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Dispersal of Shipworms among Central Pacific Islands, with Descriptions of New Species

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INTRODUCTION

Material from various islands of the central Pacific area which has recently come to my attention presents a more complete picture of the range and probable means of dispersal of certain marine wood borers than that previously known.

Surveys of the shipworm fauna have been made here and there about the fringes of the Pacific, including the Soviet Union, Japan, Australia, and the west coast of North America; and some knowledge of the marine borers of the Philippine Islands, Samoa, and Hawaii has been acquired. However, information respecting species active among the atolls and smaller islands is most inadequate. It is hoped that, as a result of widening contacts in the Pacific, additional data may be assembled regarding the marine borers ranging through this great area.

Records of marine wood borers may be obtained from a given locality by means of several methods. Drift logs or planks washed ashore often enclose only skeletal remains of shipworms (shells and pallets), which, although a legitimate record for the locality, may not represent established fauna because their origin may have been far distant. If the drift material, however, is infested by living mature shipworms, it is probable that the species will become established there and will eventually be considered part of the typical fauna of the locality. There is substantial evidence that at least one species of shipworm now per-

manently established in Hawaii was transported to the islands by drift logs.

Records of shipworms are also obtained by the examination of submerged portions of wooden structures which have been in contact with the sea for a few months: piling, floats, or the hulls of wooden boats, the cruising range of which is known to have been confined to local waters. One may be assured that marine borers recovered from such sources are typical of the locality.

The most satisfactory means, however, of obtaining records of marine wood borers in any locality is by the test-block method. Blocks of wood, large or small, which are submerged and anchored securely, are lifted at intervals for examination. By this method the time element is certain, or approximately so, the period of maturity and spawning fixed, the rate of growth determined, and other data gained which could not be obtained in other ways. Experience indicates that, in the central Pacific area, marine wood borers become well established in most woods within three months.

This report includes a list of shipworms known to have been collected in the following Pacific localities: Samoa, Canton Island, Johnston Island, Christmas Island, Palmyra Island, Wake Island, Midway Island, and the Hawaiian Islands. Specimens were recovered from drift material, from temporary marine structures, from the keels of boats, and from test blocks.

Aid in procuring material was generously given by civil administrators, the United States Navy, the United States Army and representatives of the Hawaiian Sugar Planters' Association Experiment Station. Records of previous investigators are included.

COLLECTING LOCALITIES

Western Samoa

Shells and pallets, or pallets only, of the species of shipworms here recorded were recovered from eucalypt wood (Australian origin), which was a section of the keel of a motor boat which had cruised in the waters of Western Samoa for about four years. Two of the species, *Teredo fulleri* and *T. trulliformis,* were also abundant in a section of *totara* wood forming planking of a motor launch which had been in the waters about Apia, Western Samoa, for five years. Infested wood was supplied by the Administrator of Western Samoa in 1941.

Teredo (Teredo) samoaensis Miller, Univ. Calif. Pub., Zool. 26: 145-158, 1924.

But one pallet was recovered.

Teredo (Teredo) trulliformis Miller, loc. cit.

Numerous shells and pallets were recovered.

Teredo (Zopoteredo) fulleri Clapp, Acad. Sci. St. Louis, Trans. 25 (1) : 1-16, 1924.

This is apparently the most abundant species, as fully 90 percent of the pallets recovered represent this form.

The dispersal of *T. fulleri* is remarkable. It was described from the Caribbean Sea (Virgin Islands) and considered a rare form, being taken from but two localities. In the Pacific the species was first observed in the Hawaiian area in 1940, but more recently it has been shown to be widely dispersed.

No adequate explanation of the discontinuous distribution of the species between the Caribbean and the central Pacific can be made at this time, nor can the means of its dispersal between localities such as Hawaii, Palmyra, Christmas Island, and Western Samoa be determined. Favorable to such circulation, however, is the increased ocean traffic during recent years, including craft either constructed of wood or bearing certain parts of wood which come in contact with sea water.

