



Superfamily
CARDIOIDEA

Superfamily **CARDIOIDEA**
Lamarck, 1809

Shell aragonitic, subtrigonal to subquadrate, inequilateral, usually solid, inflated, equivalve. Periostracum thin, frequently abraded. Sculpture predominantly radial. Hinge plate variable, usually with two conical cardinal teeth; laterals short, distant; dentition evanescent or absent in the adult of a few taxa. Ligament external, on strong nymph, opisthodontic, parivincular, sunken into groove. Dimyarian or monomyarian.

Widely distributed, especially in tropical and temperate shallow seas, but a few genera are boreal. The superfamily is now regarded as containing a single living family with approximately 250 species.



Family
CARDIIDAE

Family **CARDIIDAE** Lamarck, 1809

Shell aragonitic, with outer fibrous prismatic, crossed-lamellar middle, and complex crossed-lamellar inner layers. Ovoid to rounded, equivalve, inflated, frequently higher than wide. Sculpture of radial ribs, sometimes spinose or frilled; sculpture absent in a few. Periostracum thin, adherent. Umbones prominent. Hinge plate wide, with two conical, hooked cardinal teeth in each valve. Cardinal teeth cruciform when valves interlocked. Left valve with one anterior and one posterior lateral tooth; right valve with one anterior and one or two posterior lateral teeth. Ligament short, external, opisthodontic, in groove. Dimyarian, with subequal adductor muscles. Mantle lobes with wide pedal opening, usually with small area of fusion setting off inhalant and exhalant apertures; small siphons sometimes present. Foot long, geniculate. Ctenidia synaptorhabdic, plicate, heterorhabdic. Labial palps small, narrow. Alimentary canal with type 5 stomach; ducts to digestive diverticula numerous, in right and left clusters; style sac joined to mid-gut; intestine passing through ventricle of heart.

A family of large, attractive shells, commonly called cockles, containing at least 20 genera with approximately 170 species, predominantly superficial infauna of shallow seas. Five subfamilies are present in the northeastern Pacific.

We appreciate the advice of Alexander I. Kafanov, Jean-Maurice Poutiers, and Jay A. Schneider on this family.

Morphology and Biology: Ansell (1967b), Barber and Wright (1969), Breum (1970), Creek (1960), Drost (1889), Feder (1967), Johnstone (1899, 1900), Kingston (1974), Kishinouye (1894), B. Morton (1970a), Nakazima (1964a), Popov (1970, 1974, 1977, 1980b), Purchon (1939a), Savazzi (1983, 1985b), Simkiss (1960), Trueman et al. (1966a, b), Wernstedt (1942), Whyte (1975).

Systematics: Broderip and G. B. Sowerby I (1833b), Clench and Smith (1944), Dall (1901a), Fischer-Piette (1977), Jelnes et al. (1971), Kafanov and Popov (1977), Keen (1937a, 1950, 1951a, b, 1954b, 1969h, 1980), Lamy (1942-1943), Marwick (1944), R. A. McLean (1939), Reeve (1844-1845), Römer (1868, 1868-1869), J. A. Schneider (1992, 1995), L. C. Smith (1945), G. B. Sowerby II (1833-1840, in G. B. Sowerby I and G. B. Sowerby II, 1833-1841), G. B. Sowerby II (1841), Spengler (1799), R. B. Stewart (1930), Tryon (1872b), Vokes (1977, 1989), Voskuil and Onverwagt (1989), B. R. Wilson and Stevenson (1977), Xu (1964).

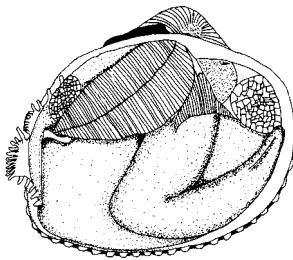
Subfamily **CLINOCARDIINAE**
Kafanov, 1975

Shell elliptical to ovate, inequilateral, oblique. Umbones prominent, prosogyrate. Sculpture of wide radial ribs and striae, or nearly smooth. Hinge plate long, arched. Teeth weak or evanescent.

