 m (J. Fitch); 3 miles off Camp Pendleton pier, Oceanside, in 100 m (F. Snodgrass); USNCEL STU II (1 and 2), 75 miles W of Port Hueneme or about 5 mi NW of San Miguel I., Santa Barbara Islands (34°06′N, 120°42′W) in 722 m; USNCEL STU I (1, 4, and 5), 81 miles SW of Port Hueneme or 25 miles SW of San Miguel Island, Santa Barbara Islands (33°44′N, 120°45′W) in 1,524–2,066 m (both J. Muraoka); Allan Hancock station 1372–41, about ¾ mile E of Empire Landing, Santa Catalina Island, Santa Barbara Islands (33°25′50″N, 118°24′50″W) in 84 m (Allan Hancock Foundation); 2 miles off Eel Point, San Clemente Island, Santa Barbara Islands in 72.2 m (F. Snodgrass).

Xylophaga rikuzenica Taki and Habe
Plate 22

Xylophaga rikuzenica Taki and Habe, 1945, Japanese Journal of Malacology (Venus), 14: 112 (off Rikuzen, Honshu, Japan). Holotype, T. Habe Collection; paratype, MCZ 194821. *Neoxylophaga rikuzenica* (Taki and Habe) 1950, Illustrated Catalogue of Japanese Shells, no. 7, p. 46, text-figs. 4, 5.

Distinctive Characters. Mesoplax composed of two inflated triangular plates with a large basal portion and ventral keel; plates in contact both dorsally and ventrally for the length of the medial margin (Plate 22, Figs. 5–7). Posterior adductor muscle scar elongate oval, tapering dorsally, and with regular herringbone markings. Valves and dorsal plates covered with a heavy, brown periostracum. Umbonal–ventral sulcus wide and deep (Plate 22, Figs. 2, 4).

Remarks. Taki and Habe (1945) briefly described this species in Japanese but included no figures. In 1950, they created the genus *Neoxylophaga* with *rikuzenica* as the type species, mentioning the small, triangular mesoplax and thick, brown periostracum as generic characters. Turner (1956) related *X. rikuzenica* to *X. washingtona* Bartsch on the basis of the dorsal plates. A paratype specimen, received through the kindness of Dr. Habe, shows that the posterior adductor muscle scar is similar to that of *X. washingtona* Bartsch, *X. praestans* Smith, and *X. aurita* Knudsen, the other species in this group with simple, unfringed lappets extending from the truncation of the excurrent siphon. *Xylophaga rikuzenica* is closely related to but differs from *X. washingtona* mainly in having a heavy, brown periostracum covering the valves and mesoplax as well as in having a much wider, deeper umbonal–ventral sulcus. Unfortunately, the siphons of *X. rikuzenica* are unknown so comparisons cannot be made on that basis. However, all species with regular herringbone markings on the posterior adductor scar known to date have similar siphons so *X. rikuzenica* can be assumed to belong to the same group. No *Xylophaga* have been taken north of Vancouver, British Columbia, but continuous collecting across the north Pacific may show that *X. rikuzenica* merges with *X. washingtona*. Until this is done, the two species are being maintained because they are recognizable and may not merge.

Range. Known only from off Rikuzen and Toyama Bay, Honshu, Japan, in depths ranging from 100 to 700 fathoms (183 to 1,270 m) (Taki and Habe, 1950).

Specimens Examined. JAPAN: off Rikuzen, Honshu in 183 m.

Xylophaga depalmai[6] Turner new species
Plates 23, 24

Holotype. MCZ 316735.

Type Locality. 3.2 miles off Fort Lauderdale, Florida (26°04′N, 80°04′W) in 152.4 m (500 ft) in a test panel.

Distinctive Characters. Shell globose, anterior slope with fine, closely set, denticulated ridges; umbonal–ventral sulcus shallow and bounded posteriorly by an indistinct ridge; posterior slope smooth. Umbonal–ventral ridge narrow and high. Muscle scars barely impressed and smooth. Mesoplax composed of two inflated, elongate plates that are coiled posteriorly, vary in shape, and are occasionally fused. Excurrent siphon truncate; lappets on dorsal surface of incurrent siphon with exceedingly fine serrations.

Description. Shell globose, valves reaching 9.8 mm in length and 9 mm in height, thin, fragile, and with a thin transparent periostracum. Pedal gape angle about 95–105°. Anterior slope sculptured with exceedingly fine, closely set, denticulated ridges; specimens 8 mm long had 40–66 ridges. Posterior portion of the anterior slope rather wide and the ridges extending to the umbonal–ventral sulcus more coarsely denticulate. Umbonal–ventral sulcus barely impressed, nearly smooth, and bounded posteriorly by a fine, indistinct ridge. Disc and posterior slope faintly marked with growth lines. Posterior slope with a low, smoothly curved dorsal margin that is not reflected.

Inner surface of valves smooth and glistening. Umbonal–ventral ridge narrow, high, and not enlarging at the ventral margin to form a knoblike condyle. Posterior adductor muscle scar barely impressed, rather small, oval, smooth, and set high on the posterior slope. Pedal retractor scar dumbbell-shaped or as two adjacent cir-

[6] Named for John DePalma, U.S. Naval Oceanographic Office, who was responsible for the tests off Fort Lauderdale, Florida; in the Tongue of the Ocean, Bahama Islands; and in Penobscot Bay, Maine.

Table 13. Measurements of *Xylophaga depalmai*.

Length (mm)	Height (mm)	Location
6.0	5.5	off Fort Lauderdale, Florida
7.6	7.0	off Fort Lauderdale, Florida
8.0	7.5	holotype
8.2	8.2	off Fort Lauderdale, Florida
8.5	7.0	off Fort Lauderdale, Florida
9.8	9.0	off Fort Lauderdale, Florida

cles just anterior to the posterior adductor scar. Ventral adductor scar large, elongate, irregularly oval, located posterior to the umbonal–ventral ridge and paralleling the ventral margin of the valve. Siphonal retractor scar small, broadly oval, and located just posterior to the umbonal–ventral ridge at the level of the pedal retractor scar. Anterior adductor scar covering the umbonal reflection and the lower surface of the mesoplax. Chondrophore and internal ligament well developed.

Mesoplax composed of two inflated, posteriorly coiled plates that may be asymmetrical, have a well-developed ventral portion, are longer than wide, with the medial margin of the plates parallel and occasionally with the two parts fused (Plate 24, Figs. 3–17).

Burrow length of specimens with valves 4–8 mm in length varying from 1.5 to 4 times the length of the valves. Posterior end of the burrows usually with a smooth, firmly packed chimney composed of fine wood fragments.

Siphons capable of complete retraction within the valves. Excurrent siphon truncated just posterior to the valves and lacking cirri. Finely serrated lappets extend from the truncation along either side of the dorsal surface of the incurrent siphon. Incurrent siphon with fine cirri surrounding the aperture. Base of the siphons covered by a fine periostracal sheath that extends along the sides of the siphons and contains fine, irregular, glasslike granules (Plate 23, Figs. 1, 4, 5).

Measurements. See Table 13.

Remarks. This species is most closely related to *X. guineensis* Knudsen from the Gulf of Guinea, West Africa. *Xylophaga depalmai* differs in being larger, having an elongate mesoplax, the posterior end of which fits between the umbos, and in having more coarsely serrated lappets on the siphons. (See also Remarks under *X. guineensis.*) From *X. tipperi* Turner n. sp., to which it is also related, *X. depalmai* differs in having an elongate inflated mesoplax that fits between the umbos rather than a broad flattened one that covers them, in having finely serrated lappets on the siphons, in having the granules on the siphons only in the periostracum rather than being embedded in the tissue, and in producing a chimney. From *X. mexicana* Dall, which it also somewhat resembles, *X. depalmai* differs in the shape of the mesoplax, in having narrower, more finely fringed lappets on the siphons, an inconspicuous ridge posterior to the umbonal–ventral sulcus, and an exceedingly thin periostracum. In addition, the granular inclusions on the siphons of *X. mexicana* are coarse, chalky, white, and arranged in a single line extending nearly the length of the siphons.

Variation exhibited in the mesoplax of *X. depalmai* is unusual and unexpected, for in most species of *Xylophaga* the mesoplax is remarkably uniform unless the specimen is injured or stenomorphic. The extreme forms (Plate 24, Figs. 11–15) are sufficiently different to be considered of specific value in this genus. However, in the more than 300 specimens obtained from the test site off Fort Lauderdale, connecting forms exist between them. The characters of the shell, the siphon, and soft parts are similar in all specimens. Consequently, because the large majority are typical (Plate 24, Figs. 16, 17), the extremes are considered to be variants.

Xylophaga depalmai Turner n. sp. was the most common species occuring in the Fort Lauderdale test. It ranged from 1 to 3.2 miles off shore and occurred in boards placed near the bottom in depths from 100

TABLE 14. DATA FOR ALL OF THE SPECIMENS OF *XYLOPHAGA DEPALMAI* N. SP. FOUND IN THE COLLECTING PANELS OFF FORT LAUDERDALE, FLORIDA.

Panel no.	Distance From Shore (miles)	Bottom Depth in Feet (m)	Depth of Panel in Feet (m)	Date of Submergence	Date of Removal	No. Specimens Examined
2 panels without numbers	2.5	300 (91.44)	on bottom	Sept. 1961	June 1962	±250
W44	1.8	100 (30.48)	on bottom	Jan. 1964	Oct. 1964	1
H50	2.3	200 (60.96)	100 (30.48)	Jan. 1964	Oct. 1964	2
H56	2.3	200 (60.96)	on bottom	Jan. 1964	Sept. 1964	5
G62	2.6	300 (91.44)	200 (60.96)	Jan. 1964	Sept. 1964	6
G68	2.6	300 (91.44)	on bottom	Jan. 1964	Sept. 1964	31
J59	2.3	200 (60.96)	on bottom	24 Jan. 1964	4 Jan. 1965	3
492	3.2	500 (152.4)	200 (60.96)	20 Oct. 1965	13 Oct. 1965	3
493	3.2	500 (152.4)	200 (60.96)	20 Oct. 1965	13 Oct. 1966	10
497	3.2	500 (152.4)	300 (91.44)	20 Oct. 1965	13 Oct. 1966	5
498	3.2	500 (152.4)	300 (91.44)	20 Oct. 1965	13 Oct. 1966	7
500	3.2	500 (152.4)	400 (121.92)	20 Oct. 1965	13 Oct. 1966	3
501	3.2	500 (152.4)	400 (121.92)	20 Oct. 1965	13 Oct. 1966	2
502	3.2	500 (152.4)	400 (121.92)	20 Oct. 1965	13 Oct. 1966	3
504	3.2	500 (152.4)	on bottom	20 Oct. 1965	13 Oct. 1966	8
505	3.2	500 (152.4)	495	20 Oct. 1965	13 Oct. 1966	6

to 500 ft (30.5 to 152.4 m). In addition, a few specimens were found in boards 100, 200, and even 300 ft off the bottom, which means that, in this species at least, the larvae range well up in the water column. As can be seen from Table 14, panels on the bottom in 300 ft (91.4 m) were the most heavily attacked. This may reflect cyclic variation in population density because the panels were exposed at different times, or that, because of the configuration of the bottom and the currents, more wood was available on the bottom in this vicinity, supporting a native population and a ready source of larvae. However, this also may indicate that this is the optimum depth for this species.

According to DePalma (1969), the salinity at the test site was uniformly high and the temperature of the water ranged from 24 to 30° C at the surface, from 20 to 25° C at 100 m, and from 7 to 9.5° C at 153 m. The northward-flowing Florida Current averaged 1.5 knots.

Range. From Florida north to Massachusetts in depths ranging from about 30 to 174 m.

Specimens Examined. UNITED STATES, FLORIDA: off Fort Lauderdale (26°04′N, 80°04′W). See Table 14. Additional records include: FLORIDA: 160

miles W of Tampa, OTEC station 3089 in 126 m; and OTEC station 3086 in 96 m. RHODE ISLAND: From rosewood panels tied to lobster pot set at 39°57′N, 69°19′W in 45.7 m (Knutton, from Al Eagle's ship *Reliance*). MASSACHUSETTS: *Delaware II*, station 369 (42°37′N, 66°27′W) from wood dredged from 174 m.

Xylophaga guineensis Knudsen
Plates 25, 26

Xylophaga guineensis Knudsen, 1961, *Galathea* Report, 5: 195–196, fig. 38 (*Galathea*, Station 52, off West Africa, 01°42′N, 07°51′E in 2,550 m). Holotype, Zoological Museum, University of Copenhagen.

Distinctive Characters. Valves globose, with exceedingly fine, closely spaced, denticulated ridges; umbonal–ventral sulcus barely impressed, bounded by a weak anterior ridge and a well-marked, narrow posterior ridge. Mesoplax composed of two inflated cornucopialike plates.

Description. Valves globose, reaching 2.2 mm in length, thin, and fragile. Pedal gape angle about 90°. Anterior slope sculptured with exceedingly fine, evenly spaced, denticulated ridges, there being about 45 in a specimen 2 mm long. Umbonal–ventral sulcus only slightly impressed, bounded anteriorly by a low, inconspicuous, rounded ridge and posteriorly by a narrow, well-defined ridge, occasionally almost bladelike. Disc and posterior slope smooth.

Inner surface of valves smooth and glistening. Muscle scars barely visible. Posterior adductor scar smooth, lobed anteriorly with the small pedal retractor just anterior to it in the upper embayment. Umbonal–ventral ridge and condyle prominent, with a parallel groove posterior to the ridge. This groove is the internal expression of the ridge bounding the sulcus on the outer surface.

Mesoplax composed of two smooth, inflated, cornucopialike plates, the horns of which curl toward each other (Plate 25, Figs. 3, 6, 8, 9); the two halves usually equal and mirror images but occasionally unequal and varying in size and shape.

Siphons about equal to the length of the shell, capable of complete retraction within the valves. Excurrent siphon truncated, about one third the length of the incurrent siphon, with narrow and minutely serrated lappets extending from the truncation along the dorsal surface of the incurrent siphon. Base of siphons covered by a filmy periostracal sheath with fine, irregular, whitish granules imbedded in it along the sides of the siphons (Plate 25, Figs. 1, 2).

Table 15. Measurements of *Xylophaga guineensis*.

Length (mm)	Height (mm)	Location
0.9		*Pillsbury*, station 260
1.3	1.2	*Pillsbury*, station 260
1.3	1.5	paratype (estimated from Knudsen, 1961, fig. 38b)
1.5	1.3	*Atlantique Sud*, station 33
2.2	2.2	*Atlantique Sud*, station 33

Measurements. See Table 15.

Remarks. When Knudsen described *X. guineensis* he had only "very fragmented shells of 5–6 individuals removed from a piece of wood; not a single complete shell present." One specimen had a complete mesoplax although only the umbonal area of the valves was present. The species was diagnosed on the basis of the mesoplax and the large sculptured, bright yellow prodissoconch.

In the course of examining wood dredged from off the western coast of Africa, I obtained four dead specimens, one with a complete mesoplax (*Atlantique Sud*, station 33), and seven small living specimens, two complete (*Pillsbury*, station 260), all of which appear to be this species. The two plates of the mesoplax of these specimens are mirror images of each other (Plate 26, Figs. 2–4). As shown under *X. depalmai* (Plate 24, Figs. 11, 12), the mesoplax is not always bilaterally symmetrical. Therefore, these new specimens from off the western coast of Africa are being considered *X. guineensis* and a description of the species based on entire specimens is given.

Although stenomorphs are commonly found in *Xylophaga* (see section on Variation), the specimens dissected from the wood dredged by the *Atlantique Sud* Expedition and the *Pillsbury* did not appear to be stunted or malformed in any way. They were not crowded and the wood was not particularly hard. Consequently, on the basis of the large number of evenly spaced ridges on the anterior slope, the well-developed mesoplax, the strength of the ridge bounding the umbonal–ventral sulcus posteriorly, and the small size of the specimens, I consider this to be a small species.

All the major characters of the siphons mentioned in the description could be seen with a dissection scope at 250×. However, the fringe on the lappets could only be detected under a compound microscope at 430×. It was impossible to determine whether or not the fringe extended the entire length of the lappet on the two specimens that had extended siphons. The siphons appear similar to those of *X. depalmai*.

Xylophaga guineensis is most closely related to *X. depalmai* taken from waters off Florida and the Bahamas. *Xylophaga guineensis* differs in being smaller; in having a smooth mesoplax composed of inflated, tubular, cornucopialike plates; in having more numerous and closely spaced, denticulated ridges on the anterior slope when comparing specimens of equal size; and in having a larger, more prominent, strongly sculptured prodissoconch. (See also Remarks under *X. depalmai*.)

The specimens that Knudsen described were taken from wood dredged in 2,550 m but the three lots of new material were from 147, 145, and 46 m. Although *X. guineensis* may extend into deep water, it is probably a fairly shallow water species, and this would agree with the known depth range of *X. depalmai*, the species to which it is most closely related. The fact that Knudsen's specimens were all dead and fragmented further substantiates the possibility that the wood was carried into deeper water after it was invaded by *X. guineensis*. The continental shelf in this area is narrow and such a movement of wood on the bottom could easily take place.

Range. Gulf of Guinea, West Africa, in depths ranging from 46 to 147 m (living material) and in 2,550 m (dead).

Specimens Examined. CAMEROONS: *Pillsbury*, station 260, off Santa Isabel Island (3°45′N, 9°05′E) in 46 m. GABON: *Atlantique Sud*, station 146, about 46 miles NNE of Port Gentil (0°03′S, 9°07′E) in 147 m; *Atlantique Sud*, station 33, 35 miles W of Ambrizette (7°16′S, 12°17′E) in 145 m.

Xylophaga mexicana Dall
Plates 27, 28

Xylophaga mexicana Dall, 1908, Bulletin Museum of Comparative Zoology, 43(6): 425 (*Albatross*, station 3422, off Acapulco, Mexico [16°47′N, 99°59′W] in 141 fathoms [257.9 m]). Holotype USNM 122947; Turner, 1955, Johnsonia, 3(34): 150, pl. 90.

Distinctive Characters. Umbonal–ventral sulcus bounded posteriorly by a narrow, sharp ridge. Mesoplax ear-shaped, inflated, the two halves not meeting medially except at the posterior end. Excurrent siphon truncated; lappets extending along the dorsal surface of the incurrent siphon finely fringed. Siphons with a single row of opaque white granules imbedded along the sides. Posterior quarter of the incurrent siphon papillose.

Description. Shell globose, valves reaching 10.5 mm in length and 9.5 mm in height, thin, fragile, and with a thin, light straw-colored periostracum on the posterior slope. Pedal gape angle about 110°. Anterior slope with exceedingly fine, closely set, denticulated ridges. Umbonal–ventral sulcus rather narrow, moderately deep, and bounded posteriorly by a narrow, sharp ridge. Disc and posterior slope sculptured with fine growth lines. Posterior margin broadly rounded. Posterior slope becoming proportionately more elongate with increased size and age, as indicated in the measurements. Umbonal reflection free and recurved anteriorly, appressed posteriorly, and covering the anterior portion of the umbonal area.

Inner surface of the valves white, smooth, and glazed. Umbonal–ventral ridge narrow, slightly segmented, and broadening only slightly toward the ventral margin to form the condyle. Posterior adductor muscle scar well impressed, smooth, broadly oval in outline, set high on the posterior slope and at the posterior margin of the valve. Pedal retractor scars nearly circular, double, and adjacent to the embayment on the anterior margin of the posterior adductor scar. Ventral adductor scar large, irregularly oval in outline, and well posterior to the umbonal–ventral ridge. Siphonal retractor scar small, bilobed, and located posterior to the umbonal–ventral ridge at a level corresponding to the pedal retractor scars. Anterior adductor scar covering the umbonal reflection. Chondrophore and internal ligament well developed.

Mesoplax somewhat variable but usually slightly longer than wide, with the medial margin of the two halves diverging. Plates ear-shaped, inflated, coiled posteriorly, and covering the umbos.