Teredo (Zopoteredo) triangularis Edmondson, B. P. Bishop Mus., Occ. Papers 17 (10) : 97-150, 1942.

Few pallets of this species were recovered.

Teredo (Cornuteredo) bensoni, new species. (Described below under Canton Island.)

Few pallets were recovered.

Eastern Samoa

Following a survey in 1924, R. C. Miller listed three species of shipworms from Tutuila, Samoa, two of which were described as new. No additional information regarding marine wood borers of Eastern Samoa is available.

Teredo (Teredo) parksi Bartsch, Biol. Soc. Wash., Proc. 34: 25-32, 1921.

This species is reported to become sexually mature more rapidly and at a smaller size in Samoa than in Hawaii.

Teredo (Teredo) furcillatus Miller, Univ. Calif. Pub., Zool. **26**: 145-158, 1924.

This species, reported to occur in limited numbers in test blocks at Tutuila, is not considered of much economic importance.

Teredo (Teredo) samoaensis Miller, loc. cit.

T. samoaensis is abundant in test blocks at Tutuila during certain times of the year. The pallets are very characteristic with a narrow, calcified distal extremity of the blade, more or less covered by brown periostracum.

Canton Island

Teredo (Teredo) samoaensis Miller, Univ. Calif. Pub., Zool. **26**: 145-158, 1924.

Canton Island lies approximately 10 degrees latitude north of Tutuila, Samoa, which is the type locality of the species. The shells and pallets were recovered from a submerged portion of a pier constructed in 1939. The material was supplied by R. S. Danner, representative of the Hawaiian Sugar Planters' Association Experiment Station, in 1941. The wood was infested by but one species of *Teredo*.

Teredo (Teredora) gregoryi Dall, Bartsch, and Rehder, B. P. Bishop Mus., Bull. **153**, 1938.

The shells and pallets of the species were recovered from a drift log washed ashore on the island. Infested wood was supplied by R. H. Van Zwaluwenburg, representative of the Hawaiian Sugar Planters' Association Experiment Station, in 1941. The drift log was of undetermined species and origin. S. J. Record, Yale School of Forestry, who examined sections of the drift log suggested a similarity to *Artocarpus* (breadfruit) and expressed an opinion that it was not of Latin American origin.

This observation opens the distribution of the shipworm to further speculation. Previously, *T. gregoryi* was known only from subtropical latitudes north of the equator. The condition of the log indicates that it may have drifted a long distance while being destroyed by the shipworm. Ocean currents apparently would preclude movements of drift toward Canton Island from the north or south but would permit such movements from the east.

Teredo (Teredo) bensoni, new species (fig. 1, *a-d*).

Shell of type specimen 5.50 mm. in height, 5 mm. in length; anterior lobe

bearing about 60 fine denticulated ridges; anterior median area occupying nearly one-half of median portion. Auricle small, its height more than twice its length. Curved lines mark surface of middle and posterior median areas and auricle. Internally auricle overlaps posterior median portion forming a broad shelf. Apophysis (blade) rather broad and long.

Pallet of type specimen 5.50 mm. long, greatest breadth 1 mm. Calcareous blade marked about the middle by a transverse groove; basal portion merging gradually into a long, stout, curved stalk; distal portion concave at extremity, outer surface deeply excavated, inner surface smooth. Pallets of type specimen free from periostracum.