This subfamily arose in the Oligocene and is recognized by the distinct shell microstructure and distribution. It is distinguished from other cardiids by the strongly prosogyrate umbones. Two living genera are limited to boreal cool and cold waters, both are present in the northeastern Pacific.

Literature: Kafanov (1975).

Genus **Clinocardium** Keen, 1936



Clinocardium nuttallii
(after J. A. Schneider, 1994)

Clinocardium Keen, 1936. Type species (OD): *Cardium nuttallii* Conrad, 1837. Recent, California.

Shell oblique to elliptical, inflated. Sculpture of radial ribs and commarginal lirae. Periostracum thin, adherent, occasionally hirsute on ribs. Umbones prominent, prosogyrate. Hinge plate wide.

The genus appeared in the Oligocene, and three subgenera are known, all represented in the northeastern Pacific. The name is derived from the Greek *kline*, a slope, and *cardia*, a heart; the gender is neuter.

Literature: Kafanov (1974a, 1978, 1980), Keen (1936).

Subgenus **Clinocardium, s.s.**

Ribs tubercular, weaker on posterior slope; periostracum smooth.

Clinocardium (Clinocardium)
nuttallii (Conrad, 1837)

Plate 73

NUTTALL COCKLE

Cardium nuttallii Conrad, 1837: 229; *C. nuttallianum*, auctt., nom. null.; *Cardium californianum* Conrad, 1837: 229 (first reviser: Middendorff, 1849); *Cochlea corbis* Martyn, auctt., non Martyn, 1784 (which is non-binomial; ICZN Opinion 456, 1957); ?*Cardium decoratum* Grewingk, 1850: 349.

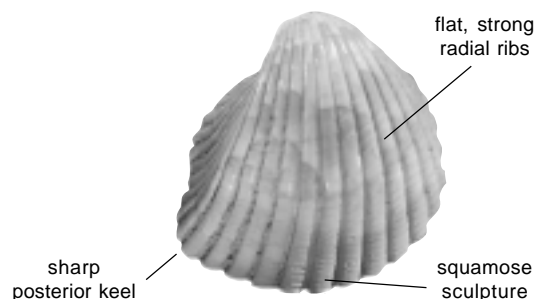
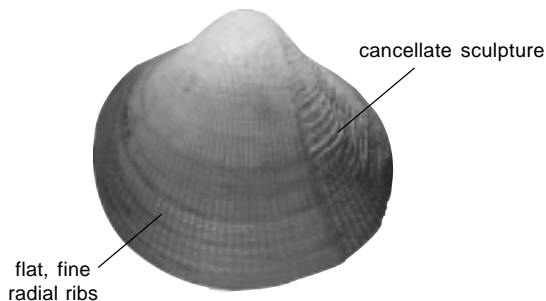
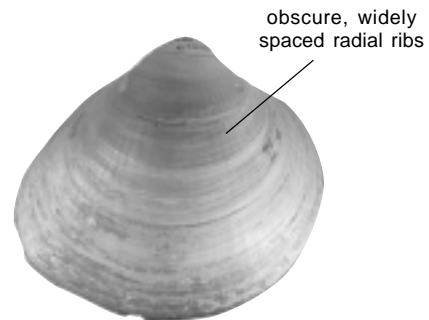
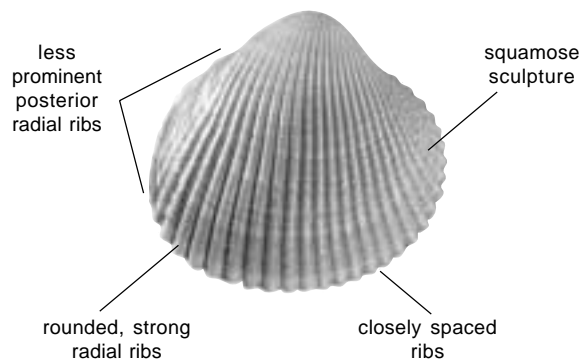
Shell large; mature specimens decidedly longer posteriorly, with beaks nearer posterior end; younger specimens more equilateral. Sculpture of about 30 strong, rounded, radial ribs, nodose where crossed by commarginal riblets. Periostracum thin. Color yellowish grey to brown; interior white, often with yellowish blush. Hinge plate narrow; teeth prominent. Inner margin deeply crenulate. Length to 140 mm.