Siphons capable of complete retraction within the valves and of extension to at least 1.5 times the length of the valves. Excurrent siphon truncated, about one third the length of the incurrent siphon, and lacking cirri. Lappets extending from the truncation of the excurrent siphon finely fringed. Posterior portion of the incurrent siphon papillose; inner edge of siphonal opening margined with numerous minute cirri. Siphons with thin periostracal sheath posteriorly and with a single row of white, opaque, irregular granules embedded along the sides.

Measurements. See Table 16.

Table 16. Measurements of *Xylophaga mexicana.*

Length (mm)	Height (mm)	Location
4.8	4.5	Malibu Reef, California
5.0	4.2	holotype
7.5	7.3	Malibu Reef, California
8.0	7.3	Santa Monica Reef, California
9.0	9.5	Hermosa Reef, California
10.5	9.0	Santa Monica Reef, California

Remarks. Xylophaga mexicana Dall was described on the basis of two right valves that were in rather poor condition and lacked a mesoplax. Consequently, it has been impossible up to now to relate it to other species. Valves of living specimens taken off California agree with those of the holotype of *X. mexicana.* Dall's specimen was from much deeper water (141 fathoms) than the Californian series (about 19 fathoms) but it could have been advectitious at that depth. *Xylophaga mexicana* Dall could, of course, be considered a *nomen dubium* but this would necessitate describing the Californian specimens. Because the valves of these specimens resemble the holotype of *X. mexicana* sufficiently well to carry the name, it seems best to establish that taxon firmly on the basis of this new material.

The size of the beaks, the smooth muscle scars, and the narrow, rather deep umbonal–ventral sulcus with a pronounced ridge at its posterior margin relate *X. mexicana* to *Xylophaga globosa* Sowerby from Chile (Turner, 1955). *Xylophaga mexicana* differs from *X. globosa* in having a much finer fringe on the lappets, in having a series of irregular, opaque granules along the sides of the siphons, and in having the posterior portion of the incurrent siphon papillose. In addition, the mesoplax of *X. mexicana* is proportionately much smaller than that of *X. globosa,* and the two plates diverge medially. In his original description, Dall (1908) did not relate *X. mexicana* to any other species in the genus. One year later (Dall, 1909), he gave the range of *X. globosa* Sowerby as from Panama to Chile but cited no specific localities. The Panamanian specimens on which he based this range may well have been *X. mexicana.* I have not seen a specimen of *X. globosa* from north of Chiloe Island, Chile. The valves of *X. duplicata* somewhat resemble those of *X. mexicana*; however, the siphons of these two species place them in different groups. (See also Remarks under *X. tipperi* Turner n. sp. and *X. japonica,* the species to which *X. mexicana* is most closely related.)

Through the kindness of John Fitch and Charles Turner of the California State Fisheries Laboratory, Terminal Island, California, I received 55 specimens of *X. mexicana* taken from test panels exposed on the "replication reef experiments" conducted by that laboratory. Old streetcars, automobile bodies, concrete shelters, and rocks were dumped offshore in several localities to serve as settling areas for marine organisms and to make the area more attractive to fish. Within a short time, the test panels and wooden portions of the streetcars were attacked by teredinids and *Xylophaga*. Because all the specimens had been dissected from the wood, it is impossible to say whether or not they produced a chimney.

Range. Living specimens known only from Santa Monica Bay, California, in about 35 m.

Specimens Examined. MEXICO: Bocochibampo, Sinaloa (dead). UNITED STATES, CALIFORNIA: All from "replication reefs" off Hermosa, Malibu, Redondo, and Santa Monica (about 33°50′N, 118°30′W) in about 35 m.

Xylophaga tipperi Turner new species
Plate 29

Holotype. MCZ 316736; paratype, MCZ 316737.

Type Locality. 3.2 miles off Fort Lauderdale, Florida (26°04′N, 80°04′W) in 152.4 m (500 ft) in a U.S. NOO test panel, submerged from October 1965 to October 1966.

Distinctive Characters. Umbonal–ventral sulcus bounded by low rounded ridges. Mesoplax ear-shaped, slightly longer than wide, compressed, and with a sharp peripheral keel. Excurrent siphon truncated; lappets on dorsal surface of incurrent siphon with a coarse fringe. Siphons with a single row of minute glasslike plaques embedded along the side and with knobby pustules at the posterior end.

Description. Shell globose, reaching 9 mm in length and 8.5 mm in height, thin, fragile, with prominent umbos and a dull, light brown periostracum. Pedal gape angle about 110°. Anterior slope sculptured with numerous close-set, denticulated ridges, there being 25 on the holotype. Umbonal–ventral sulcus slightly depressed, bounded by a threadlike rounded ridge anteriorly and a somewhat heavier one posteriorly. Posterior slope low and sculptured with distinct growth lines. Umbonal reflection free for most of its length, the ventral edge of the mesoplax fitting beneath it anteriorly.

Inner surface of the valves smooth and glistening. Umbonal–ventral ridge very prominent, nearly smooth, and not greatly enlarged ventrally at the condyle. Chondrophore and internal ligament well developed. Posterior adductor muscle scar oval, tapering dorsally, only slightly impressed, and smooth. Pedal retractor scar kidney-shaped and located adjacent to the anterior margin of the posterior adductor scar, about midway dorsoventrally. Siphonal retractor scar lightly impressed, located just posterior to the umbonal–ventral ridge at the level of the ventral margin of the beak. Ventral adductor scar usually not visible but located near the ventral margin posterior to the umbonal–ventral ridge.

Mesoplax large, ear-shaped, covering the umbos, longer than wide, compressed dorsoventrally, with a sharp peripheral keel, and a coiled early portion.

Siphons united, excurrent siphon truncated, about one third the length of the incurrent siphon. Lappets extending from the truncation along the dorsal surface of the incurrent siphon with a coarse fringe. Incurrent siphon papillose posteriorly, with a single row of glasslike plaques imbedded along the side at the juncture of the lappets and the excurrent siphon and with numerous small, broad papillae surrounding the inner rim of the aperture.

TABLE 17. MEASUREMENTS OF *XYLOPHAGA TIPPERI*.

Length (mm)	Height (mm)	Location
2.0	2.0	off Fort Lauderdale, Florida
4.6	4.1	off Fort Lauderdale, Florida
7.5	7.0	off Fort Lauderdale, Florida
8.2	7.5	off Fort Lauderdale, Florida
9.0		holotype

Burrows reaching 20 mm in length. Fecal pellets not formed into a chimney.

Measurements. See Table 17.

Remarks. This species is closely related to *X. mexicana* Dall from California but differs in having a compressed, sharply keeled mesoplax; in having glasslike rather than white, chalky plaques imbedded in the siphons; and in having much more coarsely fringed lappets on the siphons. *Xylophaga tipperi* differs from *Xylophaga dorsalis* Turton in having a definitely sculptured mesoplax, an excurrent siphon one third to one half the length of the incurrent (in *X. dorsalis* it is truncated at the posterior end of the valves), and in having glasslike plaques imbedded in the walls of the siphons. In addition, on the basis of the limited material now available, *X. tipperi* apparently does not build a chimney. *Xylophaga tipperi* differs from *X. depalmai* Turner n. sp., also from off Fort Lauderdale, in having a compressed, sharply keeled mesoplax, a much coarser fringe on the lappets, and in having glasslike plaques imbedded in a single line along the sides of the siphons. In addition, the posterior end of the incurrent siphon of *X. tipperi* is papillose. *Xylophaga bayeri* Turner n. sp., which also is found in Florida and the West Indies, differs from *X. tipperi* and all other species in Group 6 in having a broad, horizontal mesoplax (Plate 31, Fig. 3).

Only eight specimens of *X. tipperi* Turner n. sp. were obtained. They were all from panel 505 and were collected along with *X. depalmai* Turner n. sp. The specimens, even the smallest, were consistent in having a broad, compressed mesoplax as well as in the characteristics of the siphons. For data on the testing site, see information under *X. depalmai.*

Range. Known only from off Fort Lauderdale, Florida, in 152.4 m.

Specimens Examined. UNITED STATES, FLORIDA: 3.2 miles off Fort Lauderdale (26°04′N, 80°04′W) in 152.4 m (500 ft) in a test panel.

Xylophaga bayeri[7] Turner new species
Plates 30, 31

Holotype. MCZ 316738; paratype, MCZ 316739.

Type Locality. U.S. NOO test site, about 3.2 miles off Fort Lauderdale, Florida (26°04′N, 80°04′W) in 152.4 m (500 ft). From test panels submerged from October 1965 to October 1966.

Distinctive Characters. Posterior margin of the umbonal–ventral sulcus bounded by a pronounced, sharp ridge. Mesoplax of adult much broader than long, extending laterally as wings and with a sharp peripheral margin. Excurrent siphon truncated, about one third the length of the incurrent siphon. Lappets extending along the dorsal surface of incurrent siphon finely fringed.

Description. Shell globose, reaching 8 mm in length, thin, fragile, with prominent umbos and a heavy, golden-brown periostracum covering the shell and the mesoplax. Pedal gape angle about 120°. Beaked portion of anterior slope sculptured with numerous, closely set, denticulated ridges, there being 32 on the holotype. Posterior portion of the anterior slope narrow, the ridges very closely packed. Umbonal reflection broad, closely appressed over the umbos, free anteriorly, and with a funnel-like pit beneath. Umbonal–ventral sulcus moderately impressed, sculptured with growth lines, and bounded posteriorly by a pronounced, sharp ridge. Posterior slope rather low and sculptured with well-marked growth lines.

[7] Named for Frederick M. Bayer, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, Florida, who kindly loaned material collected by the research vessels *Pillsbury* and *Gerda.*

TABLE 18. MEASUREMENTS OF *XYLOPHAGA BAYERI*.

Length (mm)	Height (mm)	Location
8.0	7.5	holotype
4.2	4.0	off Mona Island, Puerto Rico
5.4	4.9	*Gerda,* station 266
6.0	5.2	*Gerda,* station 266
6.0	5.8	*Gerda,* station 266
6.2	6.0	*Gerda,* station 266
6.8	6.0	*Gerda,* station 266
8.0	8.2	*Gerda,* station 266

Inner surface of valves smooth and glistening. Umbonal–ventral ridge very prominent and distinctly segmented but not greatly enlarged ventrally at the condyle. Chondrophore and internal ligament well developed. Posterior adductor muscle scar elongate oval in outline, tapering dorsally, and smooth. Pedal retractor scar broadly oval and contiguous with the anterior margin of the posterior adductor. Ventral adductor scar large, located adjacent to the groove margining the umbonal–ventral ridge posteriorly. Siphonal retractor scar lightly impressed and located just posterior to the umbonal–ventral ridge on a level with the ventral margin of the beak. Anterior adductor scar well marked and covering most of the umbonal reflection.

Mesoplax in young specimens composed of a large ventral plate with a small, triangular dorsal portion (Plate 31, Fig. 5). Dorsal plate of the adult is much wider than long, with a sharp perphery (Plate 31, Figs. 2, 3) and pronounced concentric sculpture.

Siphons capable of complete retraction within the valves and of extension probably not more than the length of the valves. Excurrent siphon truncated, about one third length of the incurrent siphon. Lappets extending from the truncation along the dorsal surface of the incurrent siphon, finely fringed. Periostracal sheath, if present, extremely thin and lacking calcareous or glasslike inclusions.

Measurements. See Table 18.

Remarks. Xylophaga bayeri Turner n. sp. is a distinctive species apparently not closely related to any other species in this genus. Its smooth muscle scars, ear-shaped mesoplax, truncated excurrent siphon, and fringed lappets place it in Group 6 and the lack of granular inclusions in the periostracal sheath of the siphons places it more closely to *X. globosa* and *X. dorsalis* than the others in the group. The mesoplax of *X. bayeri* is basically like that of *X. dorsalis* but is greatly extended laterally.

Only two specimens were obtained from the panels placed off Fort Lauderdale, Florida, and unfortunately these were not sufficiently well preserved for detailed anatomical work. The 14 specimens taken from wood dredged off Fowey Rocks were *in situ*, but all were dead and the soft parts had disintegrated, although the mesoplax was in place. All had typical valves but some had unusually wide dorsal plates (Plate 31, Figs. 2, 3). Four complete specimens and about 25 dead and disarticulated specimens were extracted from the wood dredged off Mona Island. These were remarkably uniform in the characters of the shell and dorsal plates.

Range. From off the coast of Florida probably throughout the Caribbean, in depths ranging from 150 to 365 m.

Specimens Examined. UNITED STATES, FLORIDA: 3.2 miles off Fort Lauderdale (26°04′N, 80°04′W) in 152.4 m (500 ft) in test panel; *Gerda,* station 266, off Fowey Rocks (25°39′N, 79°58′W) in about 340 m. PUERTO RICO: Johnson–Smithsonian Expedition, station 37, midway between Mona and Desecho islands (18°11′55″N, 67°42′50″W) in about 365 m.

Xylophaga japonica Taki and Habe
Plate 32

Xylophaga japonica Taki and Habe, 1950, Illustrated Catalogue of Japanese Shells, No. 7, p. 45, text-figs. 6, 7 (Tosa Bay, Shikoku, Japan, in about 100 fathoms). Holotype, T. Habe Collection; paratype, MCZ 194822.

Distinctive Characters. Posterior slope elongate in adult specimens. Umbonal–ventral sulcus well impressed, bounded by an inconspicuous ridge anteriorly and a high narrow ridge posteriorly. Posterior adductor muscle scar smooth. Mesoplax

TABLE 19. MEASUREMENTS OF *XYLOPHAGA JAPONICA*.

Length (mm)	Height (mm)	Location
13.2	10.8	holotype (from Taki and Habe, 1950)
5.8	5.0	paratype Tosa Bay, Shikoku, Japan
3.8	3.0	off Clara Island, South Burma
2.0	1.8	off Java

large, covering the upper one half of the anterior area, extending over the umbos, ear-shaped, moderately inflated, with a narrowly rounded periphery and distinct concentric sculpture (Plate 32, Figs. 2–5). Siphons capable of extending two to three times the length of the shell. Excurrent siphon about one third the length of the incurrent, lappets extending along the dorsal surface of the incurrent siphon finely fringed, opaque white granules imbedded along the sides of the siphons. Chimney of coarse fecal pellets lining the burrow.

Measurements. See Table 19.

Remarks. At the time Taki and Habe (1950) described this species, they did not have the soft parts and therefore could not describe the siphons. However, it is clear from their description and figures that the species belongs to the *dorsalis* group (Group 6). Taki and Habe related their species to *X. indica* Smith, but noted its more elongate posterior area. It further differs from *X. indica* in its broad mesoplax for, according to Knudsen (1961), the mesoplax of *X. indica* is "oblong pear-shaped" and his figure [of it] shows it to be nearly three times as long as wide. *Xylophaga indica* is probably more closely related to *X. guineensis* and *X. depalmai* n. sp., but because the siphons are unknown, this cannot be stated definitely.

Xylophaga japonica appears to be most closely related to *X. mexicana* Dall but differs in having a larger, more highly sculptured mesoplax that extends over the umbos; in having the posterior slope more elongate; and in having the ridge bounding the umbonal–ventral sulcus more pronounced.

Unfortunately, the material from off Java and South Burma noted in the records below was poorly preserved, but it was possible to ascertain the basic characters of the siphons. The specimens from Java had been kept in alcohol since they were collected by Mortensen in 1929. The specimens from South Burma, dredged by the *Anton Bruun* and taken from a small piece of wood and the husk of a nut, had been allowed to dry.

Range. From Tosa Bay, Japan, south and west to Burma and Java, in depths ranging from 183 to 384 m.

Specimens Examined. JAPAN: Tosa Bay, Shikoku, in 183 m. JAVA: Danish Java–South African Expedition, station 10, off SE tip of Java (08°36′S, 114°34′E) in 300 m. BURMA: *Anton Bruun*, station 23, about 77 miles W of Clara Island, South Burma (10°30′N, 96°35′E) in 384 m.

GENUS *XYLOPHOLAS* TURNER 1972

Xylopholas Turner, 1972, Basteria, 36(2): 97–99.

Type Species. Xylopholas altenai Turner, original designation.

Distinctive Characters. Valves and mesoplax typical for the genus *Xylophaga*. Animal long, not capable of retraction within the valves, with a periostracal siphonal sheath posterior to the valves and a pair of lateral, chitonlike, siphonal plates at the posterior end. Siphons short, extending between the plates, the siphonal retractor muscles inserted on their inner surface. Gills and visceral mass contained between the valves as in typical *Xylophaga*. Wood-storing cecum large.

Remarks. This genus differs from *Xylophaga* in having extended excurrent and incurrent canals contained in a common sheath with siphonal plates at the posterior extremity. These plates probably arose independently but may be homologous with the siphonoplax of other pholads (i.e., *Pholadidea*), which was carried posteriorly as the animal elongated. However, the siphonal retractor muscles of these species insert on the valves rather than on the siphonoplax. The siphonal plates of *Xylopholas* probably function as do the pallets of the Teredinidae and the siphonoplax of other pholadids to close the end of the burrow. Embryological studies are needed to prove the affinities of the plates.

From *Xyloredo*, *Xylopholas* differs in having siphonal plates, a periostracal sheath on the animal posterior to the valves, and in not lining the burrow with a chitonlike or calcareous tube.

Range. To date the genus is known only from the type species found off the Lower Florida Keys in the western Atlantic and in the Gulf of Guinea in the eastern Atlantic in depths from 239 to 366 m. (Two specimens were dredged in 2,550 m but these may have been advectitious.)

Xylopholas altenai Turner 1972
Plates 33, 34

Xylopholas altenai Turner, 1972, Basteria, 36(2): 99–103, figs. 1–12 (*Gerda*, station 66, about 13 miles SE of Fowey Rocks, Florida [25°25′N, 79°59′] in 366 m). Holotype, MCZ 279315.

Distinctive Characters. Animal elongate, not capable of retraction within the valves, and with lateral, paddlelike siphonal plates at the posterior end. Shell similar to that of *Xylophaga*. Mesoplax composed of two flat, elongate plates that are held in place by the periostracum extending between the beaks dorsally. Posterior adductor muscle scar large and with transverse forking impressions. Young carried on the ventral surface just posterior to the valves.

Description. Shell globose, reaching 2.5 mm in length, thin, fragile, and with a relatively heavy, golden-brown periostracum covering the valves and mesoplax. Pedal gape angle about 90°. Beaked portion of the anterior slope recurved dorsally and sculptured with numerous strong, denticulated ridges. Umbonal reflection narrow. Umbonal–ventral sulcus narrow and only slightly impressed. Disc and posterior slope sculptured with fine growth lines only.

Inner surface of valves smooth and glistening. Umbonal–ventral ridge low, indistinct except near the ventral margin, slightly segmented, and with a small ventral condyle. Chondrophore and internal ligament well developed. Posterior adductor muscle scar large, covering most of the posterior slope, elongate oval in outline and marked with transverse, forking impressions. Pedal retractor scar irregularly and broadly oval and located about midway on the anterior margin of the posterior adductor scar. Siphonal retractor muscles inserted on the siphonal plates and collar.

Mesoplax small, not filling the gape between the beaks, composed of two flat, elongate, subrectangular plates, somewhat pointed posteriorly, sculptured with fine transverse ridges, covering the dorsal surface of the anterior adductor muscle and held in place by the periostracum.

Animal long, with a periostracal sheath covering the portion posterior to the valves and with a pair of lateral, paddle-shaped, chitonlike plates at the posterior end (Plate 33, Fig. 4). The siphons extend between the plates, and the siphonal retractor muscles insert on the inner surface of them. Siphons separate, excurrent siphon longer than the incurrent siphon, the apertures of both with fine cirri.

Gills and visceral mass contained entirely between the valves, the portion of the animal extending beyond the valves composed of a dorsal excurrent and a ventral incurrent canal combined in a common muscular and periostracal sheath, with a chitinous collar and two lateral, paddle-shaped plates posteriorly.

