Bankia setacea

The northwest or feathery shipworm

Phylum: Mollusca

Class: Bivalvia, Heterodonta, Euheterodonta

Order: Imparidentia, Myida

Family: Pholadoidea, Teredinidae, Bankiinae

Taxonomy: The original binomen for *Bankia setacea* was *Xylotrya setacea,* described by Tryon in 1863 (Turner 1966). William Leach described several molluscan genera, including *Xylotrya*, but how his descriptions were interpreted varied. Although Menke believed *Xylotrya* to be a member of the Pholadidae, Gray understood it as a member of the Terdinidae and synonyimized it with the genus *Bankia*, a genus designated by the latter author in 1842. Most authors refer to *Bankia setacea* (e.g. Kozloff 1993; Sipe et al. 2000; Coan and Valentich-Scott 2007; Betcher et al. 2012; Borges et al. 2012; Davidson and de Rivera 2012), although one recent paper sites *Xylotrya setacea* (Siddall et al. 2009). Two additional known synonyms exist currently, including *Bankia osumiensis, B. sibirica.*

Description

Size: The largest of the shipworms, with burrows that in one study were found to be up to 15mm in diameter and 1m in length (Haderlie and Mellor 1973). Body size can vary greatly. The illustrated specimen (Fig. 1) is small and has shell diameter of 5 mm.
Color: White with brownish tinges. A long soft whitish tube connects the calcareous shell and pallets (Fig. 1) (Haderlie and Abbott 1980).
General Morphology: Bivalve mollusks are bilaterally symmetrical with two lateral valves or **shells** that are hinged dorsally and surround a mantle, head, **foot** and viscera (see Plate 393B, Coan and Valentich-Scott 2007). Among the bivalves, the Heterodonta are characterized by **ctenidia** that are eulamellibranchiate, fused mantle margins and the presence of long **siphons**. Members of the family Teredinidae are modified for and distiguished by a wood-boring mode of life (Sipe et al. 2000), **pallets** at the siphon tips (see Plate 394C, Coan and Valentich-Scott 2007) and distinct anterior shell indentation. They are commonly called shipworms (though they are not worms at all!) and bore into many wooden structures. The common name shipworm is based on their vermiform morphology and a shell that only covers the anterior body (Ricketts and Calvin 1952; see images in Turner 1966).
Body: Bizarrely modified bivalve with reduced, sub-globular body. For internal anatomy, see Fig. 1, Canadian…; Fig. 1 Betcher et al. 2012.

Color:

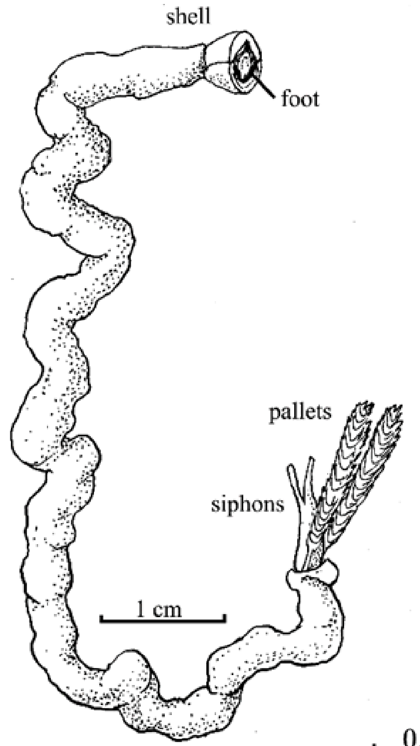
Interior: The auricle (chamber of the heart) is medium sized and rounded. A complex digestion system allows for digestion of wood, which passes from a short esophagus to an alimentary tract to a stomach and finally a caecum where wood is broken down by enzymes (for metabolic compounds see Liu and Townsley 1968, 1970). The caecum is long, blind and has thin walls (Fig. 1, Liu and Townsley 1968).

