Balanus crenatus

The crenulated barnacle

Phylum: Arthropoda, Crustacea

Class: Multicrustacea, Hexanauplia, Thecostraca, Cirripedia

Order: Thoracica, Sessilia, Balanomorpha

Family: Balanoidea, Balanidae, Balaninae

Description

Size: Small, rarely more than 13 mm in diameter (Cornwall 1977). Average size is approximately 14 mm (Cornwall 1951) with the largest individual recorded with diameter of 28 mm (Henry 1940).

Color: White with yellowish epidermis (Cornwall 1977) and exterior without colored markings (Newman 2007). Feeding cirri and penis are cream in color, with the rest of the body being rust-colored.

General Morphology: Members of the Cirripedia, or barnacles, can be recognized by their feathery thoracic limbs (called cirri) that are used for feeding. There are six pairs of cirri in *B. crenatus* (Fig. 2). Sessile barnacles are surrounded by a **shell** that is composed of a flat **basis** attached to the substratum, a **wall** formed by several articulated **plates** (six in *Balanus* species) and movable **opercular valves** including a **terga** and **scuta** (Newman 2007) (Figs. 1, 3, 5).

Shell: Shell can be rough or smooth and varies greatly (Henry 1940), but is usually more smooth than the similar species *B. glandula* (Kozloff 1993). Alaskan species are generally ridged while Oregon specimens are smoother (see Fig. 51, Kozloff 1993).

Shape: Usually broader than tall (Kozloff 1993). Conical, but can be cylindrical if crowded in hummocks, where shape and growth depends on an individual's position within the hummock (e.g. Plate 3, Barnes and Powell 1950).

Basis: Calcareous and flat, attached to hard substrate, rendering *B. crenatus* a sessile, or attached barnacle (Balanomorpha).

Wall: Formed by six unequal plates. The carinal edge of the wall projects forward over the base (Fig. 3) with radii narrow and internal surface of wall ribbed horizontally (Fig. 4). Lower inner wall can be ribbed, smooth, rough, or plicated (Henry 1940).

Longitudinal Tubes: Present within walls and visible if wall is broken (Fig. 4). Tubes occur in a single row and are uniformly spaced (Newman 2007). Some specimens can have cross-septa in the upper part of the wall.

Plates: Calcareous, nearly conical and columnar. Six in family Balanidae. Each plate is composed of parietes (exposed triangular part), alae (the overlapping plate edges) and radii (the plate edge marked off from the parietes by a definite change in direction of growth lines) (Newman 2007). The plates themselves include the carina, the carinolateral plates and the compound rostrum (see Fig. 3, *Balanus glandula,* this guide).

Opercular Valves: One pair of scuta opposite the compound rostrum and a pair of terga at carinal end of orifice (Fig. 1). Growth lines in both valves are not highly prominent. Variation in valve morphology (e.g. smooth and thin versus rough and cylindrical) may be due to habitat (Barnes and Healy 1969).

Scuta: Lacks adductor ridge, is small with flattened beaks (not peaked), and a shallow adductor muscle pit with a well-developed articular ridge (Fig. 5b).

Terga: A short spur that is wider than long and occupies at least ½ of basal margin (Newman 2007). A long, high, articu-