Measurements. See Table 20.

Remarks. Isolated valves of this species would be difficult if not impossible to distinguish from several species of *Xylophaga*; however, its reduced, flat mesoplax, elongate soft parts, and siphonal plates readily distinguish it from all other species in the Xylophagainae. Nothing is known of the biology of the species except that it has a large wood-storing cecum and, therefore, probably utilizes wood as food. The young are held within the burrow to the late ve-

TABLE 20. MEASUREMENTS OF *XYLOPHOLAS ALTENAI*.

Length (mm)	Height (mm)	Location
1.8	1.8	holotype
1.0	1.0	*Atlantique Sud*, station 147
1.5	1.4	*Galathea*, station 52
1.2	1.1	*Gerda*, station 66
1.9	1.8	*Gerda*, station 266
2.0	2.1	*Gerda*, station 266
2.0	2.5	*Gerda*, station 266
2.5	2.5	*Gerda*, station 266

liger stage when the foot has developed. They are attached to the ventral surface of the animal just posterior to the valves. The number of attached young ranged from two to eight and they averaged 0.28 mm in length. The hinge plate of the young is well developed, with two teeth and a socket in the right valve and a corresponding single tooth and two sockets in the left valve (Plate 33, Figs. 1, 2).

About 60 specimens were taken at the three stations off Florida and 10 specimens were taken from the three stations in the Gulf of Guinea. The shells of many of the specimens were in poor condition and the valves had largely dissolved, possibly a result of the wood being very acid. However, the characteristic siphonal plates readily identified the species. The two specimens taken from a coconut husk dredged off São Tomé in 2,550 m may have been advectitious; this species may not typically occur at that depth. Neither specimen carried young. The shelf in this area is very narrow and steep so that plant material could easily be carried into deep water. All other records are from depths of 239–366 m.

Range. Known only from off the Florida Keys in the western Atlantic and the Gulf of Guinea in the eastern Atlantic in depths ranging from 239 to 2,550 m.

Specimens Examined. Western Atlantic: UNITED STATES, FLORIDA: *Gerda*, station 266, off Fowey Rocks, about 16 miles SE of Miami (25°39′N, 79°58′W) in 340 m; *Gerda*, station 66, off Turtle Reef, about 13 miles SE of Fowey Rocks (25°25′N, 79°59′W) in 366 m; *Gerda*, station 220, about 30 miles S of Alligator Reef (24°25′N, 80°33.5′W) in 311 m. Eastern Atlantic: GABON: *Galathea*, station 52, off Port Victoria, São Tomé Island (1°42′N, 7°51′E) in 2,550 m (in coconut shell); *Atlantique Sud*, station 147, about 45 miles N Port Gentil, Cape Lopez (0°S, 8°58′E) in 250 m; *Atlantique Sud*, station 154, about 35 miles NE of Port Gentil (0°15′S, 8°47′E) in 239 m.

GENUS *XYLOREDO* TURNER 1972

Xyloredo Turner, 1972, Breviora, 397: 3 (type species, *Xyloredo nooi* Turner, original designation); Turner, 1973, Science, 180: 1377–1379.

Distinctive Characters. Species in this genus are characterized by having typical *Xylophaga* shells, which lack apophyses and have a mesoplax composed of two flat plates, and by making a long teredolike burrow. The posterior two thirds of the burrow has a thin calcareous lining, marked with distinct growth lines and covered with periostracum that extends to the calcareous portion anterior as a band. The part of the animal extending beyond the valves into the calcareous tube is covered by a golden-brown periostracal sheath that is continuous anteriorly with the covering of the valves and posteriorly with the periostracum of the tube. A fold of the mantle is attached to the growing end of the tube where both periostracum and calcium are added. In young specimens the tube may be composed entirely of periostracum.

Posterior to the valves, the combined incurrent and excurrent canals extend the length of the tube and are attached lightly to it at the base of the short separate siphons. Two dorsolateral ridges within the incurrent canal appear to be ciliated and possibly aid in water transport.

Remarks. Members of this genus differ from *Xylophaga* and *Xylopholas* in making a burrow that may reach more than 30 times the length of the shell and is lined with a calcareous tube. Several species of *Xylophaga* make a burrow more than five times the length of the shells and form a chimney composed of mucous-cemented fecal pellets at the posterior end of the burrows. These are not homologous with the calcareous tubes of *Xyloredo* but rather with the chimney of rock-boring pholads, as in *Parapholas* Conrad (Turner, 1955: 123).

The discovery of this teredolike genus in the Pholadidae requires a reexamination of the fossil teredinids, especially those recorded as having ringed tubes. On the basis of our present knowledge, it may be impossible to distinguish *Xyloredo* from teredinids in fossilized wood. However, if tubes are present, a microscopic analysis of their structure may aid in distinguishing between them because teredinid tubes are amorphous, whereas tubes of *Xyloredo* have a definite structure with growth rings and periostracum. Certainly *Xyloredo* should be considered when examining drilled wood thought to have come from a deep water fossilized deposit.

Although *Xyloredo* superficially resemble the Teredinidae, this is entirely convergent and does not in any way indicate relationship, nor does it suggest the evolution of the Teredinidae from the Xylophagainae. The latter lack apophyses and pallets, and have a mesoplax. In addition, none of the visceral mass or gills of the Xylophagainae extend beyond the valves posteriorly as they do in the Teredinidae.

Range. To date three species of *Xyloredo* are known, two in the western Atlantic and the other in the eastern Pacific. All occur at depths greater than 1,500 m.

Xyloredo nooi Turner
Plate 35

Xyloredo nooi Turner, 1972, Breviora, 397: 5–7, pls. 1, 2 (Tongue of the Ocean, about 4 miles off northeast tip of Andros Island, Bahama Islands [25°54′N, 77°49′W] in 1,737 m). Holotype, MCZ 279631; paratypes from the same and other panels exposed at the same locality, MCZ 279632, 279633, 279634, and 279635, and the Zoological Museum, University of Copenhagen; Turner, 1973, Science, 180: 1377–1379.

Distinctive Characters. Burrow long, teredinidlike, lined with a thin calcareous tube marked with growth rings and covered with periostracum. Shell similar to *Xylophaga,* anterior slope narrow, umbonal–ventral sulcus lightly impressed, posterior slope high and reflected dorsally. Posterior adductor muscle scar subelliptical, set high on the posterior slope, and divided into two distinct areas. Disc separated from the posterior slope by a groove on the inner surface of the valves. Mesoplax small, the two flat triangular plates composed almost entirely of periostracum. Periostracal sheath between the valves and the tube smooth.

Description. Shell globose, valves reaching 10 mm in length and 10.5 mm in height, thin, fragile; umbos prominent. Periostracum relatively thick, golden-brown, glistening, and covering entire valve. Pedal gape angle about 110°. Anterior slope sculptured with numerous denticulated ridges, there being 24 on the holotype. Umbonal–ventral sulcus narrow, slightly impressed, and sculptured with fine, irregular growth lines. Posterior slope high, reflected near the dorsal margin, and sculptured with fine growth lines. Umbonal reflection rather wide, thin, adhering to the valves in the umbonal area, free anteriorly.

Inner surface of valves smooth and glistening. Umbonal–ventral ridge narrow, high, and segmented. Chondrophore and internal ligament prominent. Disc separated from the posterior slope by a pronounced narrow groove extending from the umbo to the posterior ventral margin. Posterior adductor muscle scar large, elliptical, and divided into two areas, the upper part marked with irregular impressions, the lower with regular chevron-shaped impressions. Anterior adductor scar covering most of the umbonal reflection. Pedal retractor scars elongate, the muscles inserting in the groove separating the disc from the posterior slope.

Mesoplax small, flat, the two broadly triangular plates composed almost entirely of periostracum and located anterior to the umbos.

Burrow long, teredinidlike, and lined with a thin calcareous tube that is sculptured with distinct growth rings and covered with periostracum that extends as a

TABLE 21. MEASUREMENTS OF *XYLOREDO NOOI*.

Length (mm)	Height (mm)	Location
5.0	5.1	paratype
6.7	6.9	paratype
7.2	7.8	paratype
9.5	9.8	paratype
9.5	10.0	holotype

border at the anterior end. Tube in very young specimens composed entirely of periostracum. Between the valves and the anterior end of the tube the animal is covered with a smooth periostracal sheath, which is continuous anteriorly with the covering of the valves and posteriorly with the tube. Siphons short, separate, and apparently with a few small cirri.

Measurements. See Table 21.

Remarks. Xyloredo nooi is related to both *Xyloredo naceli* Turner from the eastern Pacific and *X. ingolfia* Turner from the North Atlantic. *Xyloredo nooi* differs from them in having a much thinner burrow lining, a high, reflected posterior slope on the valves, and a proportionately smaller, more highly placed and divided posterior adductor muscle scar. In addition, the periostracal sheath extending between the valves and the calcarious tube is smooth.

The larvae of *X. nooi* apparently do not rise very high in the water column, inasmuch as a panel 25 ft off the bottom showed no trace of them, whereas the panel directly beneath it on the bottom was riddled. On the basis of the prodissoconch still visible on some of the specimens, it would appear that the larvae are similar to those of *Xylophaga*. No evidence was found in the three riddled panels examined that the young were brooded or held in the tubes.

The burrows resemble those of teredinids and intertwine with each other but basically follow the grain of the wood. They may reach 200 mm in length and 15 mm in diameter at the anterior end. The largest tube with intact shells and animal remaining was 145 mm long; the valves were 9.5 mm in length and 10 mm in height. The panels in the Tongue of the Ocean were submerged for 34 months and inasmuch as the larger burrows were empty or contained only fragments of shells, the length of life may be about 2–2.5 years. The calcareous lining of a burrow 122 mm long extends to about 30 mm from the anterior end, thus leaving room for boring activities and changing the direction of the burrow.

Range. Known only from the type locality.

Specimens Examined. BAHAMA ISLANDS: Tongue of the Ocean, about 4 miles off NE tip of Andros Island (24°54′N, 77°49′W) in 1,737 m.

Xyloredo ingolfia Turner
Plates 36, 37

Xyloredo ingolfia Turner, 1972, Breviora, 397: 7–9, pls. 3–5 (from wood dredged by the *Ingolf* Expedition at station 67, south of Eyrabakki, Iceland [61°30′N, 22°30′W] in 975 fathoms [1,783 m]). Holotype, MCZ 279636; paratypes, MCZ 279637, and the Zoological Museum, University of Copenhagen; Turner, 1973 *Science* 180: 1377–1379.

Description. Shell globose, valves reaching 2.5 mm in length and 2.0 mm in height, thin, fragile, with prominent umbos; thin, glistening, almost colorless periostracum covering disc and posterior slope. Beaked portion of anterior slope wide, extending more than one half distance to ventral margin; sculptured with close-set and very finely denticulated ridges. Posterior portion of anterior slope about two thirds width of beak, sculptured with close-set ridges that extend to very slightly impressed umbonal–ventral sulcus. Disc sculptured with well-marked growth lines. Posterior slope small, low, and not clearly demarcated on outer surface of valve. Umbonal reflection thick, narrow, short, and free except at posterior end.

Inner surface of valves smooth, slightly shiny to chalky (perhaps owing to long preservation). Umbonal–ventral ridge wide, flattened, often varying in width, irregularly segmented, and not enlarged at ventral condyle. Chondrophore and internal liga-

TABLE 22. MEASUREMENTS OF *XYLOREDO INGOLFIA*.

Length (mm)	Height (mm)	Location
2.5	2.3	holotype
2.5	2.0	paratype
2.1	2.0	paratype
2.0	1.9	paratype
1.5	1.4	paratype
1.5	1.2	paratype

ment large. Disc not clearly separated from posterior slope. Posterior adductor muscle scar large, slightly raised, elliptical, extending nearly to ventral margin, with irregular, transverse impressions. Anterior adductor muscle scar covering umbonal reflection. Siphonal retractor muscle scars not impressed. Pedal retractor muscle scar small, elongate to oval, and located just anterior to posterior adductor muscle scar. Mesoplax of two very small, narrow, subrectangular, flat, calcified plates lying on dorsal surface of anterior adductor muscle.

Burrow 10–15 times length of valves; calcareous tubular lining three fourths length of burrow. Tube relatively heavy, marked with uniform, close-set, raised rings, and covered with light tan periostracum that extends anteriorly as border. Portion of animal between valves and tube covered by thin, irregularly ridged periostracal sheath. Siphons short; incurrent siphon slightly longer than excurrent siphon. Protoconch large, medium golden-brown, and sculptured with fine, concentric ridges.

Measurements. See Table 22.

Remarks. This species differes from *Xyloredo naceli* in having a less well-developed posterior slope, a shallow, indistinct umbonal–ventral groove, a flattened umbonal–ventral ridge, and in having the valves longer than high. It differs from *X. nooi* in having valves longer than high, in having a low, rounded posterior slope, in lacking the distinct groove on the inner surface separating the disc from the posterior slope, and in having the plates of the mesoplax subrectangular and well calcified.

Range. Known only from the type locality.

Specimens Examined. ICELAND: *Ingolf* Expedition, station 67, S of Eyrabakki (61°30′N, 22°30′W) in 1,783 m.

Xyloredo naceli Turner
Plate 38

Xyloredo naceli Turner, 1972, Breviora, 397: 9–11, pl. 6, figs. 1–5 (USNCEL STU 1-4 about 30 miles S of San Miguel Island, off Port Hueneme, Santa Barbara Islands, California [33°46′N, 120°45′W] in 6,800 ft [2,072.6 m] from panels submerged from June 1964 to July 1965). Holotype, MCZ 279638; paratype, 279639.

Distinctive Characters. Burrow teredinidlike, lined with a thin calcereous tube marked with growth rings and covered with periostracum. Shell similar to *Xylophaga,* with a narrow, slightly impressed umbonal–ventral sulcus. Posterior adductor muscle scar elliptical, almost completely covering the posterior slope and uniformly marked with transverse impressions. Mesoplax small, the two flat, triangular plates composed largely of periostracum. Periostracal sheath covering the animal between the valves and the tube papillose.

Description. Shell globose, reaching 1.5 mm in length, thin, fragile, white, with a thin, pale yellow periostracum. Pedal gape angle about 100°. Anterior slope sculptured with 8–12 widely spaced, pronounced, denticulated ridges. Umbonal–ventral sulcus narrow and only slightly impressed. Discs and posterior slope sculptured with fine growth lines only.

Inner surface of valves smooth and glistening. Umbonal–ventral ridge narrow, high, and indistinctly segmented. Chondrophore and internal ligament well developed. Posterior adductor muscle scar elliptical, extending from the dorsal nearly to the ventral margin of the posterior slope and regularly marked with transverse impressions. Pedal retractor scar not impressed. Ventral adductor only lightly impressed and located just posterior to the

TABLE 23. MEASUREMENTS OF *XYLOREDO NACELI*.

Length (mm)	Height (mm)	Location
1.1	1.2	holotype
1.0	1.0	paratype
1.2	1.3	paratype
1.5	1.5	paratype

umbonal–ventral ridge. Siphonal retractor muscles inserting on the tube.

Mesoplax small, thin, set between and anterior to the umbos, the two triangular plates composed almost entirely of periostracum. Burrow of largest specimen about six times the length of the shell. Calcareous tube lining the burrow thin, distinctly marked with growth rings, and covered with periostracum that extends as a border anteriorly. Aperture of the burrow small, round, the white lining visible within. The portion of the animal between the valves and the calcareous tube covered with a papillose periostracal sheath that is continous with the periostracum covering the valves anteriorly and the periostracal border of the tube posteriorly. Siphons short, of equal length, and apparently lacking cirri.

Measurements. See Table 23.

Remarks. This species is most closely related to *X. nooi* Turner from the western Atlantic. Only eight specimens of *X. naceli* were found and they were all very small, but these appear to be sufficiently distinct to consider them members of a separate species. *Xyloredo naceli* differs from *X. nooi* in having a heavier tube that is calcareous, even in very young specimens; and a posterior adductor muscle scar that is proportionately larger and not divided into two areas. In addition, it lacks the pronounced internal groove separating the disc from the posterior slope, and the periostracal sheath covering the animal anterior to the tube is papillose.

Nothing is known of the biology of the species except that at the sites where they were collected the temperature of the water was 2.1° C, the salinity was 34.52‰, the dissolved oxygen content was 1.26 ml/L, the pH was 7.84, and the hydrostatic pressure 3000 psi (Muraoka, 1966b).

The embryonic valves still visible on some of the specimens suggest that the mature larvae are similar to those in *Xylophaga*. *Xylophaga muraokai* was the most common borer in the panels from which the *X. naceli* were taken.

Range. Known only from the type locality.

Specimens Examined. UNITED STATES, CALIFORNIA: USNCEL STU I-4 S of San Miguel Island, Santa Barbara Islands (33°46′N, 120°45′W) in 2,072 m.

ACKNOWLEDGMENT

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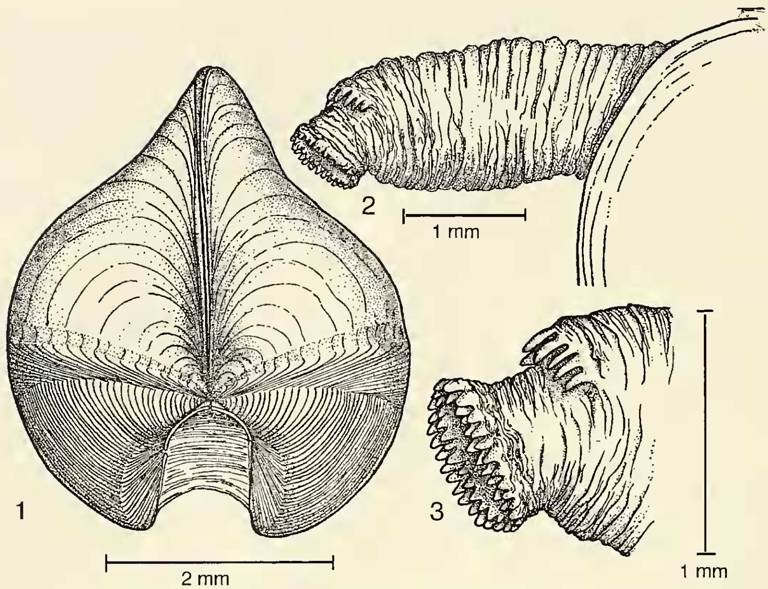


Plate 1. *Xylophaga concava* Knudsen from *Pillsbury,* station 526.

Figure 1. Dorsal view of apposed valves showing the concave posterior slope and erect mesoplax. Figure 2. Posterior end of valve and siphons. Figure 3. Enlargement of the siphonal openings to show the six large cirri on the excurrent siphon and the double row of small cirri on the incurrent siphon.

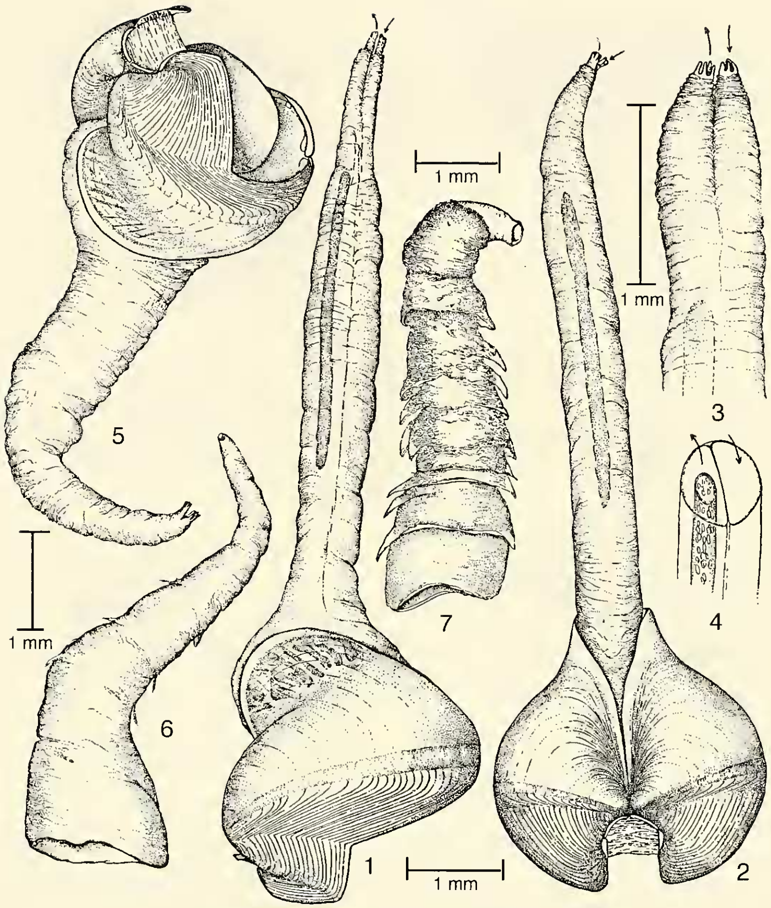


Plate 2. *Xylophaga gerda* Turner n. sp. from *Gerda,* station 499.