Exterior:

Byssus:

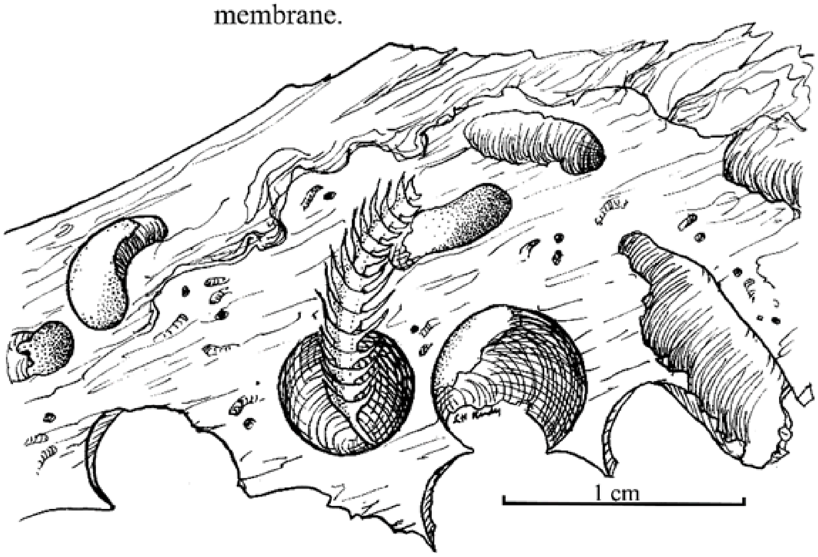
Gills: Also called ctenidia. Eulamellibranchiate or filamentous and consisting of two layers on each side of the body. Ctenidia house symbiotic bacteria that synthesize essential nutrients (e.g., amino acids) for the host individual (see **Associates**, Trylek and Allen 1980).
Shell: The two valves gape widely in front of

Bankia setacea

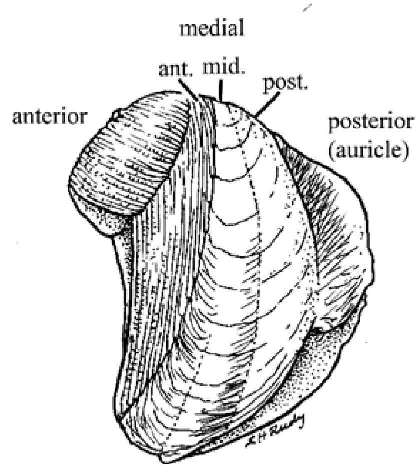


1. *Bankia setacea* (D:5mm) x2:
can be up to 15mm.

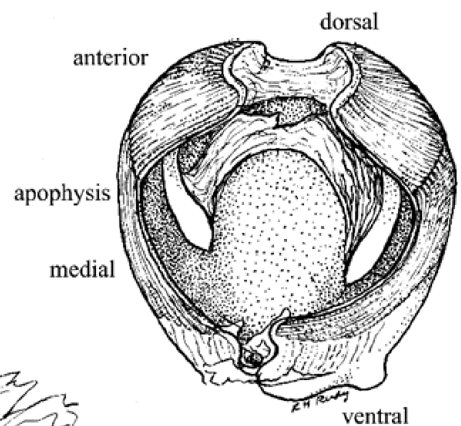
2. Pallet x12:
cone-in-cone segments with slender projections, connecting membrane.



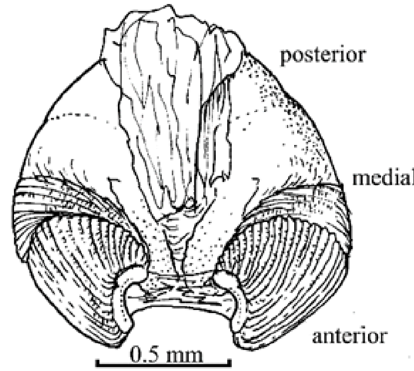
3. Shipworm burrows x4:
several sizes, some calcareous; pallet of dead animal.



a. Left lateral, showing lobes



b. Frontal



c. Dorsal

4 a.,b.,c., Shell x11.