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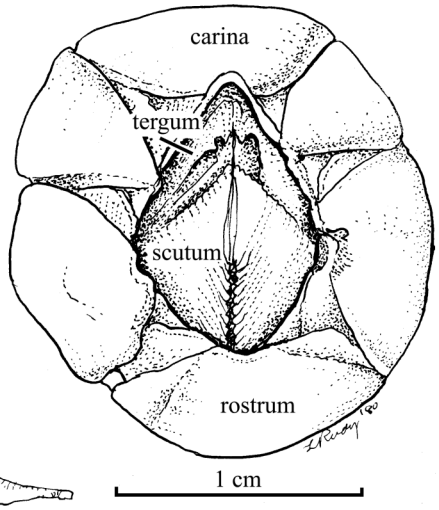
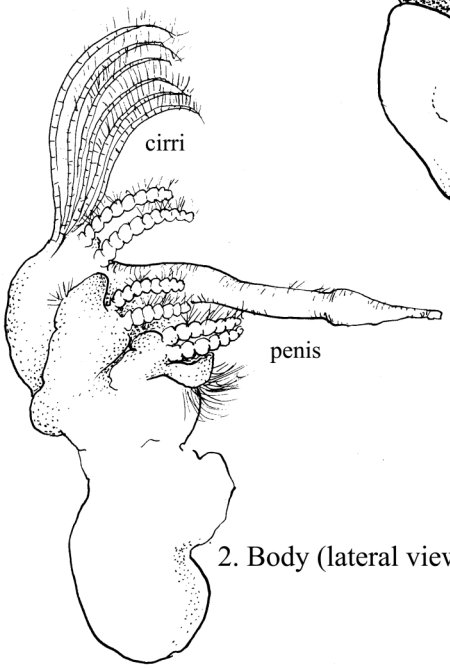
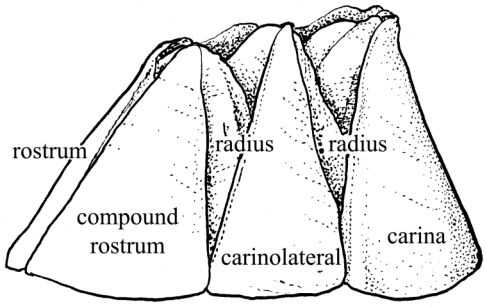


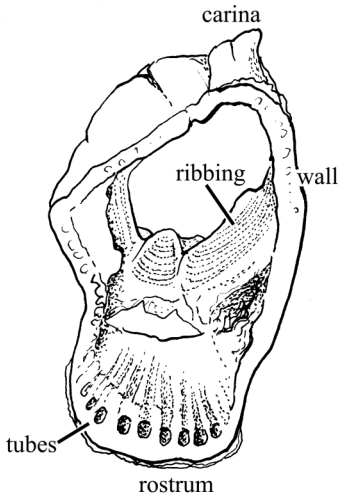
1. *Balanus crenatus* x4:
actual diameter 17 mm
six plates; compound rostrum;
orifice large, rhomboidal; opercular valves
(tergum, scutum) in pairs; exterior smooth



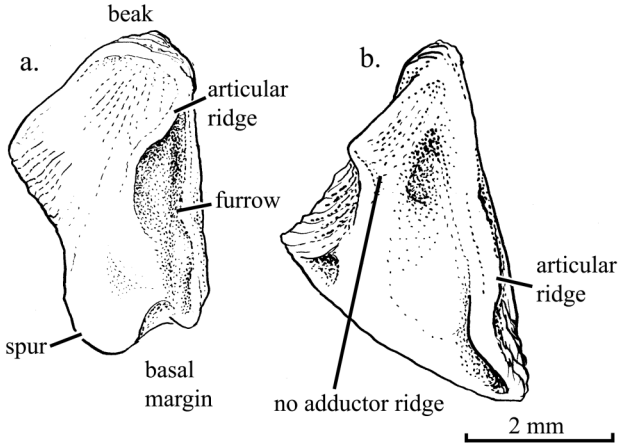
2. Body (lateral view)



3. Lateral view x4:
narrow radii



4. Posterior view x4:
wall: single row longitudinal tubes
horizontal ribbing, upper walls



5. Opercular valves x12:
a. tergum, right, interior beak flat;
spur half width basal margin;
b. scutum, right, interior
strong articular ridge, no adductor ridge

Hiebert, T.C. 2015. *Balanus crenatus. 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.

lar ridge is present with a deep furrow beside it (Fig. 5a) (Henry 1942).

Aperture: A large, rhomboidal orifice, from which the cirri emerge when feeding, is controlled by movement of the terga and scuta in conjunction with adductor and depressor muscles (Fig. 1). The internal edge projects inward in some specimens (Pilsbry 1916). When closed, plates produce a less sinuous line than is present in *B. glandula* (Kozloff 1993).

Cirri: Six pairs of feathery cirri are conspicuous (Fig. 2) and cream in color.