Figure 1. Lateral view of holotype showing the attachment of the posterior adductor muscle through the thin valve, the mesoplax that does not extend above the umbos, and the fecal cylinder in the excurrent canal. Figure 2. Dorsal view of the holotype showing the mesoplax. Figure 3. Enlargement of the posterior end of the siphons. Figure 4. Diagrammatic cross-section through the siphons and the fecal cylinder. Figure 5. Three-quarter view of holotype showing the inflated umbos and the simple curved plates of the mesoplax. Figure 6. A relatively smooth chimney composed largely of periostracum, with a thin coating of fecal material. Figure 7. A thick chimney, built in sections with "leaves" of periostracum extending at the anterior end of each section.

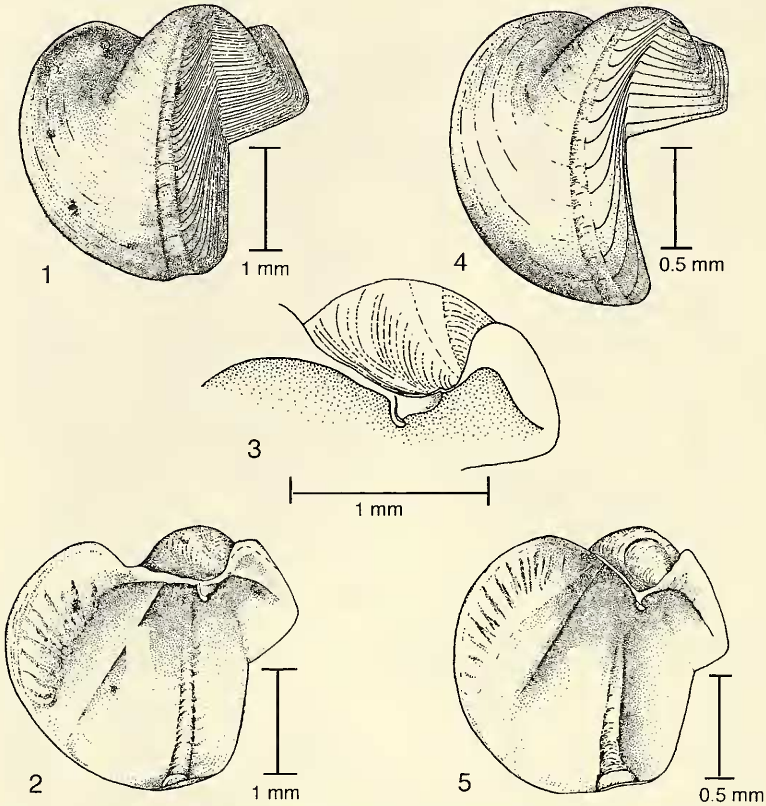


Plate 3. *Xylophaga gerda* Turner n. sp. from *Pillsbury*, station 944.

Figure 1. Outer view of right valve. Figure 2. Inner view of left valve, showing posterior adductor muscle scar and low umbonal–ventral ridge. Figure 3. Enlargement of the hinge area of left valve to show the chondrophore and anterior adductor muscle scar. Figure 4. Outer view of right valve of a young specimen. Figure 5. Inner view of left valve of young specimen showing the prodissoconch, chondrophore, and muscle scars.

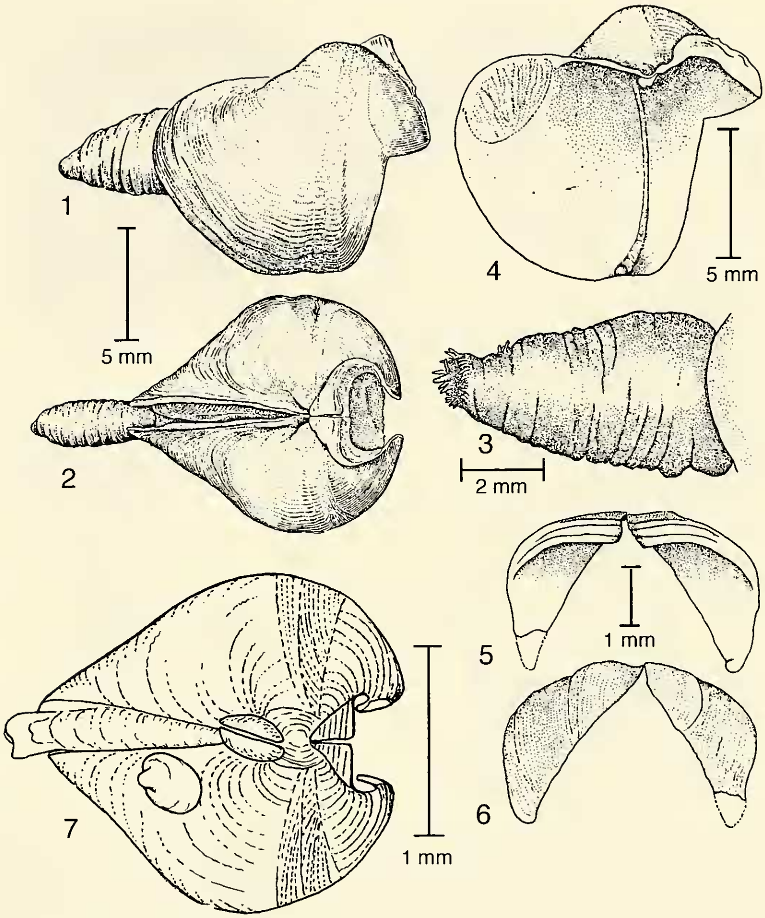


Plate 4. *Xylophaga grevei* Knudsen (Figs. 1–6 from Knudsen, 1961: 176–177).

Figures 1–4. Holotype. Figure 1. Right side of entire specimen showing siphons and mesoplax. Figure 2. Dorsal view. Figure 3. Enlargement of the siphons showing the cirri around the incurrent aperture (35) and the excurrent aperture (6). Figure 4. Internal view of left valve of the holotype showing the broadly oval posterior adductor muscle scar set high on the posterior slope. Figures 5, 6. Ventral and dorsal view of the mesoplax. Figure 7. Small specimen carrying two young from *Galathea*, station 444.

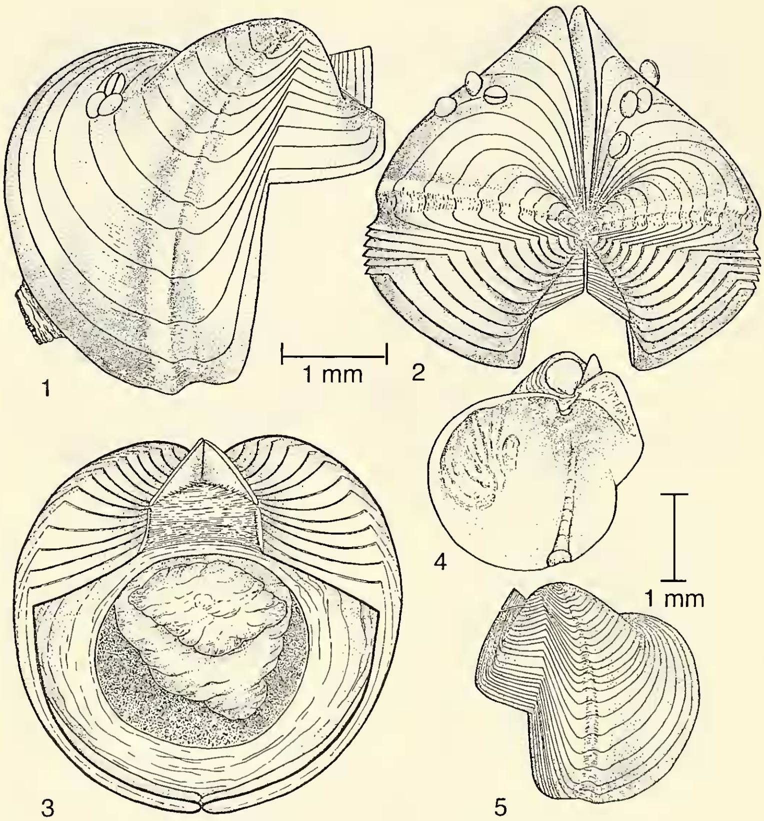


Plate 5. *Xylophaga clenchi* Turner and Culliney.

Figures 1–3. Side, dorsal, and anterior views of the holotype, showing the widely space ridges on the anterior slope of specimens boring in soft wood and the position of young and the dorsal surface. Figures 4, 5. Inner and outer views of left valve of a specimen from *Atlantis II,* station 124, showing the muscle scar and large number of ridges on the anterior slope of a specimen from hard wood.

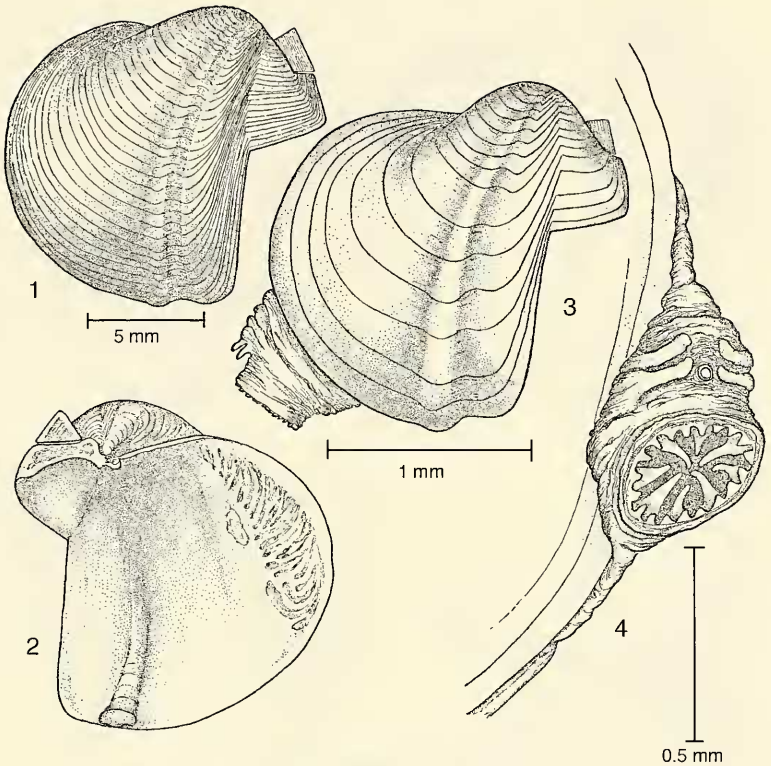


Plate 6. *Xylophaga clenchi* Turner and Culliney.

Figures 1, 2. Outer and inner views of the right valve of a large specimen with mesoplax in place, dredged by the *Pillsbury*, station 394. Figure 3. Lateral view of an entire specimen from the Tongue of the Ocean showing relative size of siphons. Figure 4. Enlargement of the siphons, posterodorsal view, to show the incurrent and excurrent apertures and the cirri around them.

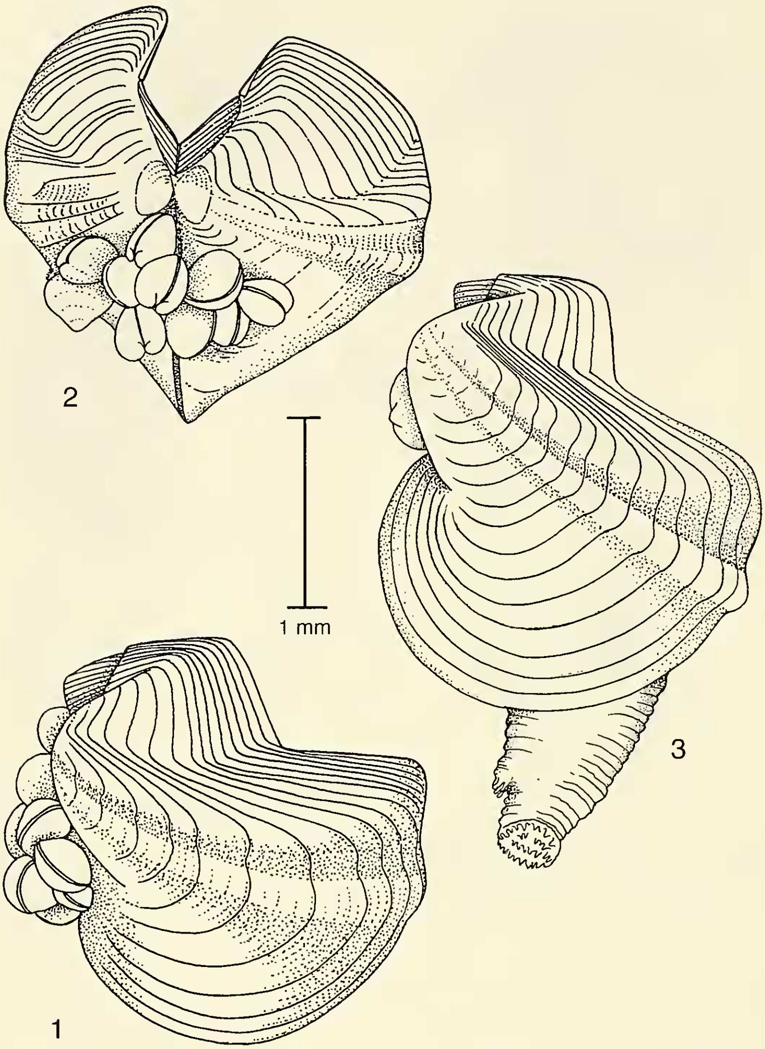


Plate 7. *Xylophaga clenchi* Turner and Culliney from *Ingolf* Expedition, station 67.

Figure 1. Lateral view of right valve with mesoplax in place and young attached to dorsal surface. Figure 2. Dorsal view of same specimen showing the prodissoconch. Figure 3. Lateral view of specimen with extended siphon.

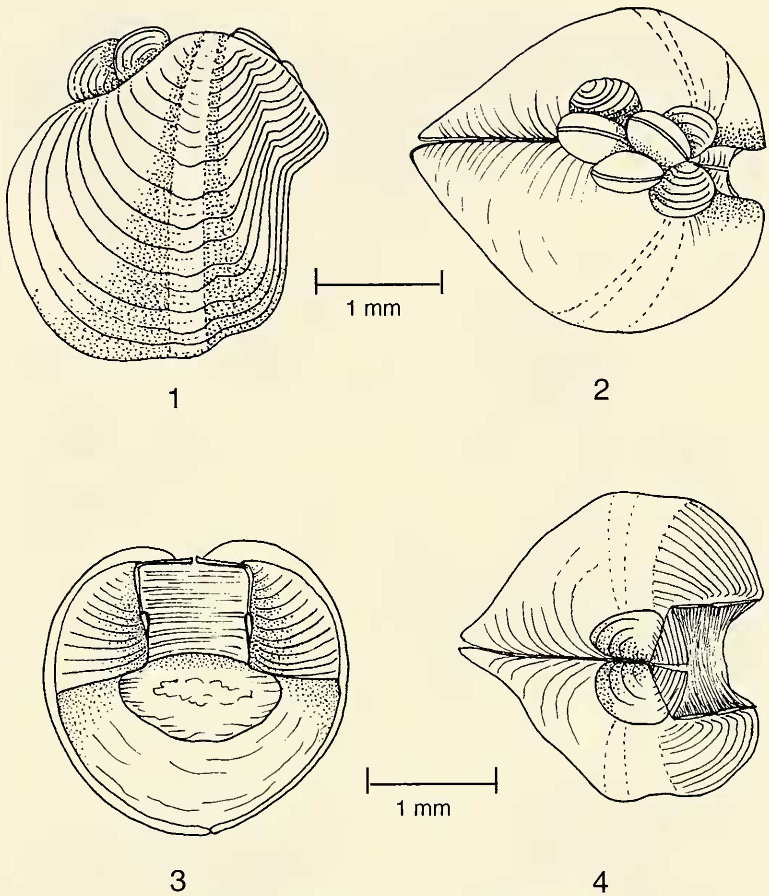


Plate 8. *Xylophaga clenchi* Turner and Culliney.

Figures 1, 2. From *Pillsbury,* station 238. Figure 1. Lateral view of right valve. Figure 2. Dorsal view of opposed valves showing prodissoconch, four young attached posterior to the umbos, and an atypical elongate, longitudinally folded mesoplax. Figures 3, 4. Specimen from *Atlantis II,* station 124. Figure 3. Anterior view of specimen with mesoplax bent at a right angle. Figure 4. Dorsal view of same specimen showing prodissoconch and mesoplax.

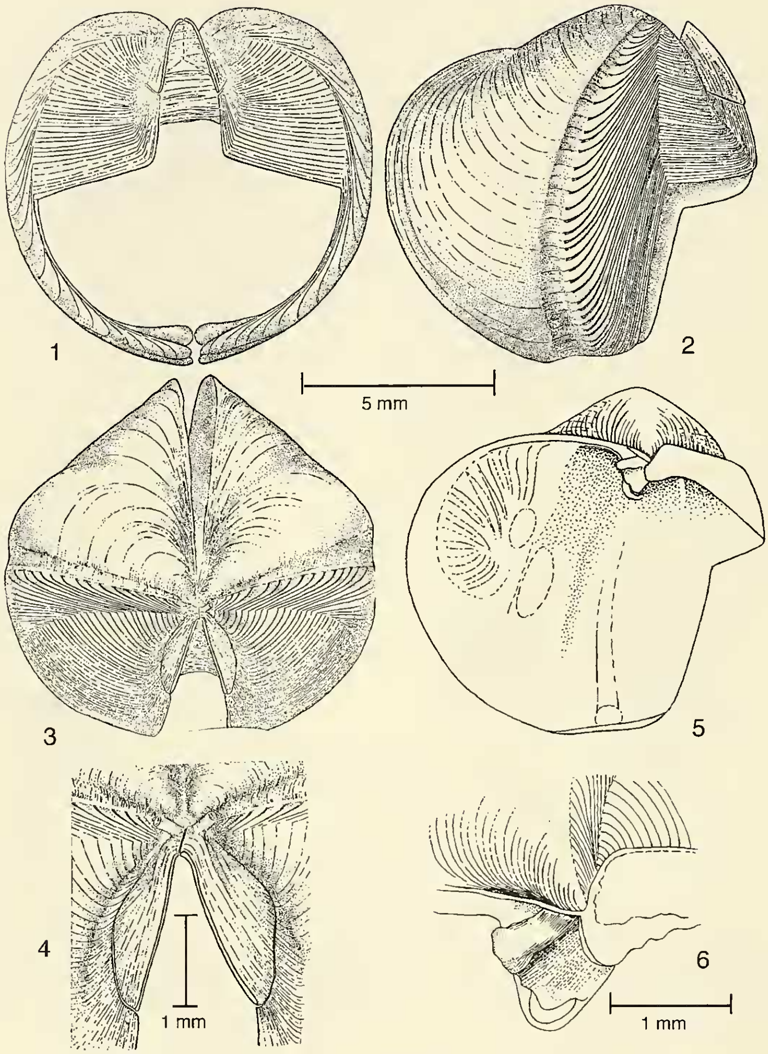


Plate 9. *Xylophaga supplicata* Taki and Habe from Tosa Bay, Shikoku, Japan.