Hiebert, T.C. 2015. *Bankia setacea. In:* Oregon Estuarine Invertebrates: Rudys' Illustrated Guide to Common Species, 3rd ed. T.C. Hiebert, B.A. Butler and A.L. Shanks (eds.). University of Oregon Libraries and Oregon Institute of Marine Biology, Charleston, OR.

the foot and behind the body (Hill and Kofold 1927; Haderlie and Abbott 1980). Each small valve with three lobes including anterior, median (composed of three separate areas), and posterior, or auricle (Figs. 4a, b, c). In *B. setacea*, the anterior lobe is fairly small, and has many numerous, close-set ridges.

Interior: An internal shell projection for foot attachment or apophysis is present (Fig. 4b) as well as articulating condyles (pivots) on ventral margins (Haderlie and Abbott 1980).

Exterior: Both valves have a file-like exterior surface for rasping wood (Liu and Townsley 1968).

Hinge:

Eyes:

Foot: Rounded and "sucker-like" (Fig. 1) and allows clam to hold onto wood (Haderlie and Abbott 1980).

Siphons: Elongate (Heterodonta, Myoida, Coan and Valentich-Scott 2007) and used for feeding and respiration (Haderlie and Abbott 1980). Males differ from females in having four rows of papillae (each up to 180 µm in length, see Fig. 14, Quayle 1992) on the exhalant siphon, which is sometimes inserted into female siphon at spawning (Haderlie and Abbott 1980; Kabat and O'Foighil 1987). The tip of the inhalant siphon is surrounded by a crown of six short tentacles (no tentacles are present on the exhalant siphon) (Quayle 1992).

Burrow: Sinuous and revealing pattern of shell's external grinding surface. Calcareous tube that is produced when individuals stop boring is sometimes apparent (see Fig. 53, Kozloff 1993). Individuals burrow deep into wooden structures, not just along surface (Haderlie and Mellor 1973) and prefer horizontal surfaces along the mudline (Walden et al. 1967). Burrowing is accomplished by alternating contractions of adductor muscles, rocking the clam and toothed valves back and forth. The burrow itself becomes cylindrical as the body of the clam slowly rotates as it burrows (Fig. 3) (Haderlie and Abbott 1980). Burrows can be up to a meter long, with burrowing rate from 43–74 mm per month (Haderlie and Abbott 1980).

Teredinidae-specific character

Pallets: Two calcareous, feather-like structures, attached to the posterior end under a fleshy collar (Figs. 1, 2). These pallets are used to close the burrow when animal is disturbed. They are symmetrical, compound, elongated, blade-like structures and consist of cone-shaped segments (Fig. 2). They are paired, Y-shaped and stacked such that the smallest and oldest pallet is most distal from the individual's body (Fig. 10, Quayle 1992). Pallets may be extracted from and visualized in dead animals (Hill and Kofold 1927).

Possible Misidentifications

Bivalve classification largely is based on ten characters (Myoida, Coan and Valentich-Scott 2007): morphology of ctenidia, shell interior and exterior, foot, byssus, adductor muscles and stomach; mode of life (e.g., burrowing); degree of mantle edge fusion; shell mineralogy; molecular phylogenetics. Within the Heterodonta, species have ctenidia that are eulamellibranchiate, mantle margins that are fused and elongated siphons. This group consists of the orders Veneroida, Pholadomyoida and the Myoida. Veneroids have well-developed hinge teeth, the Pholadomyoida are burrowers with thin shells and reduced or absent hinge teeth. The Myoida, to which *B. setacea* belongs, are burrowers and borers, with few hinge teeth. There are four local families including Myidae, Corbulidae, Pholadidae and Teredinidae.

The Teredinidae can be distinguished from other myoid families as wood borers with distinct pallets (Fig. 2) at siphon tips and anterior shell indentations. There are only three local species and *B. setacea* is easily recognized as the only species with pallets that have an elongate, Y-shaped blade and cone-shaped segments. The remaining two species have pallets that are not segmented (Kozloff 1993; Coan and Valentich-Scott 2007).