Punuk Islands, near St. Lawrence Island (63.1°N) [LACM], and Yukon Delta (61°N) [LACM], west to Dutch Harbor, Unalaska Island (53.9°N, 166.5°W) [RBCM], Alaska, through the Gulf of Alaska, and south to San Diego, California (32.7°N) [CAS]; with a disjunct population from Kamchatka to southeastern Hokkaido, Japan, in the intertidal zone to 30 m, but occasionally to 180 m, in mud and sand, sometimes in dense colonies. Reported as early as the late Miocene in western North America.

Literature: D. P. Abbott and Hilgard (1987: 186-189), J. A. Butler et al. (1968), Chang and Levings (1978), Conrad (1869c: 105), W. J. Cooke (1975), Edmonson (1919), Ertman and Jumars (1988), Evans (1972, 1975), Eyerdam (1940), Fischer-Piette (1977: 131-132), C. M. Fraser

Species Characteristics of the Family Cardiidae

Taxa	Radial ribs	Posterior end	Height/Length
<i>Clinocardium nuttallii</i>	rounded, strong, squamose, closely spaced	with less prominent radial ribs	length > height
<i>Clinocardium ciliatum</i>	sharp, strong, widely spaced	with less prominent radial ribs	subequal to length > height
<i>Clinocardium blandum</i>	rounded, low, smooth, closely spaced	not demarcated	length > height
<i>Clinocardium californiense</i>	rounded, low, smooth to slightly squamose, widely spaced	with radial undulations, and less prominent radial ribs	length > height
<i>Serripes groenlandicus</i>	obscure, widely spaced	occasionally with weak, low radial ribs	length > height
<i>Serripes laperousii</i>	obscure, widely spaced	occasionally with weak, low radial ribs	length much > height
<i>Serripes notabilis</i>	obscure, more prominent on ends	occasionally with weak, low radial ribs	height > length
<i>Americardia biangulata</i>	flat, strong, squamose	set off by sharp keel	subequal
<i>Laevicardium elatum</i>	obscure, widely spaced	not demarcated	height > length
<i>Laevicardium substriatum</i>	obscure, closely spaced	not demarcated	length > height
<i>Nemocardium centifilosum</i>	flat, fine, closely spaced	with cancellate sculpture	subequal
<i>Trachycardium quadragenarium</i>	sharp, strong, spinose	with more pronounced spines	subequal



(1931), V. F. Gallucci and B. B. Gallucci (1982), U. S. Grant and Gale (1931: 307-308), Haderlie and Abbott (1980: 371), Hertlein and Grant (1972: 261-262), Kafanov (1980: 306), Kellogg (1915: 667-668), Kilmer (1973), Mitchell (1935), Okutani et al. (1989: 108), A. M. Robinson and Breese (1982), Scarlato (1981: 345), J. A. Schneider (1994), Silvey (1968), L. S. Smith and Davis (1965), Strathmann (1987: 334), Talmadge (1972), C. C. Taylor (1960), Weymouth and Thompson (1931).

Subgenus Ciliatocardium
Kafanov, 1974

Ciliatocardium Kafanov, 1974. Type species (OD): *Cardium ciliatum* Fabricius, 1780. Recent, Greenland.

Shell inflated, subequilateral. Sculpture of strong radial ribs, triangular in cross section, never tubercular, becoming more widely spaced anteriorly. Periostracum thick, with radial rows of setae on rib peaks.

Recorded as early as the Oligocene.

Literature: Kafanov (1981), Kafanov and Savitskii (1982).