Figure 1. Anterior view of opposed valves with mesoplax in place. Figure 2. Lateral view of entire specimen from the right with mesoplax in place. Figure 3. Dorsal view of opposed valves tipped slightly forward to show the minute tubes at the posterior end of the mesoplax. Figure 4. Enlargement of mesoplax and umbonal area, looking down into the cavity formed by the incurving of the umbos. Figure 5. Inner view of left valve showing chondrophore with large tooth. Figure 6. Enlargement showing chondrophore with large tooth.

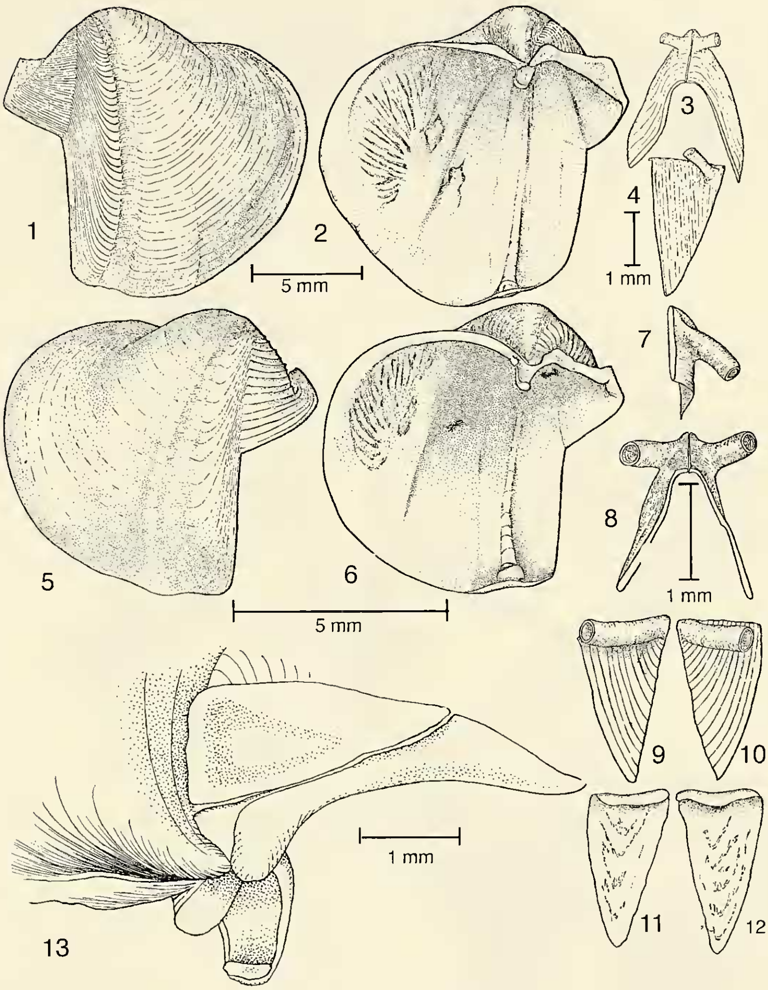
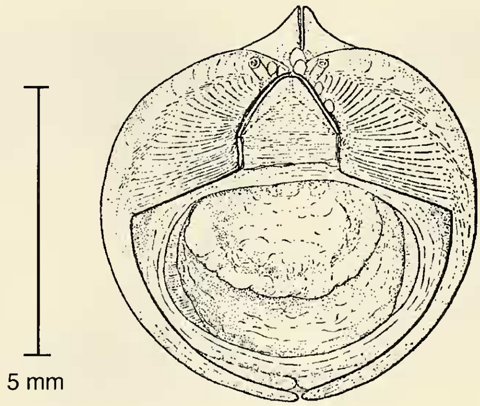


Plate 10. *Xylophaga whoi* Turner n. sp.

Figures 1–4. Specimen from *Pillsbury*, station 944. Figures 1, 2. Outer and inner views of the left valve. Figure 3. Frontal view of mesoplax with smallest tubes seen. Figure 4. Side view of left plate of mesoplax. Figures 5–12. Holotype. Figure 5. Outer view of right valve. Figure 6. Inner view of left valve. Figure 7. Dorsal view of left plate of mesoplax. Figure 8. Frontal view of mesoplax. Figures 9, 10. Outer surface of left and right plates of mesoplax with average-size tubes. Figures 11, 12. Inner surface of left and right plates of the mesoplax showing the curvature at the dorsal margin and the pore to the inner surface just below it. Figure 13. Enlargement of the hinge area of the left valve to show the chondrophore with a large tooth on it posterior dorsal margin, the umbonal reflection, and the inner surface of the mesoplax.



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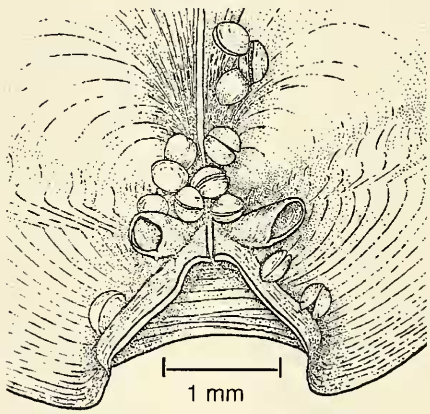

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Plate 11. *Xylophaga whoi* Turner n. sp. from *Pillsbury,* station 394.

Figure 1. Anterior view of entire animal showing mesoplax in place, the anterior adductor muscle, the pedal opening of the mantle, the retracted foot, and young on the dorsal surface of the valves. Figure 2. Enlargement of the umbonal area, mesoplax, and attached young.

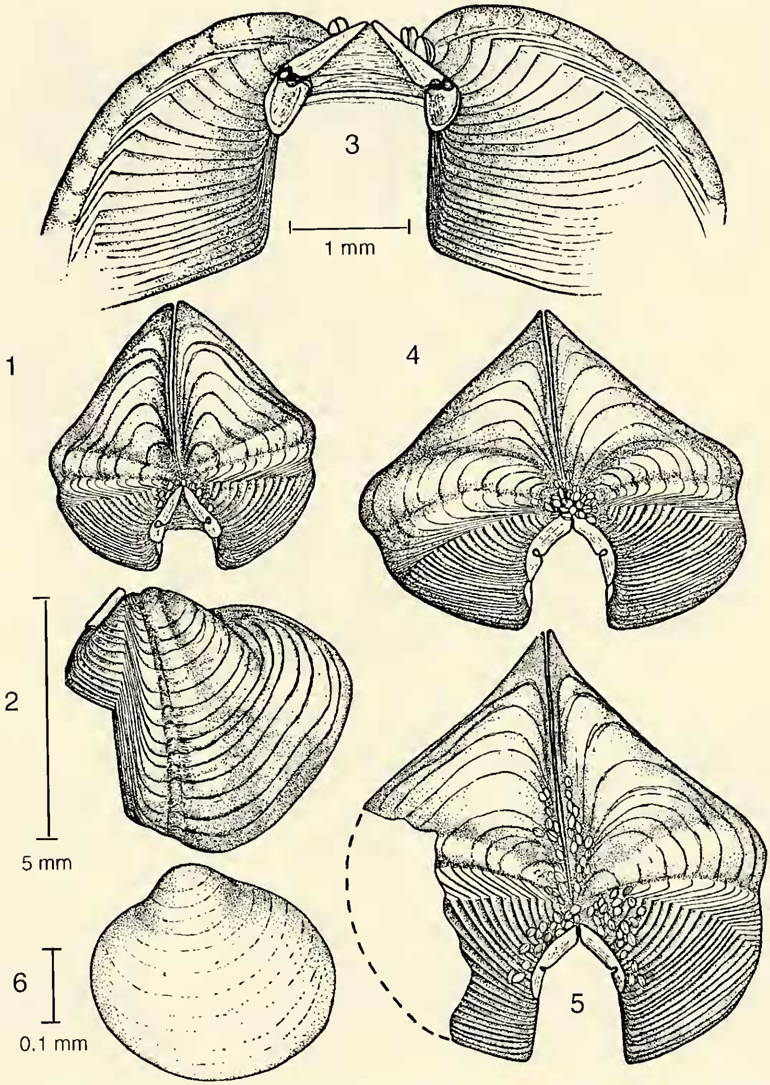

Plate 12. *Xylophaga profunda* Turner n. sp. from U.S. Naval Oceanographic Office test site, Tongue of the Ocean, Andros Island, Bahama Islands.

Figures 1–3. Holotype. Figure 1. Dorsal view showing round ridge posterior to the umbonal–ventral sulcus, the mesoplax, and attached young. Figure 2. Side view of left valve. Figure 3. Enlarged anterior view of dorsal area to show mesoplax. Figures 4, 5. Dorsal view of paratypes to show range of length–width relationships, concavity of posterior slope, as well as arrangement and number of young. Figure 6. Enlarged young.

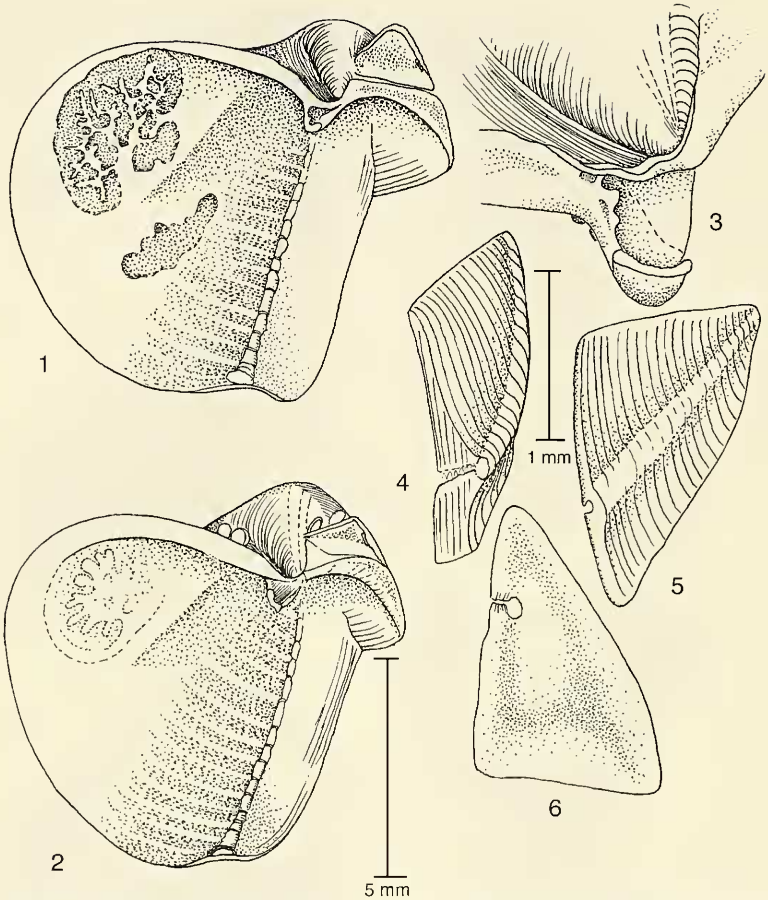

Plate 13. *Xylophaga profunda* Turner n. sp. from U.S. Naval Oceanographic Office test site Tongue of the Ocean, Andros Island, Bahama Islands.

Figures 1, 2. Inner view of left valve of two specimens to show differences in intensity of muscle scar impressions, the riblike ridges extending from the umbonal–ventral ridge, the placement of the mesoplax, and the chondrophore. Figure 3. Enlargement of the hinge area of the left valve to show the chondrophore. Figures 4–6. Anterior, dorsal, and ventral view of mesoplax.

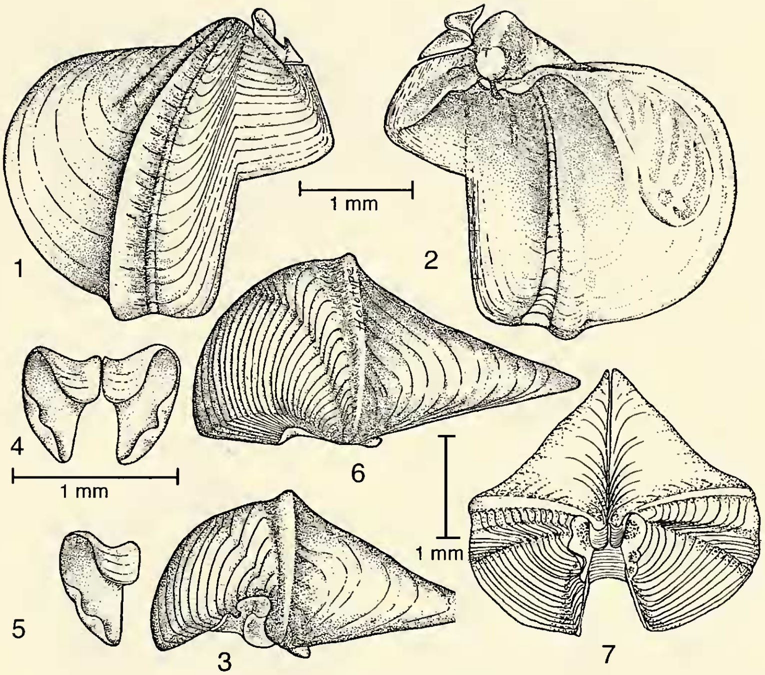

Plate 14. *Xylophaga abyssorum* Dall.

Figures 1–5. Specimens from U.S. Naval Oceanographic Office test site, Tongue of the Ocean, Andros Island, Bahama Islands. Figure 1. Outer view of right valve of immature specimen with mesoplax in place and showing ridge posterior to umbonal–ventral sulcus. Figure 2. Inner view of same valve, showing groove posterior to umbonal–ventral ridge, ligament, and characteristic muscle scar of young specimen. Figure 3. Dorsal view of same valve with mesoplax in place. Figures 4, 5. Mesoplax of young specimen with large ventral portion. Figure 6. Dorsal view of right valve of holotype of *Xylophaga abyssorum* for comparison with Figure 3. Figure 7. Dorsal view of young specimen from *Gerda,* station 266, with mesoplax developing lobes on dorsal portion.

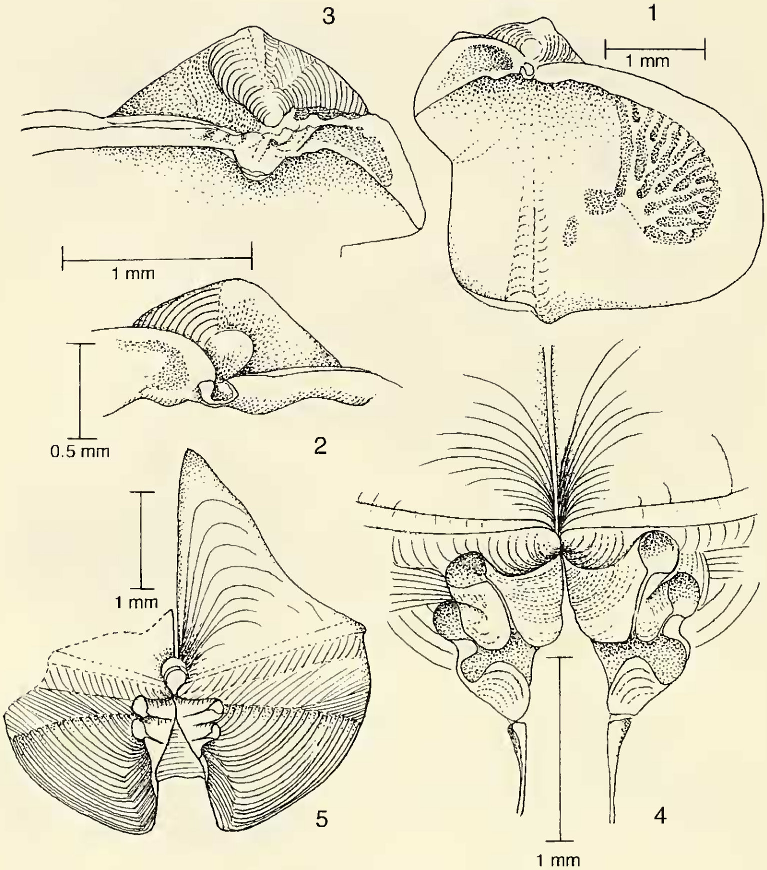

Plate 15. *Xylophaga abyssorum* Dall.

Figures 1–4. Specimens from *Pillsbury,* station 944. Figure 1. Inner view of right valve showing muscle scars, deep groove posterior to the umbonal–ventral ridge, and the small chondrophore. Figure 2. Enlargement of hinge area of same specimen. Figure 3. Hinge area of left valve. Figure 4. Dorsal view of umbonal area with mesoplax in place. This is the most elaborate mesoplax observed, having two tubes and a third developing. Figure 5. Dorsal view of specimen from *Gerda,* station 266, with two tubes formed on each plate of the mesoplax and with two young just posterior to the umbos.

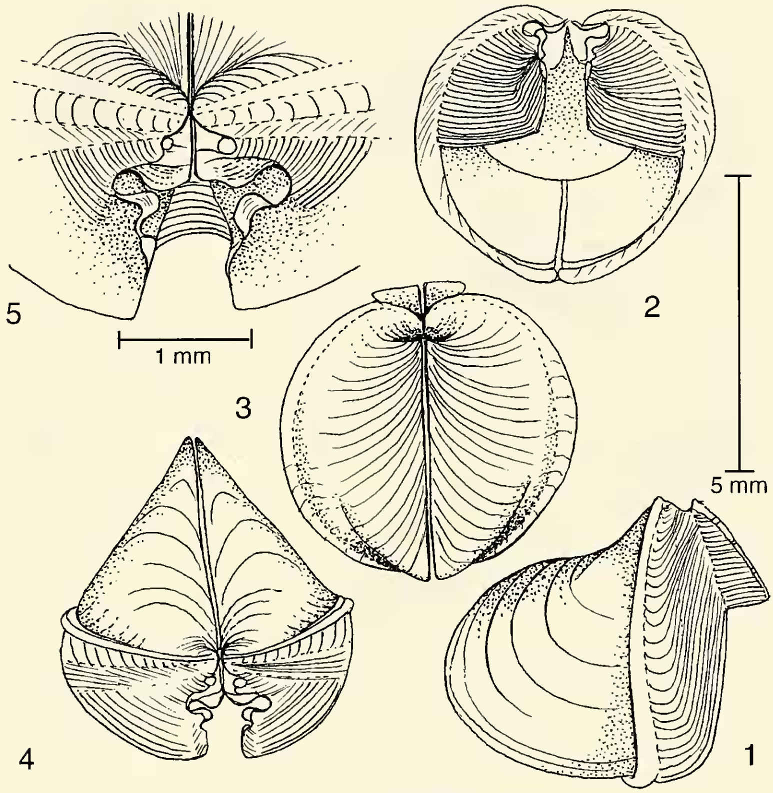

Plate 16. *Xylophaga abyssorum* Dall.

Figures 1–5. Specimen from *Pillsbury,* station 944. Figure 1. Lateral view of right valve. Figure 2. Anterior view of opposed valves with mesoplax in place. Figure 3. Posterior view of opposed valves with mesoplax in place and showing the inflated umbos and ridge. Figure 4. Dorsal view of opposed valves. Figure 5. Enlarged view of mesoplax and umbonal area.