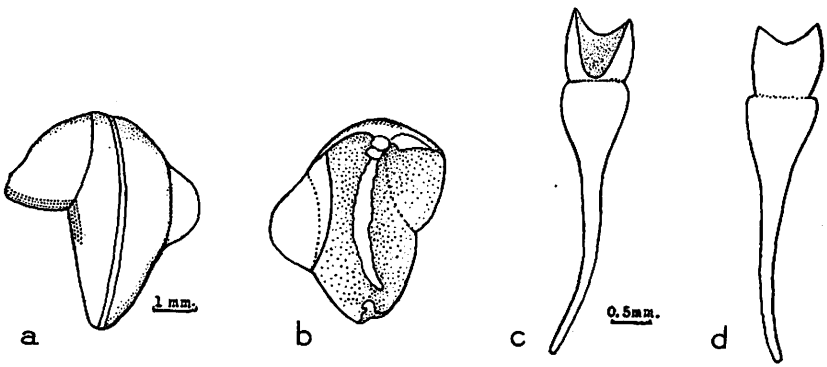

FIGURE 1.—*Teredo (Teredo) bensoni:* **a**, left valve, outer surface (Canton Island); **b**, left valve, inner surface; **c**, pallet, outer surface, without periostracum; **d**, pallet, inner surface.

Type specimen and paratypes in Bishop Museum.

The species was recovered from the wooden guard rail of the dredger *Benson* on its return to Honolulu after completing operations at Canton Island. In addition to shells and pallets, living mature specimens 50 to 75 mm. long were taken from the infested wood.

Four months after the return of the dredger from Canton Island, a single immature shipworm closely resembling the type specimen was recovered from a test block in Honolulu Harbor near the dry dock where the *Benson* had been reconditioned.

In 1941 pallets similar to those of the type specimen were taken from wood received from Western Samoa. These specimens have the outer surface of the blade of the pallets partly covered with dark brown periostracum.

The transportation of living shipworms from Canton Island to Hawaii in wooden portions of an ocean going dredger suggests means by which marine borers may be dispersed from island to island.

JOHNSTON ISLAND

Teredo (Teredora) gregoryi Dall, Bartsch, and Rehder, B. P. Bishop Mus., Bull. **153,** 1938.

Shells and pallets were taken from a Douglas fir drift log on the shore of Johnston Island by members of the Tanager Expedition in 1923.

A single pair of valves, 14 mm. in height, was recovered from a creosoted fir pile which served as portion of a float for about 14 months. The material was supplied by the Navy in 1944. The creosoting of the pile was apparently light and lacking uniformity. There was also some action by *Limnoria.*

Teredo (Teredops) diegensis Bartsch, Nautilus 30 (4) : 47-48, 1916.

A Douglas fir plank, 1.5 inches thick, supplied by the Navy in 1944, was badly damaged by this shipworm and also by *Limnoria.* The period of submergence of the wood was about 14 months. The shells and pallets of the shipworm recovered closely resembled those of the same species in Hawaiian waters.

Bartsch, who described *T. diegensis* from the California coast (San Diego), is disinclined to accept its dispersal among the Pacific islands.

For the purpose of comparing specimens purporting to be of this species in Pacific island waters with those of the type locality, at my request, M. A. Miller of the Biological Laboratory, Naval Fuel Depot, San Diego, installed test blocks in San Diego Bay in 1941 from which he recovered specimens of *Teredo* during the following summer. The specimens were determined as *T. diegensis* by W. S. Coe of Scripps Institution of Oceanography and sent to Hawaii for comparison with those of the islands. A careful examination confirmed the identity of the species from the two sources.

From evidence at hand *T. diegensis* appears to be dispersed over a wide area in the central Pacific, being especially abundant about the larger of the Hawaiian islands, and represented at Midway Island by a subspecies. Recent observations suggest an even more extensive range for the species.

An assortment of shells and pallets of shipworms received from C. J. J. Watson of Brisbane, Australia, includes pallets of teredos from Brisbane Harbor and the coast of New Guinea which closely resemble those of the typical *T. diegensis* of Hawaii. D. D. Moore, of the Maritime Services Board of New South Wales, who has carefully compared *T. tristi* Iredale, of Brisbane Harbor, *T. pertigens*

Iredale, of Sydney Harbor, and the New Guinea form with typical examples of *T. diegensis* Bartsch, is of the opinion that they are all identical (personal communication).

Teredo (Teredo) sp.