Clinocardium (Ciliatocardium)
ciliatum (Fabricius, 1780)

Plate 73

HAIRY COCKLE

Cardium ciliatum Fabricius, 1780: 410; *C. islandicum* Bruguière, 1789: 222, ex Chemnitz MS; *C. icelandicum*, *auctt., nom. null.*; ?*C. boreale* Broderip and G. B. Sowerby I, 1829: 368; *C. arcticum* G. B. Sowerby II, 1834: *Cardium* fig. 26; *C. pubescens* Couthouy, 1838: 61; *C. dawsoni* Stimpson, 1862: 58; *C. hayesii* Stimpson, 1863: 142; *C. californiense comoxense* Dall, 1900c: 1093; *C. chikagawaense* Kotaka, 1950: 46; *Ciliatocardium ciliatum tchuktchense* Kafanov, in Scarlato, 1981: 343; ?*C. likharevi* Kafanov, in Scarlato, 1981: 344; *C. ciliatum nordenskioldi* Kafanov, 1981: 52; *C. ciliatum ochotense* Kafanov, 1981: 54.

Shell thin, inflated, ovate, subequilateral to slightly oblique, longer posteriorly. Sculpture of sharp, triangular radial ribs with wide interspaces. Periostracum thick, adherent, with setae on rib crests. Inner shell margin crenulate. Length to 70 mm.

Some workers may wish to follow Kafanov (1981) in recognizing several subspecies, including *C. (C.) c. nordenskioldi* in the high Arctic, *C. (C.) c. tchuktchense* in the Chukchi Sea, *C. (C.) c. ochotense* in the Sea of Okhotsk, *C. (C.) c. ciliatum* in much of the rest of the Arctic, and perhaps *C. (C.) c. dawsoni* from the Pleistocene of Arctic Canada.

Panarctic and circumboreal; from the Beaufort Sea (71°N) [LACM], throughout the Bering Sea to Amchitka Island, Aleutian Islands (51.5°N, 179.0°E) [NMC], south to Barkley Sound, Vancouver Island, British Columbia (48.9°N) [RBCM], and south to Kamchatka to the Kurile and Sakhalin islands, in 10 - 150 m.

Literature: F. R. Bernard (1979b: 45), Fischer-Piette (1977: 134-135), U. S. Grant and Gale (1931: 309, 310), Kafanov (1980: 312; 1981: 46-58), Kuznetsov (1963: 102-110), Lubinsky (1980: 38-39), N. L. MacGinitie (1959: 176), J. McDonald et al. (1981: 1168, 1171), Ockelmann (1959: 118-121), Okutani et al. (1989: 109), Petersen (1978: 106-107), Poppe and Goto (1993: 96), Scarlato (1981: 343-344), Theroux and Wigley (1983: 36), Tsuchida and Kurozumi (1995: 20-22).

Subgenus Keenocardium
Kafanov, 1974

Keenocardium Kafanov, 1974. Type species (OD): *Cardium californiense* Deshayes, 1839. Recent, north-eastern Pacific.

Ribs rounded, not tubercular, evident on posterior slope.

Recorded as early as the Oligocene.

Clinocardium (Keenocardium)
blandum (A. A. Gould, 1850)

Plate 73

LOW-RIB COCKLE

Cardium (Serripes) blandum A. A. Gould, 1850b: 276; 1852: 415; 1860: pl. 36; *Cardium (Cerastoderma) fucanum* Dall, 1907a: 112; *C. fucanum*, *auctt., nom. null.*