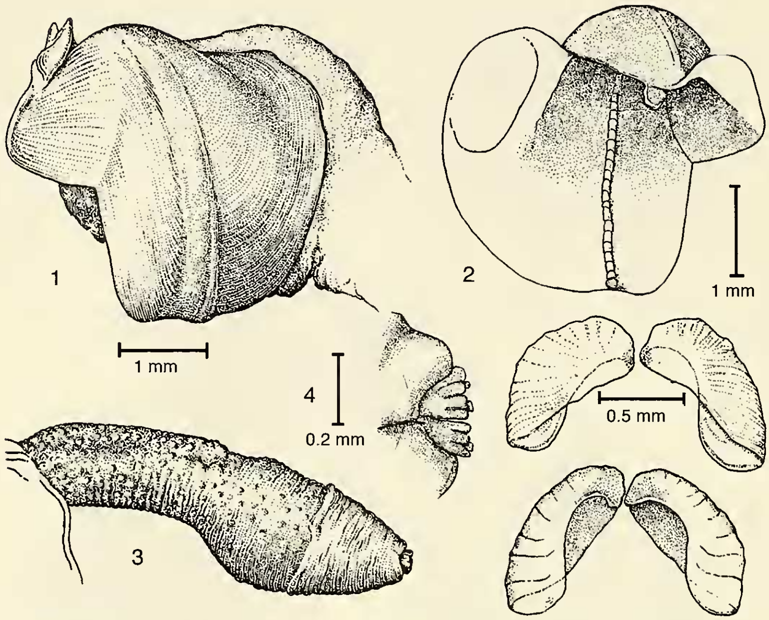

Plate 17. *Xylophaga duplicata* Knudsen from *Galathea,* station 745, Gulf of Panama (all from Knudsen, 1961: 175).

Figure 1. Lateral view of left side of holotype, showing the mesoplax in place, standing off from the surface of the valves. Figure 2. Inner view of left valve of a paratype showing the small smooth posterior adductor muscle scar. Figure 3. Left side of extended siphon of a paratype. Figure 4. Enlarged view of posterior end of the siphon. Figure 5. Dorsal view of the mesoplax. Figure 6. Ventral view of mesoplax.

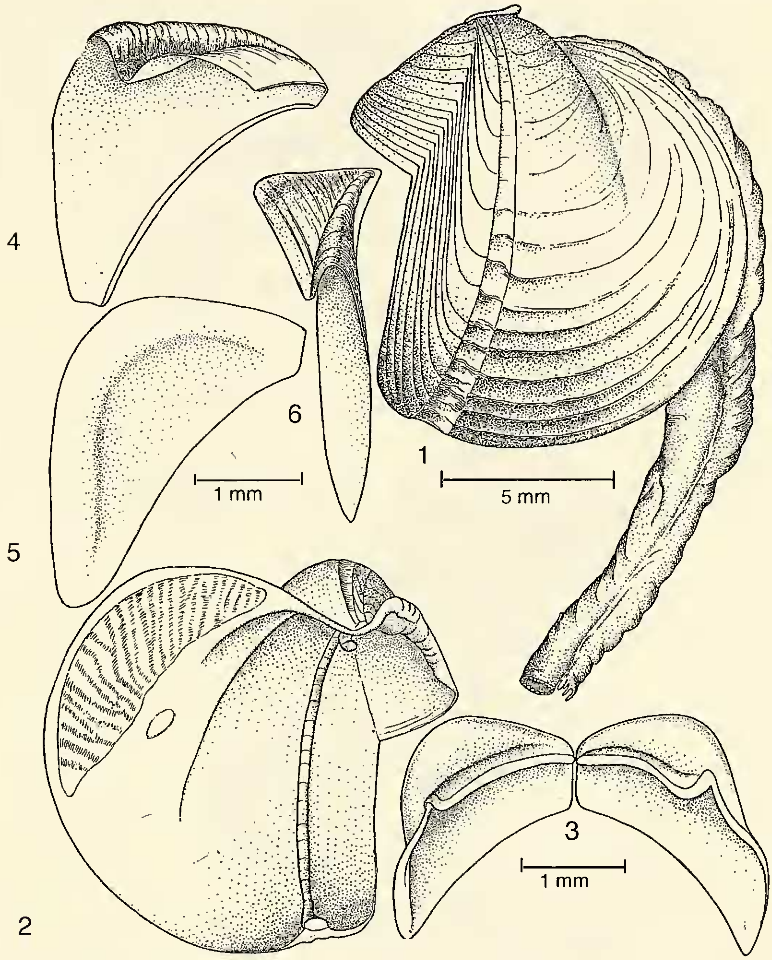

Plate 18. *Xylophaga muraokai* Turner n. sp. from U.S. Naval Civil Engineering Laboratory Test Site I.

Figure 1. Lateral view of holotype showing siphons. Figure 2. Inner view of left valve showing muscle scar and simple chondrophore. Figure 3. Dorsal view of the two plates of the mesoplax of a mature specimen showing large basal portion. Figure 4. Dorsal view of right plate of mesoplax. Figure 5. Ventral view of left plate of mesoplax. Figure 6. Lateral view of left plate of mesoplax.

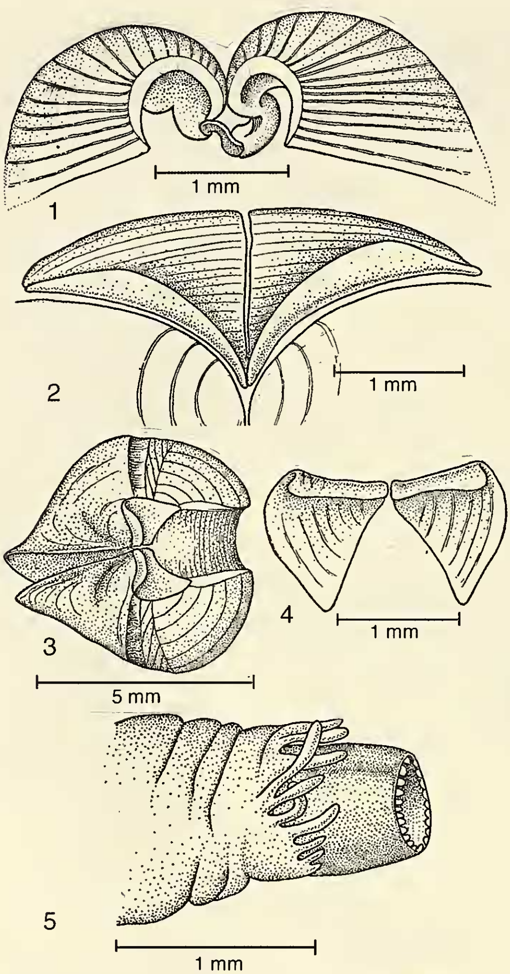

Plate 19. *Xylophaga muraokai* Turner n. sp. from U.S. Naval Civil Engineering Laboratory Test Site I.

Figure 1. Anterior view of hinge area showing chondrophore and internal ligament. Figure 2. Posterior view of mesoplax fitting between the umbos. Figure 3. Dorsal view of young specimen with partially developed mesoplax. Figure 4. Mesoplax of young specimen. Figure 5. Enlargement of posterior end of siphons showing cirri around the siphonal apertures.

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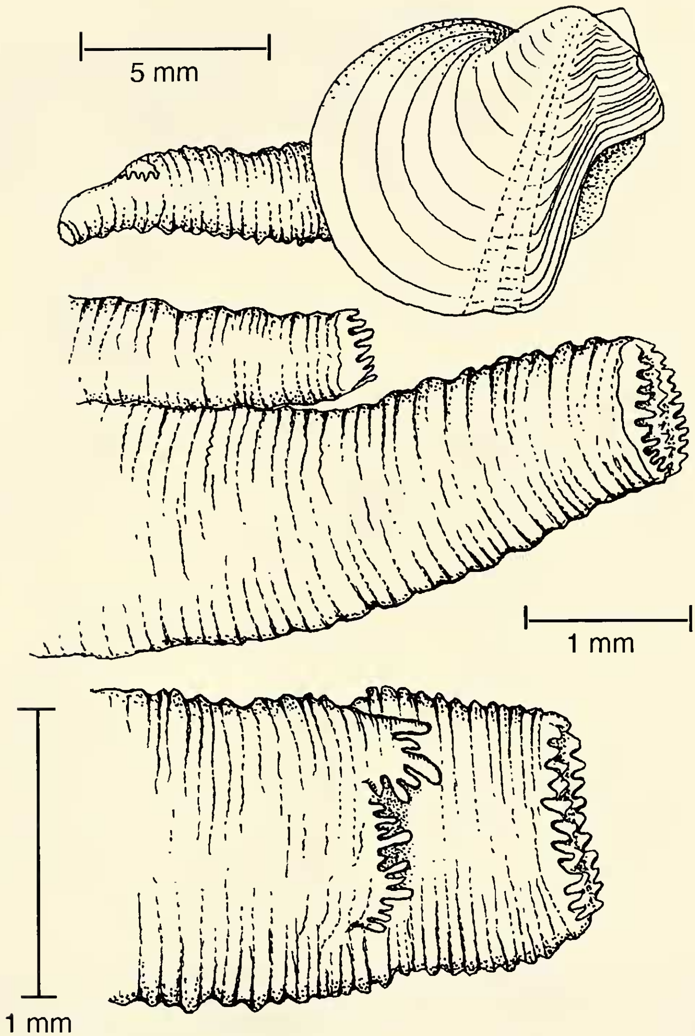

Plate 20. *Xylophaga atlantica* Richards from about 15 miles off Ipswich, Massachusetts, in 73 m.

Figure 1. Entire specimen with siphons extended, showing relative lengths. Figure 2. Enlargement of the posterior end of the siphons, lateral view. Figure 3. Enlargement of the posterior end of siphons dorsal view showing the numerous small cirri surrounding the incurrent siphonal aperture and the larger, less numerous cirri of the excurrent siphon.

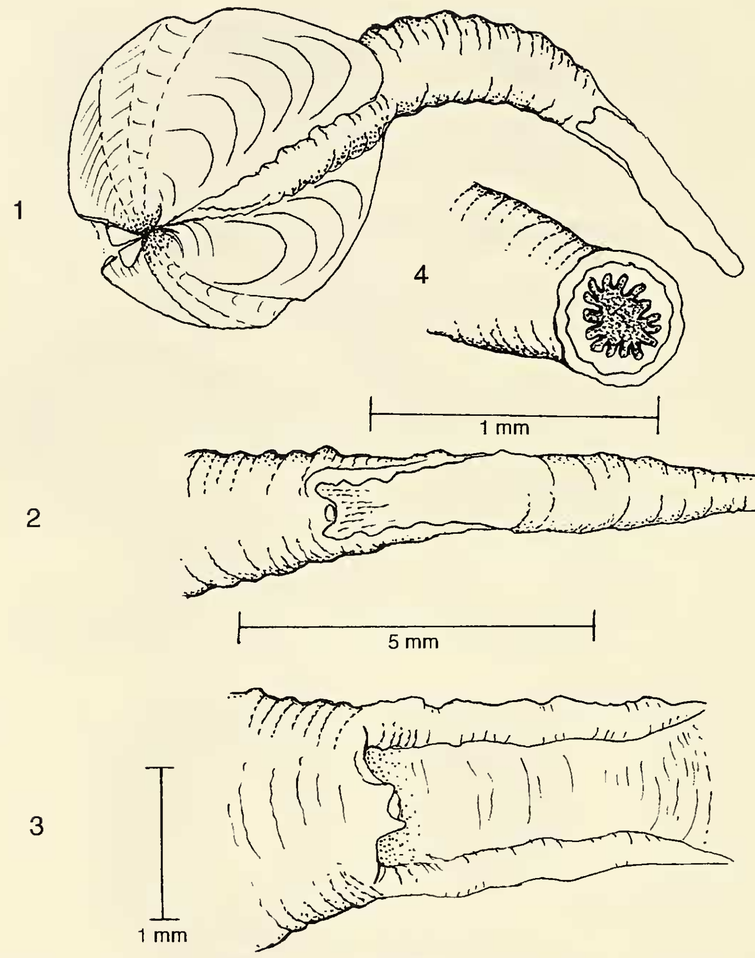

Plate 21. *Xylophaga washingtona* Bartsch.

Figures 1–3. Specimen from U.S. Naval Civil Engineering Laboratory Test Site I. Figure 1. Dorsal view of entire specimen showing the relative length of the siphons. Figure 2. Dorsal view of siphons from just anterior to the truncation of the excurrent siphon. Figure 3. Dorsal view of siphons in area of truncation to show contracted aperture of the excurrent siphon of a short tube, and the short lateral lobes extending from the truncation. Figure 4. Specimen from about 40 miles W of Silver Point, Oregon. Aperture of incurrent siphon showing cirri.

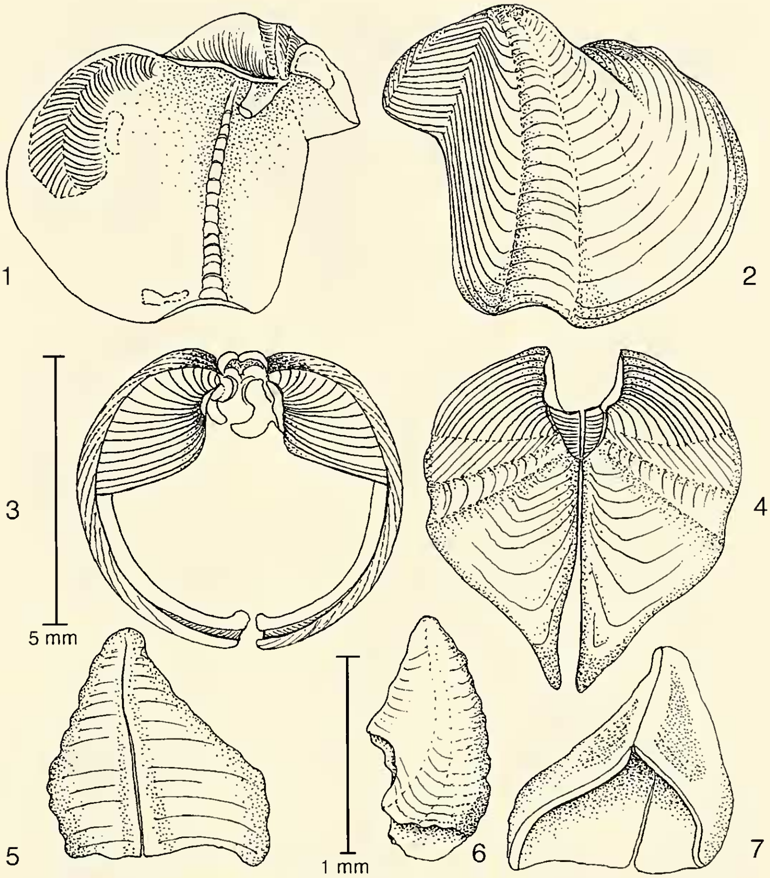

Plate 22. *Xylophaga rikuzenica* Taki and Habe from off Rikuzen, Honshu, Japan. Paratype, Museum of Comparative Zoology 194821.

Figure 1. Inner view left valve showing posterior adductor muscle with herringbone markings. Figure 2. Outer view of left valve showing broad ventral sulcus. Figure 3. Anterior view of opposed valves showing mesoplax in place, the condyles, and chondrophore. Figure 4. Dorsal view of opposed valves showing mesoplax in place, umbonal reflection, and broad, deep umbonal–ventral sulcus. Figures 5–7. Dorsal, lateral, and ventral views of the mesoplax showing the large ventral portion.

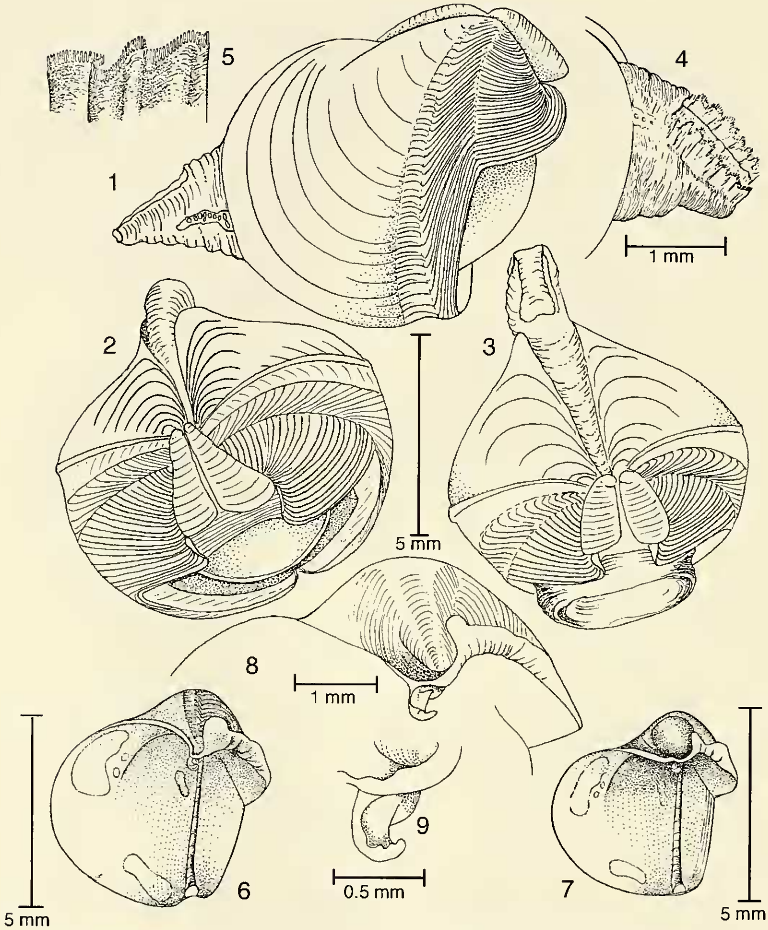

Plate 23. *Xylophaga depalmai* Turner n. sp. from U.S. Naval Oceanographic Office test site off Fort Lauderdale, Florida.

Figure 1. Lateral view of holotype showing siphons with lateral periostracal sheath containing clusters of irregular glasslike granules. Figure 2. Dorsal view of holotype showing mesoplax that is only slightly coiled posteriorly. Figure 3. Dorsal view of specimen with slightly more coiled mesoplax. Figure 4. Siphons showing fringed lappets. Figure 5. Enlargement of fringe. Figure 6. Inner view of left valve showing muscle scars. Figure 7. Inner view of left valve showing prodissoconch. Figure 8. Enlargement of hinge area of left valve showing umbonal reflection and chondrophore. Figure 9. Enlargement of chondrophore.

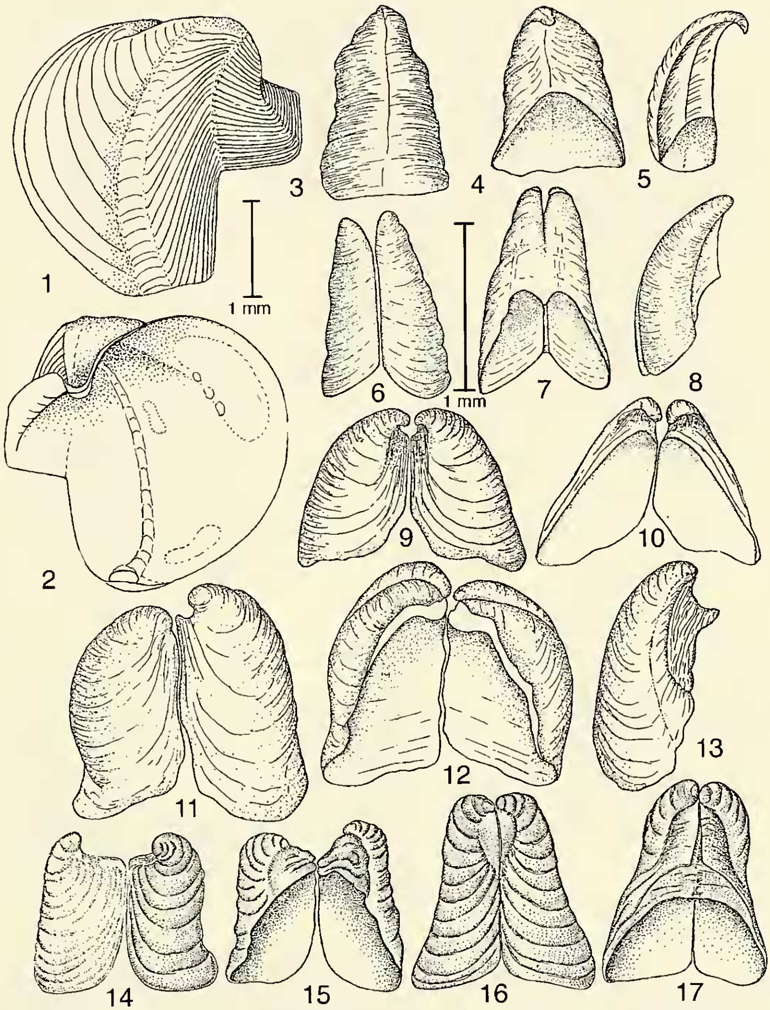

Plate 24. *Xylophaga depalmai* Turner n. sp. from U.S. Naval Oceanographic Office test site off Fort Lauderdale, Florida.