An undetermined species, associated with the preceding, is represented by a few, somewhat imperfect pallets which were recovered from the infested plank. The pallets show some resemblance to those of *Teredo (Teredo) hiloensis* Edmondson (B. P. Bishop Mus., Occ. Papers 17(10) : 97-150, 1942), which was described from Hilo, Hawaii, but has been taken in limited numbers in Honolulu Harbor. Shells could not be positively identified with the pallets.

The possible means of dispersal of marine borers have doubtless increased in recent years through greater activity of small to medium-sized surface craft, some of which are of wooden construction. It is not surprising that the shipworm fauna of Johnston Island should be closely identified with that of Hawaii, as the intervening distance is less than 800 miles.

Christmas Island (north Pacific)

Infested wood from the dock area at London, Christmas Island, was supplied by Robert B. Dunlap, Infantry Adjutant, who also supervised the installation of test blocks in shoal water in that vicinity. In a personal communication, Lieutenant Dunlap reports that marine borers are quite active about the island and cites the recent collapse of a pier, the supporting piling of which was eaten away at the water line. The samples of wood from the dock area were found to be badly damaged by *Limnoria* and also by several species of shipworms.

Teredo (Zopoteredo) fulleri Clapp, Acad. Sci. St. Louis, Trans. 25(1) : 1-16, 1924.

Pallets of this very distinctive species were recovered from the infested wood. They were apparently from mature specimens, but few in number. Judging from the material examined, this species is probably not a serious menace in that locality, because of its paucity.

Teredo sp. (fig. 2, *a, b*).

Pallets 5 mm. in length; blade 2 mm. long, sides parallel, distal extremity deeply concave forming a two-pronged fork; outer surface convex, almost completely covered with a brown periostracum, drawn out into two sharp points; inner surface flat, not covered by brown periostracum. Stalk fairly stout, slightly curved in specimens observed, 3 mm. in length.

An undetermined species is represented by pallets only, shells not being definitely associated with the pallets. The pallets bear some resemblance to those of *T. parksi* and *T. bartschi* but differ in the parallel sides of the narrow blade. They also differ from those of *T. bensoni* in not being so deeply excavated on the outer surface, and in a more abrupt mergence of the blade into the stalk. Pallets recovered from the infested wood are in Bishop Museum.

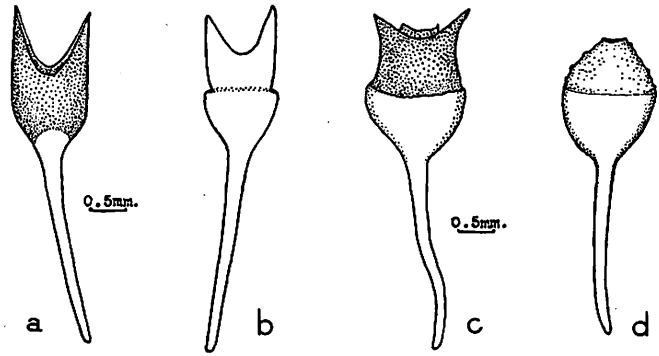

FIGURE 2.—*Teredo* sp.: a, pallet, outer surface (Christmas Island); b, pallet, inner surface; c, pallet, outer surface (Christmas Island); d, pallet, without periostracum.

Teredo sp. (fig. 2, *c, d*).

Pallets rather stout, 5 mm. in length; calcareous portion of blade oval in form, length 2 mm., width 1.5 mm.; outer surface convex, inner surface flat. Roughened distal half of blade covered on outer surface by a light-brown periostracum drawn out into two sharp points which project slightly beyond the extremity of the calcareous portion. Narrow distal extremity of calcareous portion with a shallow concavity. Stalk a little longer than blade, straight or bent, cylindrical, tapering to a narrow, rounded end.

With respect to the shape of the calcareous portion of the blade of the pallet, this species bears some resemblance to *Teredo* (*Teredo*) *hiloensis,* of Hawaii, but in the Christmas Island form the stalk is proportionately longer and less stout. Pallets are in Bishop Museum.