Shell medium-sized, oval, somewhat longer posteriorly, inflated. Sculpture of

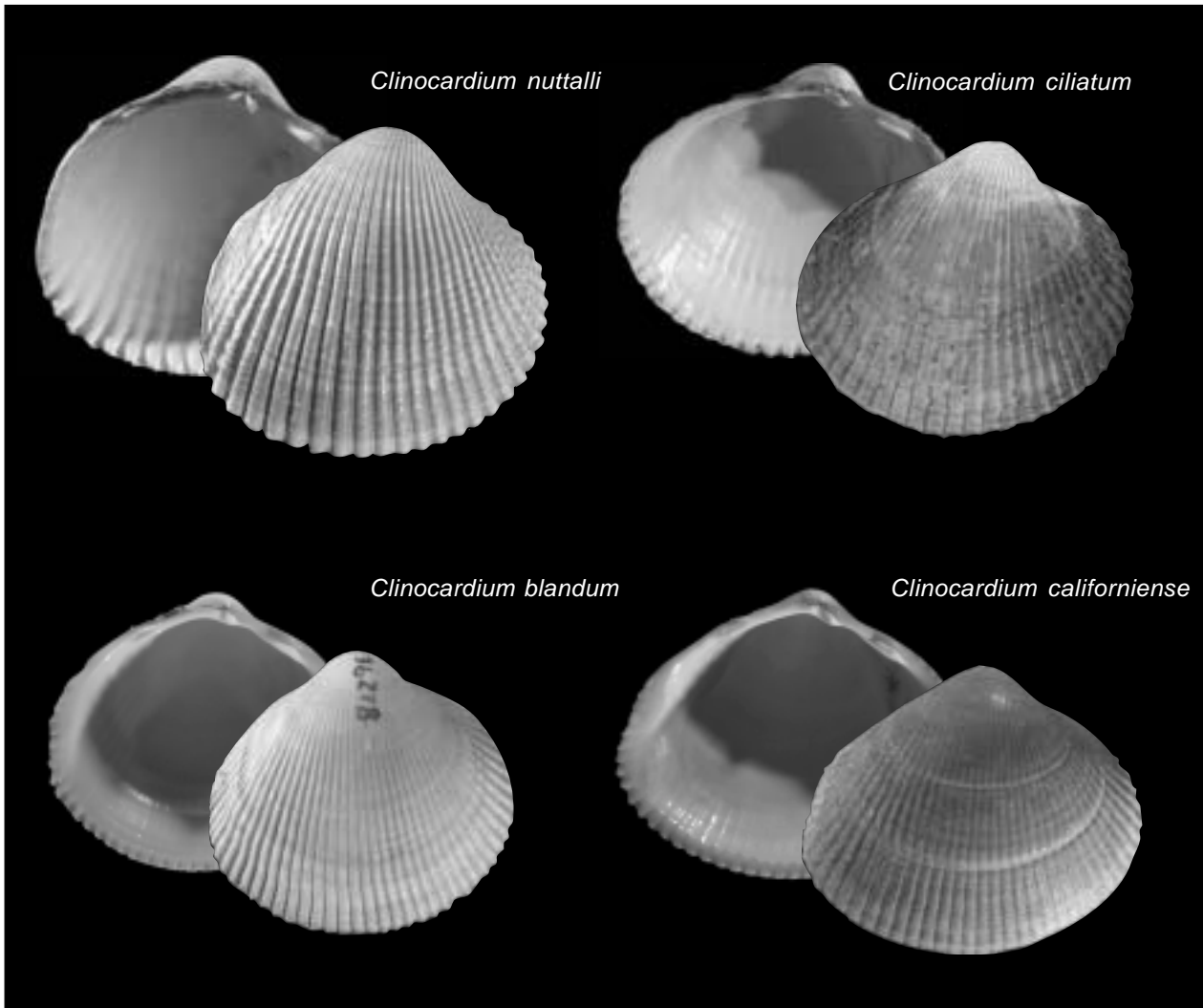


Plate 73. Family Cardiidae. *Clinocardium nuttalli*, California, length 56 mm; *Clinocardium ciliatum*, Alaska, length 28 mm; *Clinocardium blandum*, Alaska, length 24 mm; *Clinocardium californiense*, Washington, length 30 mm. See appendix for further specimen data.

numerous (about 45), low ribs sometimes overlain by feeble commarginal riblets; interspaces generally narrow. Folds on posterior slope weak. Beaks more inflated than in *C. californiense*. External color yellow to brown. Inner shell margins shallowly crenulate. Length to 50 mm.