Teredo navalis, the common and cosmopolitan shipworm, was introduced to San Francisco around 1910 (Hill and Kofold 1927). *Teredo navalis* has simple, spade-shaped pallets, without the separate conical elements of *B. setacea. Teredo navalis* also causes more damage to wooden structures than *B. setacea*, being much more adaptable to extremes of temperature and salinity. It is usually much smaller than *B. setacea* and its burrows are nearer the surface. Another introduced species, *Lyrodus pedicellatus,* occurs locally and differs from *T. navalis* by having more periostracum covering the distal half of the pallet, rather than a pallet that is almost entirely calcareous (Coan and Valentich-Scott 2007). *Lyrodus pedicellatus* also has narrower pallets than *T. navalis* (Quayle 1992). Other *Bankia* species are warm water animals, and do not range north of San Diego (Hill and Kofold 1927).

Ecological Information

Range: Type locality is San Francisco Bay, California (Turner 1966). Known range from Bering Sea, Alaska to southern Baja California (Haderlie and Abbott 1980).

Local Distribution: Oregon distribution along open coasts and in estuaries including Yaquina (Betcher et al. 2012) and Coos Bays and the Charleston boat basin.

Habitat: Wood that is floating or in piles, but individuals do not burrow in buried wood (Haderlie and Abbott 1980). Great efforts have been made to discourage settlement and destruction of coastal man-made wooden structures. Some repellents slow, but do not completely deter the shipworm. (see also **Behavior**).

Salinity: Prefers full strength sea water (particularly for spawning, Kabat and O'Foighil 1987) of open oceans and doesn't tolerate reduced salinity (Ricketts and Calvin 1971). Can survive in salinities up to 50 (Haderlie and Abbott 1980).

Temperature: Prefers cold habitats and tends to lay eggs during the coldest months. Reported temperature range (Puget Sound, Washington) is from 7 to 12°C (Johnson and Miller 1935; Betcher et al. 2012).

Tidal Level: Subtidal to 70m. Individuals occur as deep as 200 meters (Monterey Bay, California, Haderlie 1983b), but are most dense at 0.3 meters above mudline (Haderlie and Mellor 1973). Individuals were also collected from wooden panels suspended at depths of 1–3 meters (Betcher et al. 2012).

Associates: Known macro invertebrate associates include small isopods from the genus *Limnoria* (e.g., see *Limnoria tripunctata*, this guide; Kozloff 1993) as well as the isopod *Ianiropsis derjugini* (see description in this guide), which was found in Charleston harbor with *B. setacea*. Shipworms are also known to host a community of bacterial endosymbionts that aid in the digestion of consumed wood (Trylek and Allen 1980; Siddall et al. 2009; Betcher et al. 2012). These symbionts are cellulolytic nitrogen-fixing bacteria and reside in the shipworm's gills (ctenidia) and are acquired by vertical transmission, i.e., from parent to offspring (Sipe et al. 200).

Abundance: As many as 720 per square meter at 60 meters deep, but fewer individuals in shallower water (Hill and Kofold 1927).

Life-History Information

Reproduction: Oviparous (Coe 1941). *Bankia setacea* exhibits protandric consecutive hermaphroditism, where all young begin as males and about half develop into females later in life (Coe 1941; Haderlie and Abbott

1980; Kabat and O'Foighil 1987). Oocytes are 47–50 µm in diameter and sperm heads are 5 µm in length. Fertilization occurs outside burrows during coldest temperatures and in full strength salinity. Self-fertilization is possible (Coe 1941; Kabat and O'Foighil 1987). Spawning occurs year-round with peaks in Feb–May (Washington, Kabat and O'Foighil 1987) and fall and spring (southern California, Coe 1941) and can be triggered by a rapid change in water temperature or salinity (Quayle 1992). The complete development of *B. setacea* has not been described, but that of its Atlantic coast congener, *B. gouldi*, was described by Culliney in 1975.