Another species recovered from the Christmas Island material is here represented by pallets only, shells of the form not being positively identified.

PALMYRA ISLAND

Teredo (Zopoteredo) triangularis Edmondson, B. P. Bishop Mus., Occ. Papers 17 (10): 97-150, 1942.

Submerged portions of a wooden pier recently constructed in the

lagoon at Palmyra Island were found to be badly damaged by shipworms, including this species. The infested wood was supplied in 1943 by George Walker, United States Navy.

The type locality of the species is Kahului, Maui, but it is known to occur about several of the larger Hawaiian islands. Although proof is lacking, it is highly probable that marine borers have been transported from Hawaii to Palmyra Island by means of dredgers or other craft serving in construction operations.

Teredo (Zopoteredo) fulleri Clapp, Acad. Sci. St. Louis, Trans. **25** (1) : 1-16, 1924.

Sections of the submerged pier at Palmyra Island were found to be heavily attacked by this species, along with the preceding one. Mature, fertile specimens were abundant.

Teredo (Teredo) trulliformis Miller, Univ. Calif. Pub., Zool. **26**: 145-158, 1924.

This species was associated with the preceding ones in sections of the submerged pier. Shells and pallets of immature and adult specimens were recovered, but infestation by the species was light.

Wake Island

Teredo (Teredora) gregoryi Dall, Bartsch, and Rehder, B. P. Bishop Mus., Bull. **153**, 1938.

Shells and pallets of the species were taken by members of the Tanager Expedition in 1923 from a drift log washed ashore on the island. This is the most western locality in the Pacific at which the species has been recovered, so far as the present record shows.

A Douglas fir test block placed in the lagoon at Wake Island in 1941 by the Navy was without infestation by marine borers at the end of 30 days. The interval was probably insufficient for attacks by shipworms or *Limnoria*.

Midway Island

Teredo (Teredora) gregoryi Dall, Bartsch, and Rehder, B. P. Bishop Mus. Bull. **153**, 1938.

Shells and pallets of the species were recovered by members of the Tanager Expedition in 1923 from a Douglas fir drift log washed ashore.

An untreated fir pile lifted in March 1939, by the Army Engineers, after having been in place in the lagoon for nearly a year, showed some damage caused by this species. Test blocks installed in the lagoon in 1941 by the Navy were heavily infested by the species, indicating that it had become well established in that locality.

The species is typical of drift logs, from which it has been recovered in widely separated areas, mostly in the north Pacific tropical and subtropical latitudes. It reaches a large size when fully grown, some burrows in drift logs being nearly one inch in diameter and more than two feet long. Living specimens of such size, however, have not been recorded. Although most of the drift logs stranded on the shores of north Pacific islands have their origin on the northwest American coast, the shipworm has not been reported from west American waters. It is probable that the attack on logs is made in the open sea.

Teredo (Teredops) diegensis Bartsch var. **midwayensis,** new variety (fig. 3, *a, b*).

This form which seems to merit a varietal designation apparently is the prevailing shipworm about Midway Island.

The rather bulbous shell differs in no appreciable degree from that of the typical form of *T. diegensis* of the central Pacific area, but a number of distinctive features are noted about the pallet of the new variety. The calcareous portion of the blade of the pallet is short, broad at the base and rapidly tapers toward a narrow, distal extremity. The proximal portion of the outer surface is traversed by several shallow, longitudinal grooves. The greatest width and the length of the calcareous portion of the blade are approximately equal. The stalk is

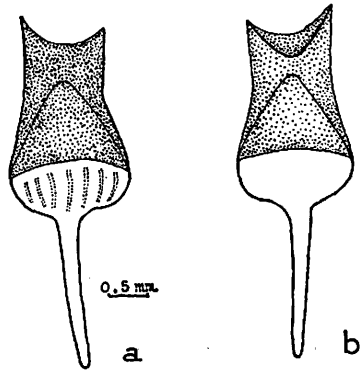

FIGURE 3.—*Teredo* (*Teredops*) *diegensis* var. *midwayensis:* **a,** pallet, outer surface (Midway Island); **b,** pallet, inner surface.

short, slightly exceeding the calcareous blade in length. The very black periostracum, covering one-half the blade, extends about 1 mm. beyond its tip. Type and paratypes of the new variety are in Bishop Museum.