Possible Misidentifications

There are three groups (i.e. superorders) of cirripeds including the Rhizocephala, (parasites among crustaceans), the Acrothoracica (shell-less burrowing forms) and the Thoracica. The Thoracica contains 1,000 species worldwide including the monophyletic taxa, Lepadomorpha, the stalked barnacles, and the Balanomorpha, or sessile barnacles (Perez-Losada et al. 2008; Chan et al. 2014). Among the sessile forms, there are four families represented locally. The family Chthamaloidea includes members of the genus *Chthamalus,* which has alae on its rostral plates, not radii. *Chthamalus dalli* is found both with and at higher tide levels than *B. glandula,* and individuals are usually brown. The family Tetraclitoidea has one species locally (*Tetraclita rubescens*) and is characterized by a wall that is composed of four plates (rather than six in the Balanidae).

The remaining two families include the Balanidae and Archaeobalanidae. The Archaeobalanidae includes the genera *Armatobalanus*, *Conopea*, *Hesperibalanus* and *Semibalanus* (each with one local species). The latter genus includes a common local intertidal species *S. cariosus* (and former member of the genus *Balanus*). An isolated *S. cariosus*, is with splinter-like spines, nearly black cirri and is not likely to be confused with another barnacle. It has a thatched appearance, being irregularly ribbed and its walls have uneven, longitudinal tubes (Pilsbry 1916). However, where it is crowded or eroded, these spines may be worn off or not developed, and the barnacle would have to be distinguished from other common barnacles by its terga and scuta, and by its unique and unusual membraneous base. *Semibalanus cariosus* have terga with a long pointed spur, quite different from either *B. crenatus* or *B. glandula*. *Semibalanus cariosus* commonly co-occurs with *B. crenatus*, *B. glandula*, as well as with *Chthamalus dalli*. Juvenile *S. cariosus* will show a typical heavy ribbing and starry basis outline, which would distinguish it from young *B. crenatus* or *B. glandula*. Generally, these latter two species are found higher in the intertidal than *S. cariosus*, which occurs mostly subtidally.

Balanidae encompasses the genera *Megabalanus*, *Paraconcavus*, and *Menesiniella* (each with one local species), *Amphibalanus* (three local species) and *Balanus* (four local species). *Balanus crenatus* is generally found in the intertidal at a lower level than the ubiquitous and morphologically similar *B. glandula*. *Balanus glandula* has no longitudinal wall tubes (except when young) and it differs in the structure of terga and scuta: the terga are very wide and have longer spurs and the scuta have no adductor ridge (compare Fig. 5 with *B. glandula* Figs. 4, 5, this guide). *Balanus crenatus*, on the other hand, has a shell wall with a single row of uniformly spaced tubes (Newman 2007). *Balanus crenatus* is a difficult barnacle to identify: "Not only does every external character vary greatly in this species, but the internal parts very often vary to a surprising degree, and to add to the difficulty, groups of specimens do not

rarely vary in the same manner" (Charles Darwin in Cornwall 1951). *Balanus nubilus*, the giant acorn barnacle, is easily distinguished from *B. glandula* by its large size, reaching 100 mm in diameter, and a shell aperture that is relatively large and flaring (Newman 2007). *Balanus trigonus* is a lower intertidal species with a southern distribution (to Monterey Bay, California).

Ecological Information

Range: Type locality is the English coast. Known range includes the North Atlantic and Pacific from the Bering Sea to Santa Barbara, California. *Balanus crenatus* is a common species in the fossil record.

Local Distribution: Protected waters of most northwest bays including many sites in and around Coos Bay.

Habitat: Suitable substrates include pilings, worm tubes, mollusk and crab shells, boat bottoms, wood and other hard substrates (Kozloff 1993). Individuals also often occur amongst eelgrass and debris.

Salinity: Collected at salinities of 30 and is usually found in full-strength seawater, although individuals were found on Vancouver Island in brackish water (Henry 1942).

Temperature: Found in cold and temperate waters.

Tidal Level: Low intertidal down to 165 meters, but is usually from shallower waters along Pacific coasts (Pilsbry 1916).

Associates: Co-occurs with other barnacle species including *B. glandula*, *S. cariosus* (British Columbia, Canada, Cornwall 1977), and *Chthamalus dalli* (Puget Sound, Washington, Henry 1940). In mud and eelgrass, associates include amphipods, littorine snails, isopods, *B. glandula*, and the mussel, *Mytilus edulis* (South Slough). Readily settles on recently dead *Ensis americanus* shells (internal and external shell portions) (Donovan et al. 2013).