Larva: Teredinidae developmental modes vary from brooding lecithotrophic larvae to planktotrophic larvae (Sipe et al. 2000). In *B. setacea*, development occurs in the lab at salinities from 16–40 and temperatures 8–14˚C (Kabat and O'Foighil 1987). Following fertilization, free-swimming blastulae develop at 4–5 hours and embryos develop into trochophore larvae at 12–14 hours (Haderli and Abbott 1980), which proceed to two shelled veliger larval stages, called prodissoconch I (the first and earliest shell, 120–130 µm) and II (200 µm) (Quayle 1992). Bivalve veligers are characterized by a ciliated velum that is used for swimming, feeding and respiration. The veliger larva is also found in many gastropod larvae, but the larvae in the two groups can be recognized by shell morphology (i.e., snail-like versus clam-like). Once the larva develops a foot, usually just before metamorphosis and loss of the velum, it is called a pediveliger. In *B. setacea*, wild-caught larvae were described by Quayle (1953). Larval shell is almost round and becomes increasingly yellow with age and growth (e.g. prodissoconch II, for shell size and shape distribution, see Fig. 4, Brink 2001) at which point the shell has a distinct dark rim around the margin. *Bankia setacea* larvae have long pelagic life, and can swim up to four weeks in field conditions at 12–15˚C (Quayle 1953) to two months in the lab at 15˚C (Coe 1941; Kabat and O'Foighil 1987). Advanced larvae are 250 µm in length and resemble small bivalves and vertically migrate to the surface at night and six meters depths during the day (Kabat and O'Foighil 1987). They must settle on wood (Haderlie and Abbott 1980) and settlement occurs from Oct–Dec (Puget Sound, Washington, Johnson and Miller 1935 in Coe 1941) or Oct–July (California). In the Port of Everett, Washington, settlement occurred year round and peaked from Aug–Oct, and may be prevented by high water temperatures in summer months. Settlement may be induced by waterborne cues from conspecifics or wood previously bearing conspecifics (Gara et al. 1997). Initial boring is done by the young larva, which creates a pin-sized hole that grows as the animal within it does (Ricketts and Calvin 1952).

Juvenile: Newly settled spat are 245 µm by 256 µm and develop pallets by the time they are 500–600 µm in length. They can completely cover themselves in a burrow within 24 hours of settlement and reach sexual maturity after as little as four months (Kabat and O'Foighil 1987). Males and females can be differentiated once they measure 20 to 50 cm (Coe 1941).

Longevity: Longest lived individuals were 8–14 months in one Monterey Bay, California study (Hill and Kofold 1927).

Growth Rate: Growth rate is temperature dependent with slowest growth occurring under 10°C (average 50 mm per month), fastest at over 10°C. (average 100 mm per month). The greatest individual growth observed was 610 mm in five months with burrow diameter of 12 mm (see Quayle in Haderlie and Mellor 1973). Research also suggests that growth rates depends on wood species and individual density (Quayle 1992).

Food: Wood (e.g, Douglas Fir, Fig. 3, Haderlie 1983a; Gara et al. 1997) as shipworms are able to digest cellulose. Although the nutritive quality of wooden material to the clam has been debated, it is likely that some wood is digested and nutrients absorbed by microvilli within a large ceacum (see **Internal** body, Bazylinkski and Rosenburg 1983). *Bankia setacea* is also known to eat plankton (Haderlie and Abbott 1980) and filters water with ciliary action of ctenidia (Kozloff 1993).

Predators:

Behavior: Young *B. setacea* follow wood grain. Thus, burrows are parallel and do not intersect (Kozloff 1993). Several individuals (e.g., 1–10) can destroy untreated soft wood in less than a year (Walden et al. 1967; Haderlie and Abbott 1980). Boring rate is 2.7 cubic centimeters per month or about 49 cubic centimeters in a lifetime (Haderlie and Mellor 1973; Davidson and de Rivera 2012). *Bankia setacea* is a greater bioeroder than other burrowing and boring invertebrates (e.g., the burrowing isopod *Sphaeroma quoianum*, Davidson and de Rivera 2012). Individual “attacks” on wood are most common from July to February (see Fig. 22, Quayle 1992) and includes many local wood species (e.g., Alder, Birch, Maple, etc., Table 7, Quayle 1992).

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