Figures 1–5. Specimen with the two plates of mesoplax fused. Figure 1. Outer view of right valve. Figure 2. Inner view of right valve showing lightly impressed muscle scars. Figure 3. Dorsal view of fused plates of mesoplax. Figure 4. Ventral view of mesoplax. Figure 5. Lateral view. Figures 6–8. Dorsal, ventral, and lateral view of mesoplax with plates partially fused ventrally. Figures 9, 10. Dorsal and ventral views of a mesoplax, which is broadened anteriorly and has a reduced ventral portion. Figures 11–13. Dorsal, ventral, and lateral views of an unusually broad mesoplax with unequal plates and reduced ventral portion. Figures 14, 15. Dorsal and ventral views of a broad mesoplax strongly coiled posteriorly, with a widened median area that separates the coils. Figures 16, 17. Dorsal and ventral views of a typical mesoplax with only the periostracal portion of the ventral portion fused.

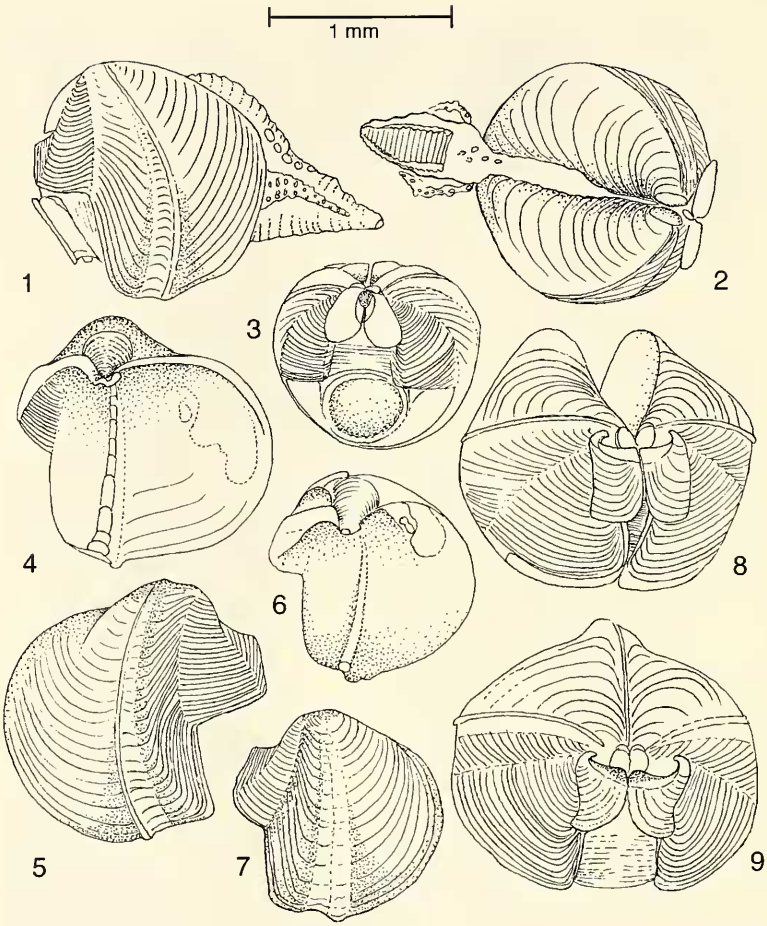

Plate 25. *Xylophaga guineensis* Knudsen.

Figures 1–3. Specimen from *Pillsbury,* station 260. Figure 1. Lateral view of entire animal showing foot, siphons, and periostracal sheath with fine whitish granules. Figure 2. Dorsal view showing siphons, prodissoconch, mesoplax, and loose periostracal sheath with granules. Figure 3. Anterior view showing foot, anterior adductor muscle, and mesoplax in place. Figures 4, 5. Specimen from *Atlantique Sud,* station 33. Figure 4. Inner view of right valve showing specimen with high flaring posterior slope, prodissoconch, posterior adductor muscle scar, and deep groove bounding the umbonal–ventral ridge. Figure 5. Outer view of right valve showing wide anterior slope and narrow, bladelike ridge posterior to the shallow umbonal–ventral sulcus. Figures 6–9. Specimens from *Atlantique Sud,* station 146. Figure 6. Inner view of right valve of specimen with low, rounded posterior, small posterior adductor muscle scar set very high. Figure 7. Outer view of left valve with very closely set ridges on anterior slope. Figures 8, 9. Dorsal views to show variation in the mesoplax in place.

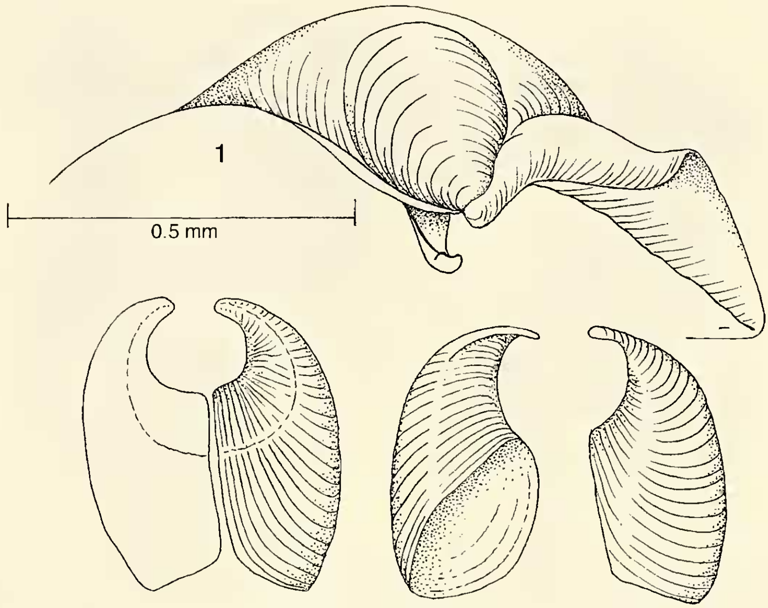

Plate 26. *Xylophaga guineensis* Knudsen.

Figure 1. Specimen from *Atlantique Sud* station 146. Umbonal area showing chondrophore, prodissoconch, and umbonal reflection. Figures 2–4. Specimens from *Atlantique Sud,* station 33. Figure 2. Dorsal view of opposed plates of mesoplax. Figure 3. Ventral view of right plate of the mesoplax to show long cornucopialike shape. Figure 4. Dorsal view of right plate of mesoplax.

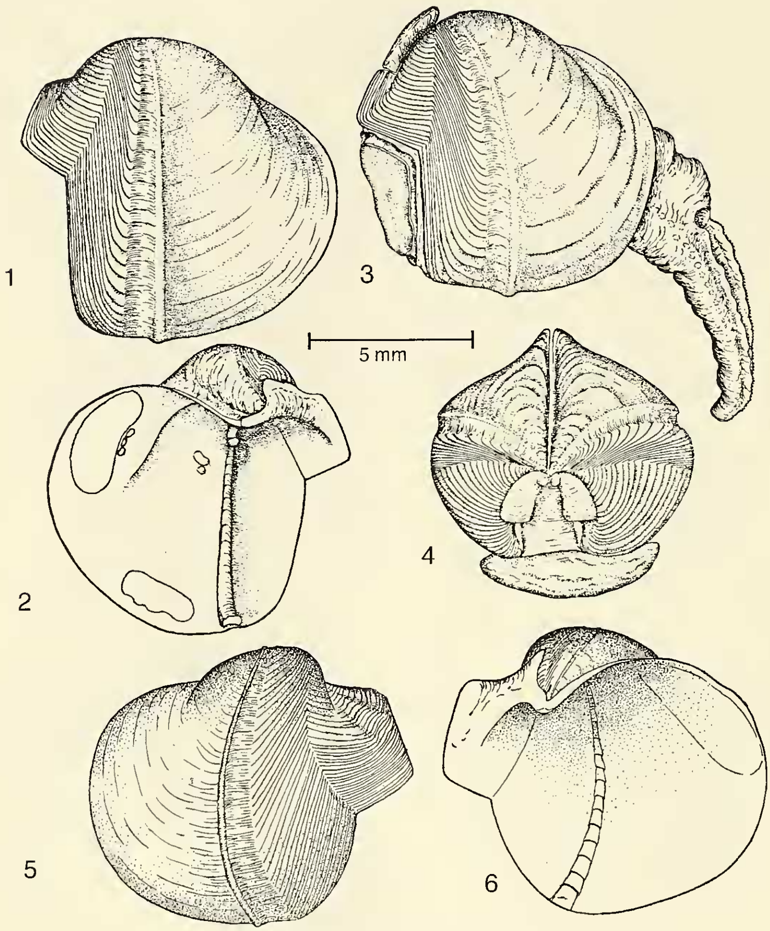

Plate 27. Xylophaga mexicana Dall.

Figures 1–4. Specimens from "replication reef," Santa Monica Bay, California. Figures 1, 2. Outer and inner views of left valve of specimen close to the holotype. Figure 3. Lateral view of entire specimen showing inflated mesoplax and siphons. Figure 4. Dorsal view of entire specimen showing mesoplax and expanded foot. Figures 5, 6. Outer and inner view of right valve of the holotype (from Turner, 1955, pl. 90).

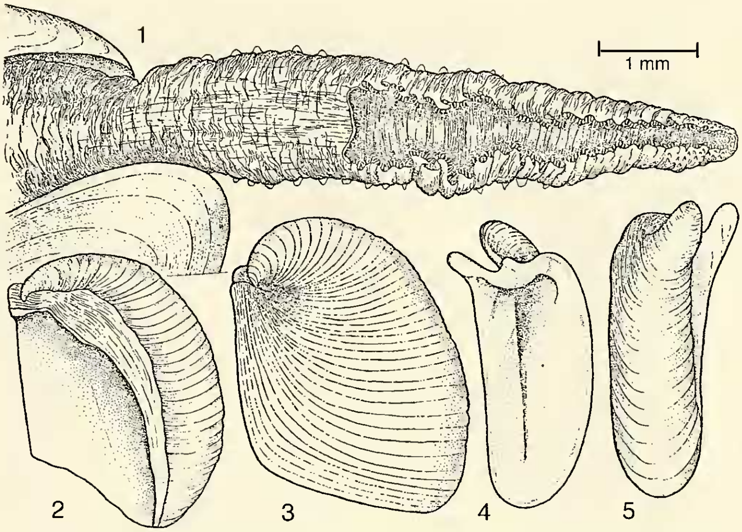

Plate 28. *Xylophaga mexicana* Dall from "replication reef," Santa Monica Bay, California.

Figure 1. Enlargement of the siphons to show the truncation of the excurrent siphon, the finely fringed lappets, granules embedded along the side of the siphon, and the papillose end of the incurrent siphon. Figures 2, 3. Ventral and dorsal view of mesoplax. Figures 4, 5. Inner and outer lateral views of mesoplax showing flange that fits down between the umbos.

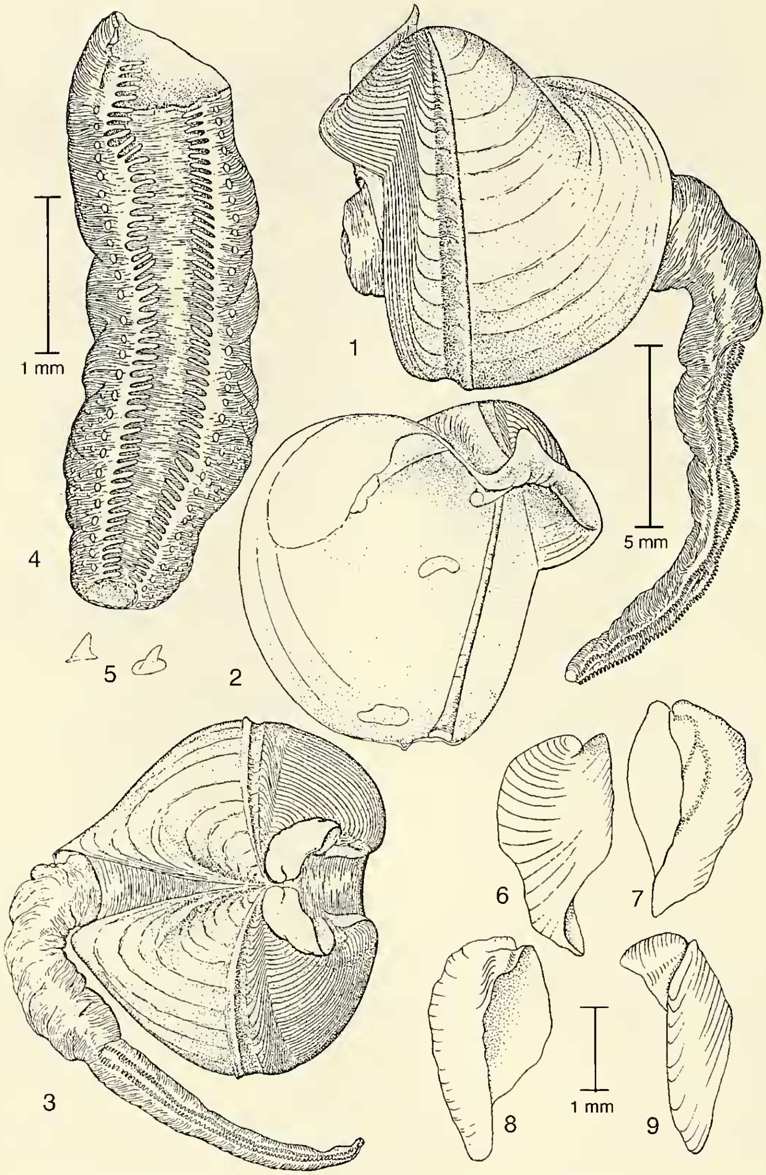

Plate 29. *Xylophaga tipperi* Turner n. sp. from U.S. Naval Oceanographic Office test site off Fort Lauderdale, Florida.

Figure 1. Lateral view of holotype showing foot and extended siphons. Figure 2. Inner view of left valve to show smooth posterior adductor muscle scar. Figure 3. Dorsal view showing mesoplax in place. Figure 4. Enlargement of posterior end of incurrent siphon to show the fringed lappets and the single row of glasslike plaques along the side. Figure 5. Lateral and three-quarters view of glasslike plaques. Figures 6–9. Mesoplax. Figure 6. Dorsal view of right plate showing flat surface and faint sculpture. Figures 7, 8. Ventral view of right and left plates. Figure 9. Lateral view of right plate to show the compressed main portion and the posterior ventral flange that extends down between the umbos.

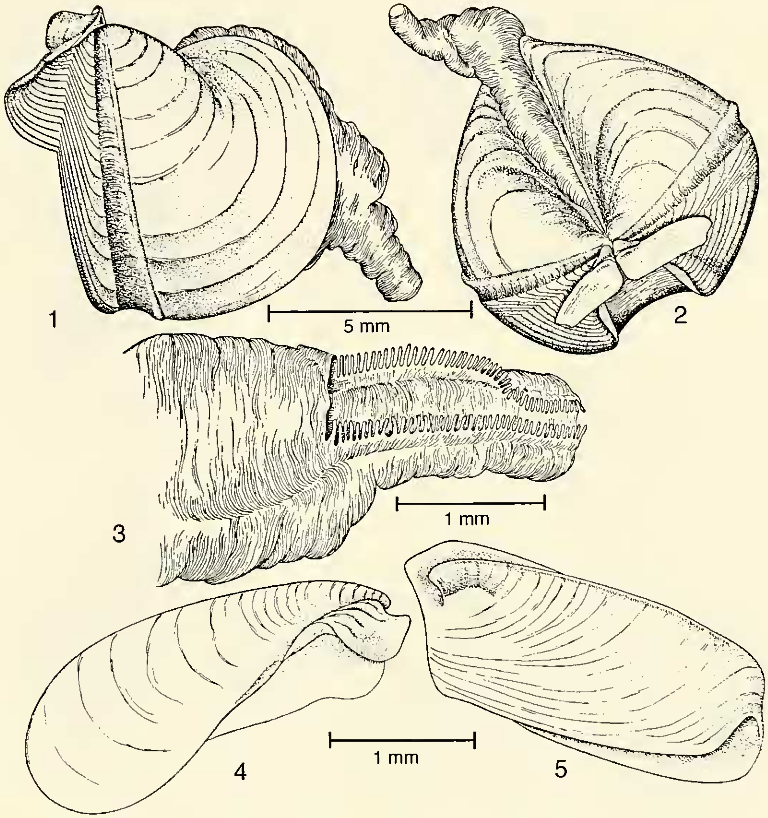

Plate 30. *Xylophaga bayeri* Turner n. sp. from U.S. Naval Oceanographic Office test site off Fort Lauderdale, Florida.

Figure 1. Lateral view of holotype showing siphons and mesoplax in place. Figure 2. Dorsal view of holotype, showing the lateral extension of the mesoplax. Figure 3. Enlargement of the siphons showing the truncated excurrent siphon and the fringed lappets. Figure 4. Ventral view of the mesoplax. Figure 5. Dorsal view of the mesoplax.

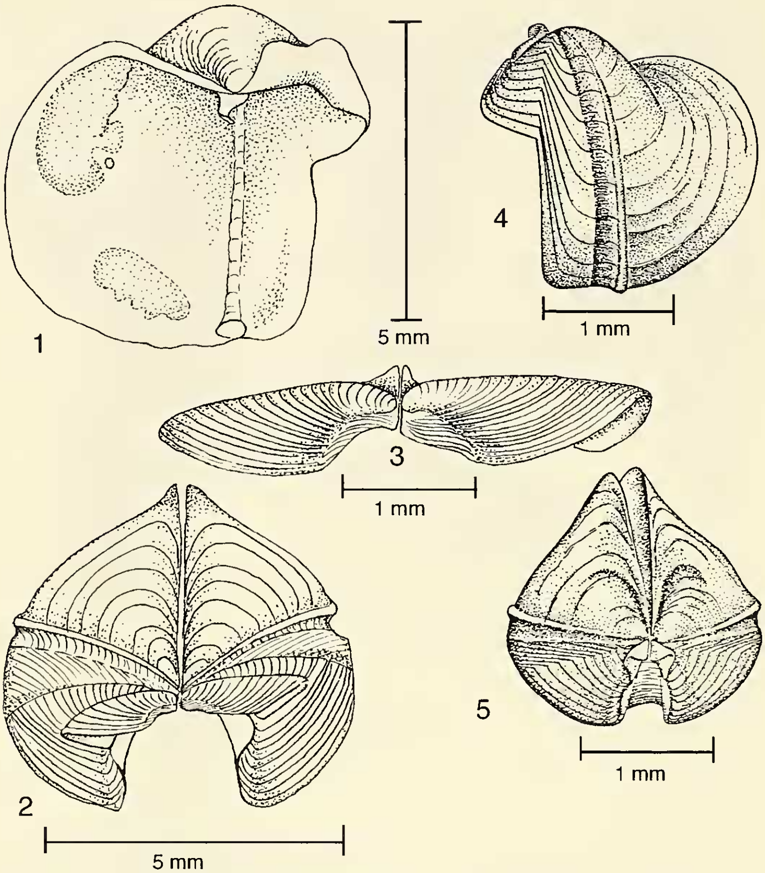

Plate 31. *Xylophaga bayeri* Turner n. sp.