We cannot distinguish *C. fucanum* from *C. blandum*. *Clinocardium fucanum* was based on small specimens from the Puget Sound area that are more equilateral. This species, as is the case with other cardiids, is variable in shape. Some specimens are rounded and inflated, others more elongate posteriorly and flattened; some are yellowish, some dark brown. The entire range of shapes and colors may be seen at a single station. Nor have we found rib count useful in distinguishing the two entities. However, the problem merits additional investigation.

Pribilof Islands (56.5°N) [LACM], south to Pavlof Bay, Alaska Peninsula (55.4°N) [CAS], west to Unalaska Island (53.6°N, 166.8°W) [LACM], through the Gulf of Alaska, including Prince William Sound (60.8°N) [CAS], Alaska, and south to Salt Point, Sonoma County, California (38.7°N) [LACM], in 20 - 80 m. Recorded as early as the Pliocene of California.

Literature: Kafanov (1980: 308, 309).

**Clinocardium (Keenocardium)
californiense** (Deshayes, 1839)

Plate 73

ALEUTIAN COCKLE

Cardium californiense Deshayes, 1839b: 360; 1841: pl. 47; *C. pseudofossile* Reeve, 1844: pl. 10;
C. californiense "genuina" Middendorff, 1851: 248; *Clinocardium uchidai* Habe, 1955a: 11;
Laevicardium interrogatorium Fischer-Piette, 1977: 21.

Shell medium-sized, elongate, slightly longer posteriorly, less inflated than *C. blandum*. Sculpture of numerous (about 46) high, rounded radial ribs, less nodose than those in *C. nuttallii*, often with wide interspaces, especially in large specimens. Posterior end with one or more strong radial undulations. Beaks small. Color light yellow to dark brown. Inner shell margins shallowly crenulate. Length to 75 mm.

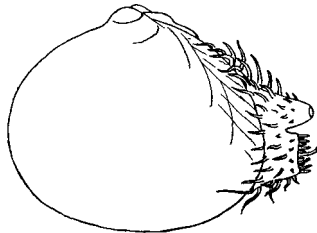
Named in error as having come from California; Kafanov (1980) restricted the type locality to Kamchatka. Kafanov (1974b), believing that *Cardium boreale* Broderip and G. B. Sowerby I, 1829: 368, was an overlooked earlier name for this species, requested that the International Commission on Zoological Nomenclature suppress it. However, the Commission decided that this name is a *nomen dubium*, and the petition was not accepted (Melville, 1984). (Here we placed *C. boreale* as a possible synonym of *Clinocardium ciliatum*.)

It is possible that *C. (K.) californiense uchidai* may be a recognizable Asian subspecies. However, its relationship to *C. (K.) bulowi* (Rolle, 1896) from Japan and Korea has yet to be fully resolved.

Chukchi Sea (69°N) [LACM], throughout the Bering Sea, west to Amchitka Island, Aleutian Islands (51.5°N, 179.0°E) [NMC], throughout the Gulf of Alaska, to Cook Inlet (59.2°N) [LACM], possibly southeast to Ketchikan (55.3°N) [LACM], Alaska, and south to the Kurile Islands (Scarlato and Ivanova, 1974) and Japan, in 10 - 100 m. A record of this species from Puget Sound (J. A. Schneider, 1993b) proved to be based on a specimen of *C. blandum* (J. A. Schneider, letter, 6 October 1993).

Literature: Fischer-Piette (1977: 21, 132-134), U. S. Grant and Gale (1931: 309), Kafanov (1980: 309), Kafanov and Savitskii (1982: 55-56), Kas'ianov et al. (1983: 73), Okutani et al. (1989: 107), Scarlato (1981: 345-346), Tsuchida and Kurozumi (1995: 19), Voskuil and Onverwagt (1991b: 116).