Abundance: Quite common (Cornwall 1951) among the sessile barnacles and may be the most common of all invertebrates on rocky shores (Yonge 1963).

Life-History Information

Reproduction: Cirripeds usually brood their eggs and *B. crenatus* has two broods per year, even at the southern edge of range (Barnes and Powell 1953). Individuals are hermaphroditic and self-fertilization is possible, but not common (Pilsbry 1916; MacGinitie and MacGinitie 1949; Yonge 1963). Eggs and embryos are retained in ovisacs within the mantle cavity and are discharged as nauplii after four months (Høeg et al. 1987; Arnsberg 2001). Light does not affect growth, fertilization or embryonic development (Newman and Abbott 1980) and reproduction in *B. crenatus* can occur continuously, but is limited by available food and temperature (17˚C) (Crisp and Patel 1969). For detailed reproductive anatomy see Høeg et al. (1987).

Larva: Cirriped broods hatch as nauplius larvae and undergo 4–6 naupliar stages, each larger and more setose than the last (Høeg et al. 1987; Arnsberg 2001; Chan et al. 2014). For naupliar setal formulae and antenna morphology, see Branscomb and Vedder 1982. Larvae molt to the second naupliar stage shortly after hatching (Branscomb and Vedder 1982). The generalized cirriped nauplius has a triangular or shield-shaped carapace with frontolateral horns and a conspicuous naupliar eye (Fig. 1, Arnsberg 2001; Figs. 22.1–22.2, Chan et al. 2014). In *B. crenatus*, the nauplius carapace is slightly curved anteriorly, between the frontolateral horns (Fig. 9B, Arnsberg 2001). The last three naupliar stages have similar morphology to *Semibalanus cariosus*, but are smaller. To differentiate between species with superficially similar nauplii (e.g. *S. cariosus, B. glandula, B. crenatus*) see Fig. 9 (Arnsberg 2001). The final larval stage in cirripeds is called a cyprid, a non-

feeding stage that attaches to a substrate by its antennae, secretes a cement (for biochemical composition of cement, see Walker 1972; Naldrett and Kaplan 1997) and builds the adult calcareous shell (Ricketts and Calvin 1971). Cyprids are oblong and composed of a bivalve shell, six thoracic appendages, a pair of compound eyes and a conspicuous lipid reserve anteriorly (Fig. 3, Arnsberg 2001; Figs. 22.2–22.3, Chan et al. 2014). Cyprids prefer rough surfaces for settlement (Yonge 1963), and although algal abundance may positively influence larval settlement in other barnacle species (Strathmann et al. 1981), *B. crenatus* individuals settle on clean surfaces (Hudon et al. 1983). Cyprid larvae in *B. crenatus* have a rounded posterior and a ventral margin that is straight. The carapace is shiny and smooth, with one pair of distinct black pigment spots just posterior to the eyes and is larger than the congener *B. glandula* at 700–960 µm in length (Fig. 10, Arnsberg 2001). The cyprids of *B. crenatus* are most similar to those of *B. nubilus*, but they have a narrower anterior, a distinct evenly curved posterodorsal margin, and black pigment carapace spots (Arnsberg 2001). Larval duration is approximately 2–3 weeks in the plankton (Newman and Abbott 1980) and metamorphosis occurs between 14 and 62 hours after initial attachment to substrate (Meadow 1969). Settlement is dependent on biological, chemical and physical cues as well as the presence of conspecifics with over 30% of settlement occurring on adult shells (Miron et al. 1996).

Juvenile:

Longevity:

Growth Rate: Shell growth in *B. crenatus* is highly dependent on whether individuals are crowded in dense hummocks or solitary (Barnes and Powell 1950). Individuals measured on settlement plates reached near their maximum size (rostro-carinal length of 20–25 mm) within the first growing season (Millport, United Kingdom, Barnes and Powell 1953). In the first three months after metamorphosis, growth rate ranges between 0.1 and 3.9 mm per month (Meadow 1969). Body growth occurs in conjunction with molting, as is seen in other crustaceans (Kuris et al. 2007).

Food:

Predators:

Behavior:

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