This variety seems to be well established at Midway Island. A Douglas fir pile, in the lagoon for nearly a year, was badly damaged by the form; and special test blocks placed in the lagoon were heavily infested by it.

Variations in the length and breadth of the pallet are seen among specimens of the typical *T. diegensis* in other localities of the central Pacific, but nowhere except at Midway Island is the short, broad blade of the pallet so constant, and in no other locality has its grooved character been noted.

Hawaiian Islands

As a result of investigations by Bartsch (1921); Miller (1924); Dall, Bartsch, and Rehder (1938) and Edmondson (1942, and subsequently), the following shipworms are reported about the larger of the Hawaiian islands:

Teredo (Teredo) parksi Bartsch, Biol. Soc. Wash., Proc. 34: 25-32, 1921.

The species was once considered the prevailing one in Hawaii, but at the present time is generally displaced by other forms.

Teredo (Teredo) bartschi Clapp, Boston Soc. Nat. Hist., Proc. 37(2): 31-38, 1923.

This species, described from the coast of Florida, was recognized in Hawaii by Miller. The determination for Hawaii was questioned by Dall, Bartsch, and Rehder and tentatively placed in synonymy under a new species, *T.* (*Teredops*) *hawaiensis*. Miller's determination of the species for Hawaii is recognized by me.

Teredo (Teredo) furcillatus Miller, Univ. Calif. Pub., Zool. 26: 145-158, 1924.

Reported in limited numbers from Samoa and Hawaii by Miller. Since that time the species has not been observed in Hawaii.

Teredo (Teredo) hiloensis Edmondson, B. P. Bishop Mus., Occ. Papers 17(10): 97-150, 1942.

Described from Hilo, Hawaii, and also recovered from test blocks in Honolulu Harbor.

Teredo (Teredo) honoluluensis, new species (fig. 4, *a-c*).

Shell of type specimen 4 mm. high and of similar length; anterior lobe with about 50 fine, denticulated ridges; anterior median portion occupying one-third the total median area. Auricle large, its height twice its length. Internally, auricle forms a shelf by overlapping the posterior median area.

Pallets of type specimen 4.5 mm. in length; blade flattened, similar on outer and inner surfaces; basal portion merging gradually into a long, stout stalk; distal margin of calcareous portion smoothly truncate with rounded corners. A thin yellowish periostracum covering both surfaces of blade becomes dark brown near distal extremity. Free distal margin of periostracum damaged but there is a suggestion of a shallow concavity.

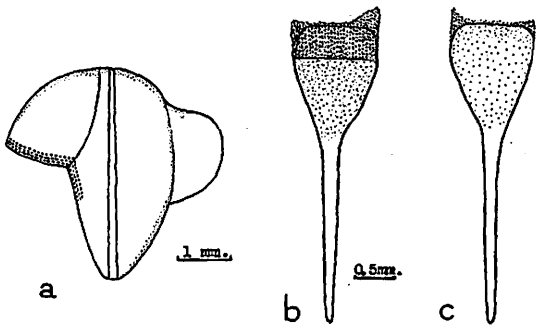

FIGURE 4.—*Teredo (Teredo) honoluluensis:* a, left valve, outer surface (Oahu): b, pallet, outer surface; c, pallet, inner surface.

The holotype was recovered from a test block in Honolulu Harbor. The species seems to resemble *T. furcillatus* Miller and also *T. hiloensis* Edmondson in the thin sparse periostracum covering the blade of the pallet. It differs from both, however, in the shape of the calcareous portion of the blade, the evenly truncate distal border being a distinctive feature of the new species.

Type specimen (shell and pallets) in Bishop Museum.