Genus **Serripes** A. A. Gould, 1841



Serripes groenlandicus
(after Morse, 1919)

Serripes A. A. Gould, 1841, *ex Beck* MS. Type species (M): *Cardium groenlandicum* Mohr, 1786. Recent, Greenland.

Aphrodite I. Lea, 1837, *non Link*, 1837. Type species (M): *A. columba* I. Lea, 1839, = *Cardium groenlandicum* Mohr.

Shell inflated, thick to thin, subequilateral to longer posteriorly. Umbones prominent. Sculpture obsolete; lateral slopes with weak radial striae, frequently with irregular commarginal growth lines. Inner shell margin smooth. Hinge plate weak; dentition generally lost in large specimens.

Recorded as early as the Oligocene. The name is derived from the Latin *serra*, a saw, and *pes*, a foot; the gender is masculine. This genus is divided into two subgenera.

Literature: Noda (1961), Otuka (1935).

Subgenus **Serripes, s. s.**

Beaks low, orthogyrate. Lateral teeth not sharply set off from shell by a deep cleft.

**Serripes (Serripes)
groenlandicus** (Mohr, 1786)

Plate 74

GREENLAND SMOOTHCOCKLE

Cardium groenlandicum Mohr, 1786: 129, *ex Chemnitz* MS; *Mactra radiata* Donovan, 1803: pl. 161; *Cardium edentula* Montagu, 1808: 29; *Aphrodite columba* I. Lea, 1837: 111; *Cardium boreale* Reeve, 1845, pl. 22, *non Broderip* and G. B. Sowerby I, 1829; *C. fabricii* Deshayes, 1855b: 333; *Serripes groenlandicus protractus* Dall, 1900c: 1112; *Mactra fujinensis* Yokoyama, 1923b: 5; ?*Serripes* (?) *uvutschensis* Il'ina, 1963: 76.