Figures 1–3. Specimen from *Gerda,* station 266. Figure 1. Inner view of valves showing smooth muscle scar; narrow, high umbonal–ventral ridge, and broad, recurved umbonal reflection that adheres to the valve. Figure 2. Dorsal view of specimen showing broad umbonal reflection and the mesoplax. Figure 3. Enlargement of the mesoplax, dorsal view. Figures 4, 5. Specimen from U.S. Naval Oceanographic Office test site off Fort Lauderdale, Florida. Figure 4. Lateral view of a young specimen with partially developed mesoplax. Figure 5. Dorsal view of a young specimen with partially developed mesoplax.

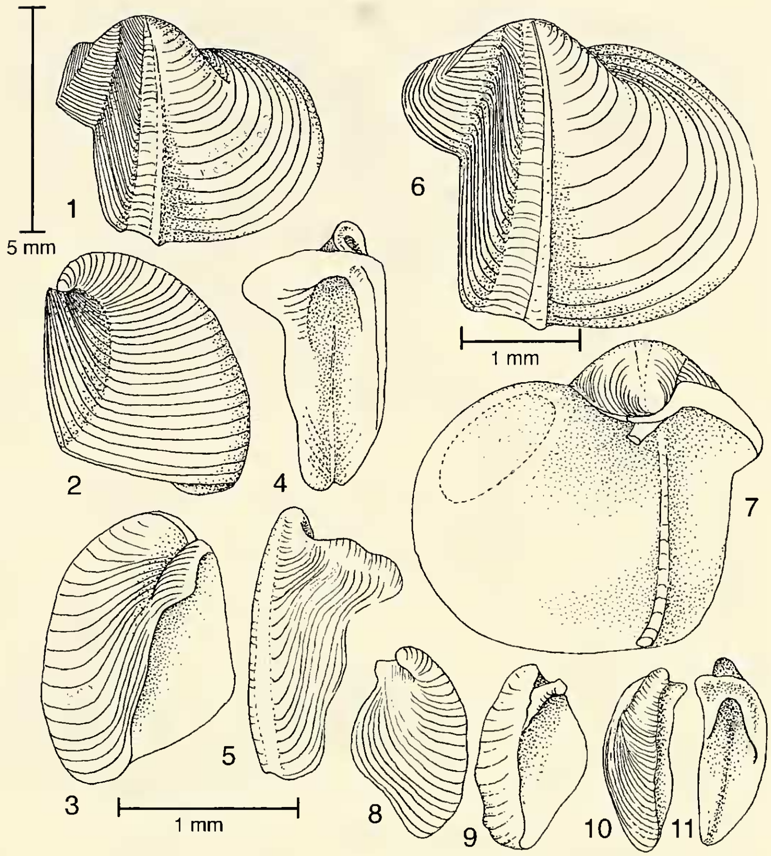

Plate 32. *Xylophaga japonica* Taki and Habe.

Figures 1–5. Paratype from Tosa Bay, Shikoku, Japan. Figure 1. Outer view of left valve showing thin ridge posterior to umbonal–ventral sulcus and elongate posterior slope. Figure 2. Dorsal view of mesoplax with distinct concentric sculpture. Figure 3. Ventral view of mesoplax showing flange that fits between umbos. Figure 4. Inner lateral view. Figure 5. Outer lateral view showing flange. Figures 6–11. Specimens from *Anton Bruun*, station 23. Figure 6. Outer view of left valve. Figure 7. Inner view of right valve showing chondrophore and smooth posterior adductor muscle scar. Figure 8. Outer view of mesoplax of a small specimen. Figure 9. Inner view of mesoplax of a small specimen. Figure 10. Outer lateral view of mesoplax of a small specimen. Figure 11. Inner lateral view of mesoplax of a small specimen.

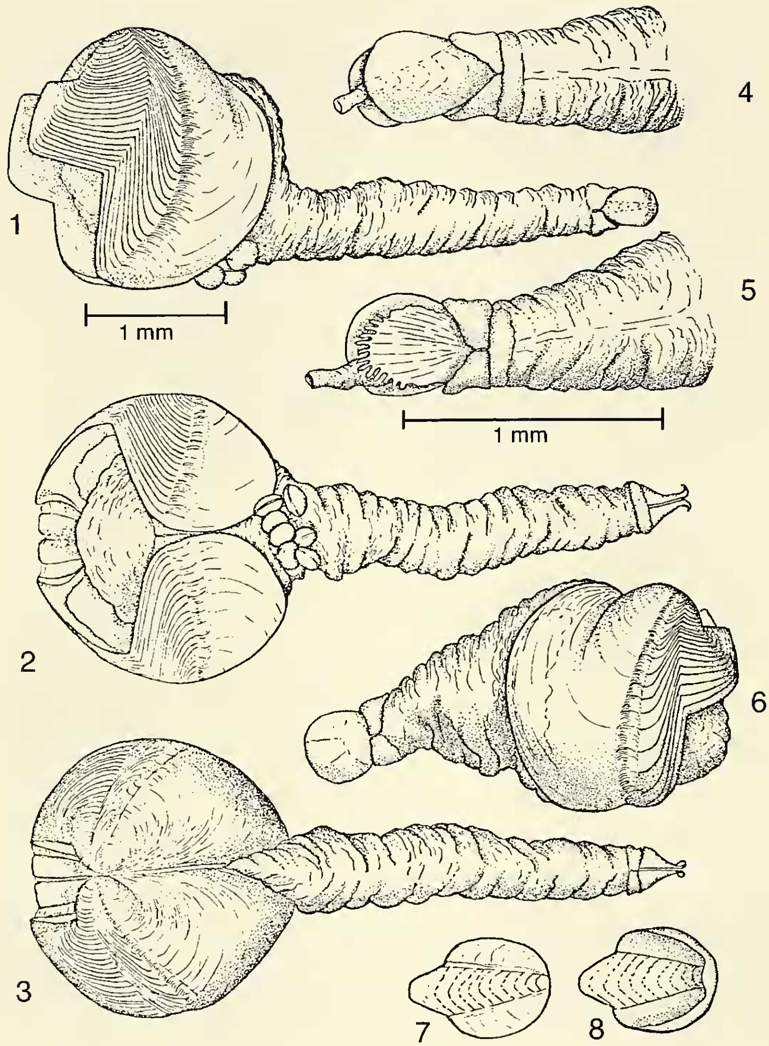

Plate 33. *Xylopholas altenai* Turner from *Gerda,* station 66.

Figures 1–3. Holotype. Figure 1. Lateral view of entire animal with the anterior adductor muscle relaxed so that the mesoplax is flattened and not visible, showing siphonal plates and young carried on ventral surface. Figure 2. Ventral view showing the mesoplax held in place by periostracum, the ventrally carried young, and the recurving of the siphonal plates. Figure 3. Dorsal view showing the mesoplax in place and the umbonal reflection. Figure 4. Enlargement of posterior end with the incurrent siphon projecting beyond the siphonal plate. Figure 5. Posterior end with left plate removed to show the muscle that extends into the cavity of the plate to which the siphonal retractor muscles attach. Figure 6. Lateral view of a very small specimen, contracted anteriorly so that the plates of the mesoplax are folded upward. Figure 7. Outer view of siphonal plate. Figure 8. Inner view of siphonal plate.

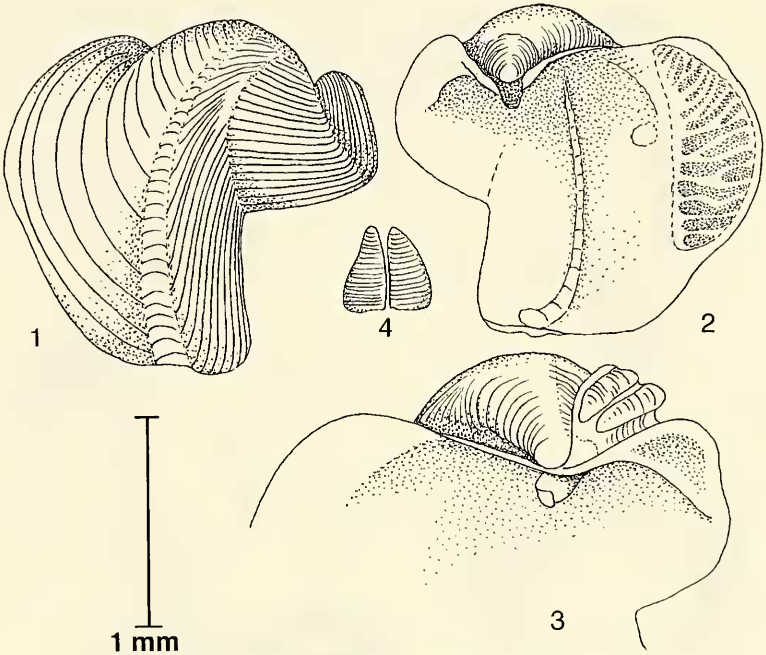

Plate 34. *Xylopholas altenai* Turner from *Gerda*, station 66.

Figure 1. Outer view of right valve showing beaked portion of the anterior slope. Figure 2. Inner view of right valve showing the large posterior adductor muscle scar, pedal retractor scar, prodissoconch, and ligament. Figure 3. Inner view of upper part of left valve to showing the chondrophore and the mesoplax in its periostracal membrane. Figure 4. Dorsal view of the two plates of the mesoplax.

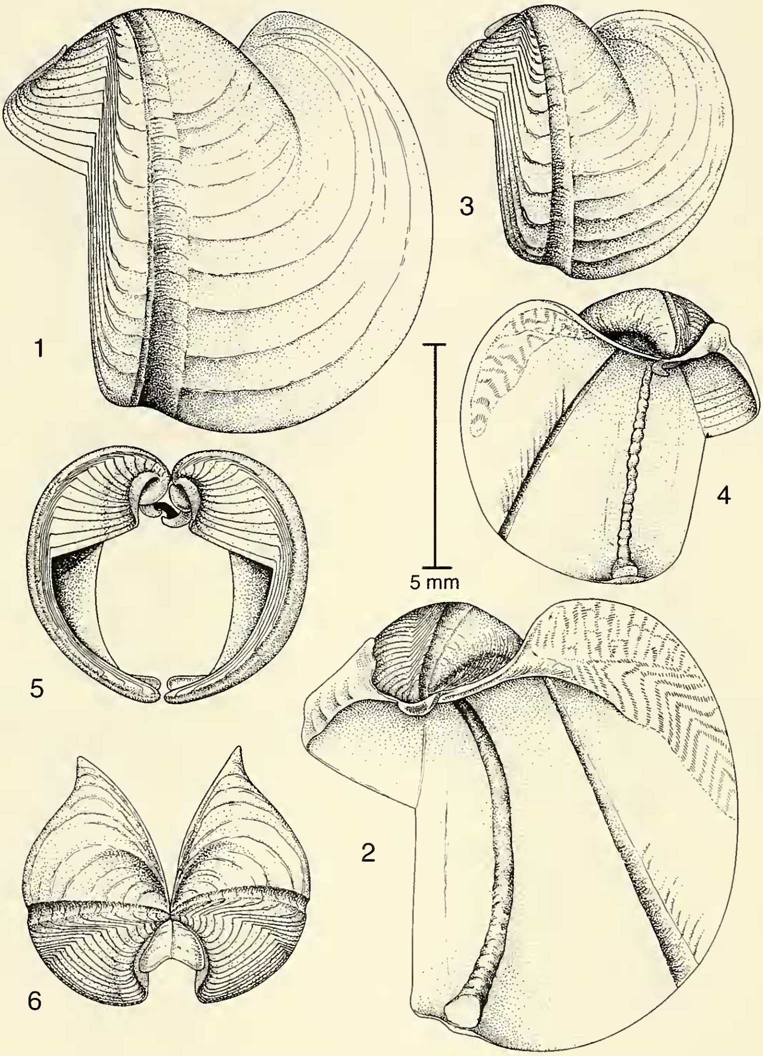

Plate 35. *Xyloredo nooi* Turner from U.S. Naval Oceanographic Office test site, Tongue of the Ocean, Bahama Islands.

Figure 1. Inner view of left valve showing divided muscle scar. Figure 2. Outer view of left valve. Figure 3. Outer view of left valve of holotype showing the flaring posterior dorsal margin. Figure 4. Inner view of right valve of holotype showing the divided posterior adductor muscle scar, the deep groove separating the disc from the posterior slope, and the umbonal reflection. Figure 5. Anterior view of opposed valves, showing the chondrophore and internal ligament. Figure 6. Dorsal view showing the thin mesoplax.

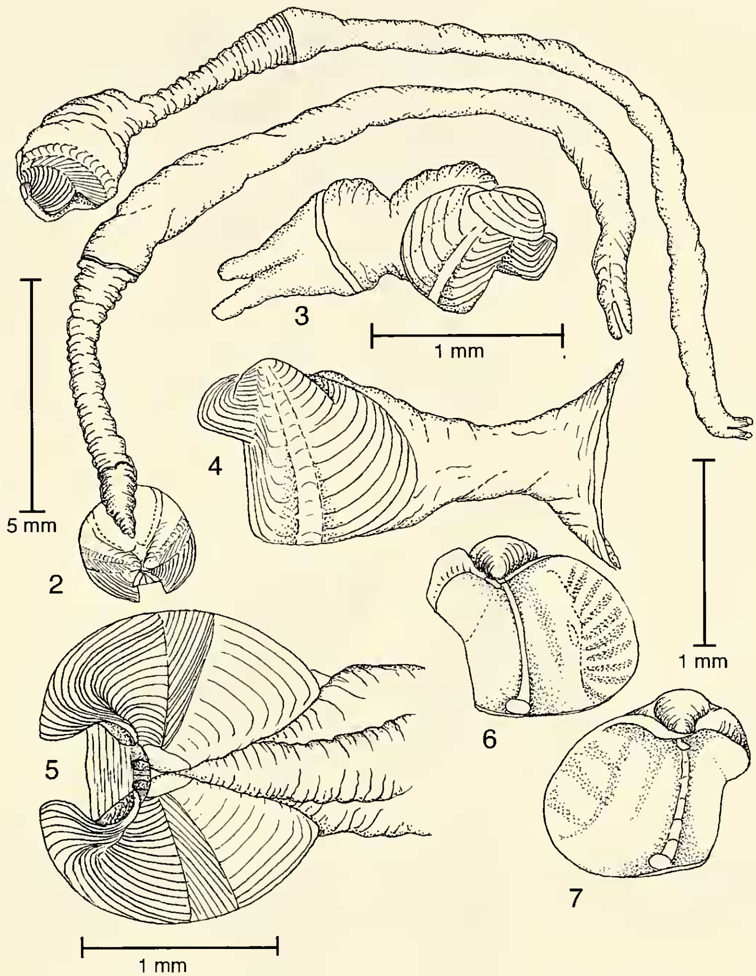

Plate 36. *Xyloredo ingolfia* Turner from *Ingolf* Expedition, station 67.

Figure 1. Lateral view of an entire animal, showing the periostracal sheath, the extended anal and siphonal canals, and the short siphons. Figure 2. Dorsal view of an entire animal, showing the periostracal sheath, the extended anal and siphonal canals, and the short siphons. Figure 3. Lateral view of a very young specimen showing the large prodissoconch and the produced beaked portion of the anterior slope. Figure 4. Lateral view of left valve with periostracal sheath attached. Figure 5. Dorsal view showing the produced, recurved beaks, the umbonal reflection, and the mesoplax with only the central portion of each plate calcified. Figure 6. Inner view of right valve with well-marked posterior adductor muscle scar. Figure 7. Inner view of left valve with lightly marked scar and large prodissoconch.

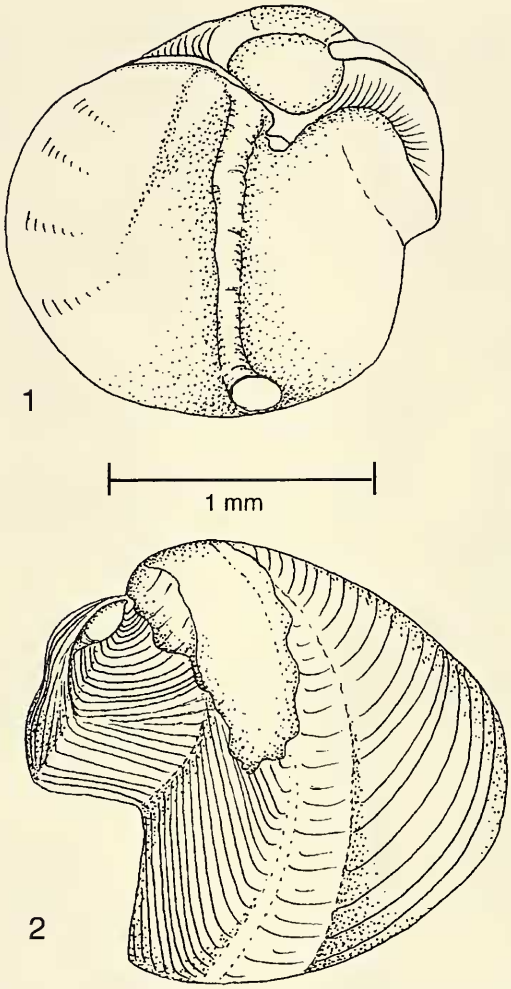

Plate 37. *Xyloredo ingolfia* Turner from *Ingolf* Expedition, station 67.

Figure 1. Inner view of left valve showing large prodissoconch, strong umbonal–ventral ridge, reduced posterior slope, and lightly impressed posterior adductor muscle scar. Figure 2. Outer view of left valve showing the produced beak and rounded low posterior slope.

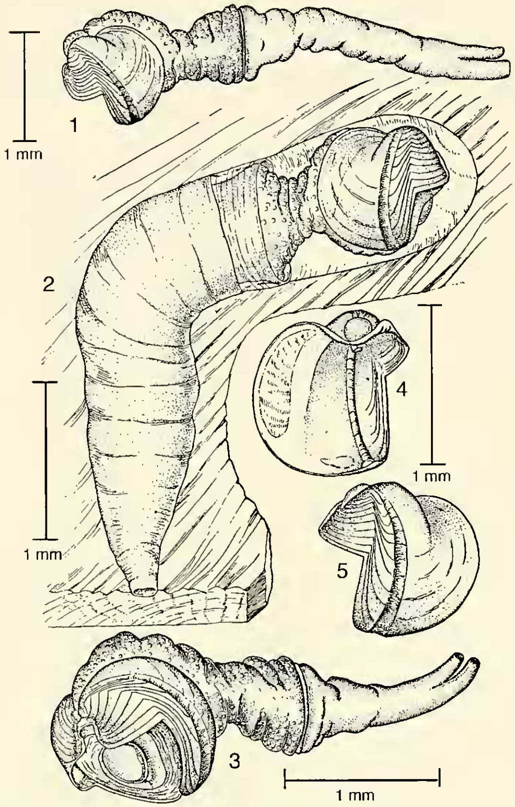

Plate 38. *Xyloredo naceli* Turner from U.S. Naval Civil Engineering Laboratory Test Site I (submersible test unit I-4).

Figure 1. Lateral view of holotype. Figure 2. Lateral view of specimen partially dissected from the wood showing the calcereous tube with the anterior periostracal margin and the papillose periostracal sheath covering the animal between the tube and the valves. Figure 3. Anterior-lateral view of entire specimen showing foot and mesoplax. Figure 4. Inner view of left valve showing muscle scars and chondrophore. Figure 5. Outer view of left valve.

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Taxon names are printed in italics. Page numbers in bold refer to illustrations; those in italics refer to species descriptions; t indicates table.