Teredo (Cornuteredo) milleri Dall, Bartsch, and Rehder, B. P. Bishop Mus., Bull. **153,** 1938.

The species is very widely distributed in the Hawaiian area. The specific name *milleri,* as suggested by the authors, replaces that of *T. affinis* Deshayes, determined for Hawaii by Miller. The new name is tentatively accepted by me.

Teredo (Cornuteredo) medilobata Edmondson, B. P. Bishop Mus., Occ. Papers **17** (10): 97-150, 1942.

This small species is very active in certain localities about Oahu, and has also been taken from the shores of Kauai and Maui.

Teredo (Zopoteredo) trulliformis Miller, Univ. Calif. Pub., Zool. **26**: 145-158, 1924.

This is a very distinctive species described from Hawaii and until recently believed to be limited in its range to that area. It is now known to be widely dispersed among islands of the Pacific.

Teredo (Zopoteredo) triangularis Edmondson, B. P. Bishop Mus., Occ. Papers **17** (10) : 97-150, 1942.

Known to be distributed generally among the larger of the Hawaiian islands, being especially abundant in Kahului Harbor, Maui. It is also established at Palmyra Island and reported from Western Samoa.

Teredo (Zopoteredo) fulleri Clapp, Acad. Sci. St. Louis, Trans. **25** (1) : 1-16, 1924.

Widely dispersed among the larger islands of the Hawaiian area, and very active at Palmyra Island and in the waters of Western Samoa.

Teredo (Teredora) gregoryi Dall, Bartsch, and Rehder, B. P. Bishop Mus., Bull. **153,** 1938.

Typical of drift logs throughout wide areas of the north central Pacific and thus widely dispersed among the Hawaiian Islands, where it may also be recovered from test blocks. There is a drift log record of the species from Canton Island in the south Pacific.

Teredo (Teredops) diegensis Bartsch, Nautilus **30** (4) : 47-48, 1916.

Recognized in Hawaii by Miller, but determination questioned by Dall, Bartsch, and Rehder and placed in synonymy under a new species, *T.* (*Teredops*) *kauaiensis.* Miller's determination is accepted by me.

Teredo (Teredops) hawaiensis Dall, Bartsch, and Rehder, B. P. Bishop Mus., Bull. **153,** 1938.

Recovered from a section of palm wood dredged by the *Albatross* off the south coast of Oahu at a depth of 211-53 fathoms.

Bankia (Nausitora) oahuensis Edmondson, B. P. Bishop Mus., Occ. Papers **17** (10) : 97-150, 1942.

The species is known from only one locality about Oahu. It was taken in local drift material in Kalihi Entrance, where the sea water is diluted by a fresh water stream.

Bankia (Neobankia) hawaiiensis Edmondson, loc. cit.

Widely dispersed among the larger Hawaiian islands, this species is very active in Honolulu Harbor. Comparison with the Hawaiian form of specimens of *Bankia rubra* Sivickis (Philippine Jour. Sci. **37**: 285-298, 1928) collected by D. D. Moore on the shore of New Guinea suggests their possible identity. If this is established, the name *B. rubra* takes precedence over *B. hawaiiensis.*

Bankia (Neobankia) konaensis Edmondson, loc. cit.

Recovered only from local drift wood on the Kona coast of the island of Hawaii.

Bankia (Bankiella) sp. Edmondson, loc. cit.

This is an undetermined form known only from imperfect pallets taken from timbers of a float anchored at Waikiki, Oahu.

SUMMARY

A striking similarity of species of marine wood borers is seen among the various islands of the central Pacific area. The remarkable range of distribution of several species of shipworms, including that of *Teredo diegensis, T. fulleri,* and *T. gregoryi,* is cited.

The identity of Hawaiian species with those of comparatively near-by localities, such as Johnston and Palmyra Islands suggests possible recent dispersal by means of light ocean-going craft of wooden construction. The introduction of at least one species into Hawaii from Canton Island by such means supports this view.