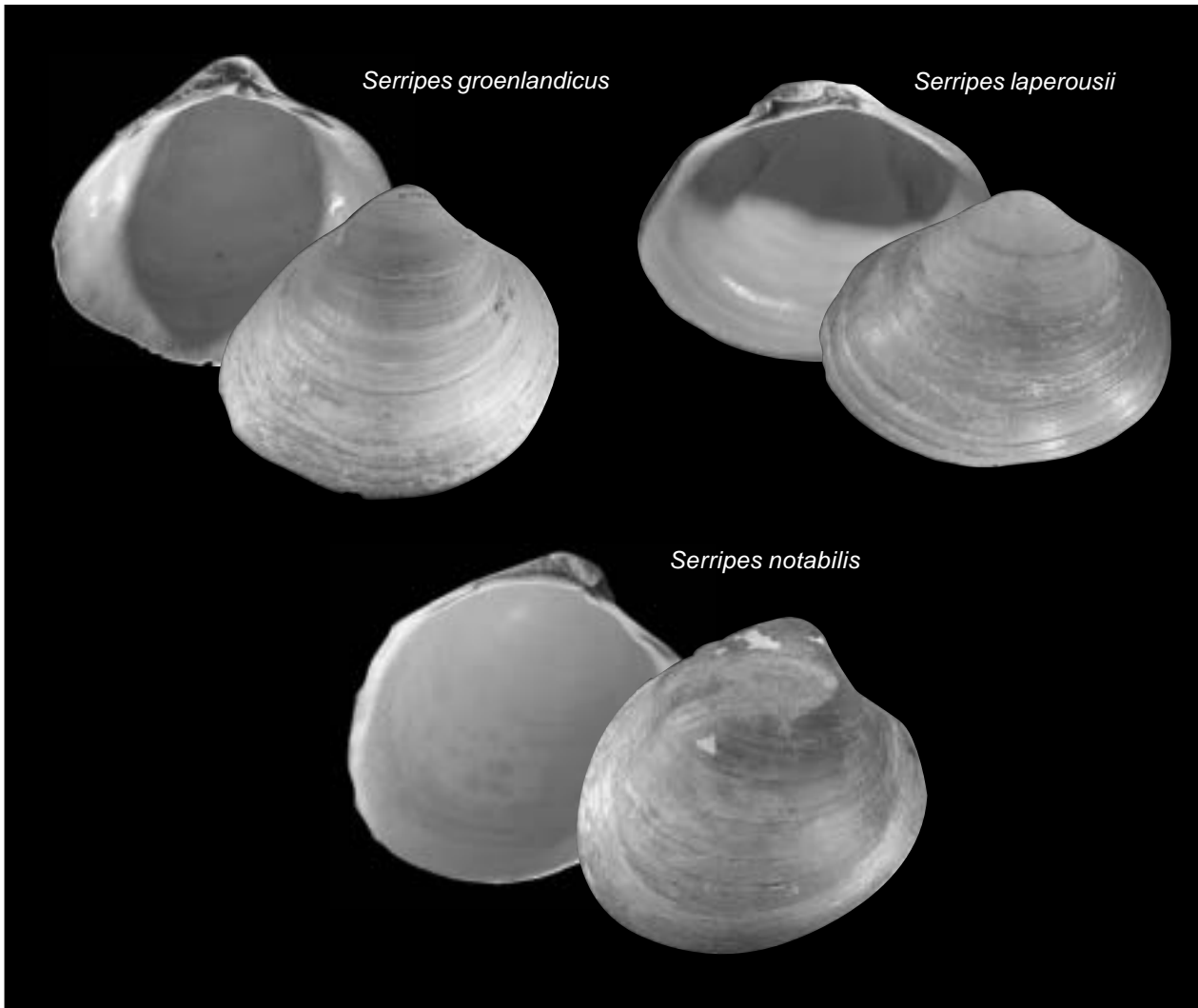


Plate 74. Family Cardiidae. *Serripes groenlandicus*, Alaska, length 81 mm; *Serripes laperousii*, Alaska, length 93 mm; *Serripes notabilis*, Japan, length 80 mm. See appendix for further specimen data.

Shell thin, brittle, ovate, inflated, somewhat longer posteriorly, rounded ventrally. Umbones prominent, orthogyrate. Sculpture feeble; radial striae present on anterior and posterior ends, especially evident in small specimens. Periostracum straw-colored to dark brown; interior white, sometimes blushed with brown to salmon. Juvenile specimens ovate, slightly longer posteriorly. Periostracum light brown; interior white. Length to 112 mm.

Panarctic and circumboreal; Point Barrow (71.4°N) [LACM], the Chukchi Sea, throughout the Bering Sea shelf, to Amchitka Island, Aleutian Islands (51°N, 179°E) [NMC], Alaska, south to Puget Sound, Washington (48°N) [LACM]; in the North Atlantic from Greenland to New England; in the western Pacific south to Japan; in the intertidal zone to 80 m. Recorded as early as the Pliocene in Alaska.

Literature: F. R. Bernard (1979b: 46-47), Fischer-Piette (1977: 82-84), U. S. Grant and Gale (1931: 314), Kafanov (1980: 318-319), Lubinsky (1980: 39), N. L. MacGinitie (1959: 176-177), E. S. Morse (1919: 174-175), Noda (1961: 223-224), Ockelmann (1959: 113-118), Oganessian (1996), Petersen (1978: 102-106), Poppe and Goto (1993: 99), Scarlato (1981: 347), Warén (1993: 198-199).

Serripes (Serripes) laperousii
(Deshayes, 1839)

BROAD SMOOTHCOCKLE

Cardium laperousii Deshayes, 1839b: 360; 1841: pl. 48.

Plate 74

Shell thicker than in *S. groenlandicus*, elongate-ovate, posterior end decidedly longer. Umbones broad. Sculpture less evident than in *S. groenlandicus*, but juveniles with a few lateral radial striae on anterior and posterior ends. Juveniles equilateral, elongate. Periostracum dull brown; interior white. Length to 137 mm.

The type locality was cited in error as "Mers de Californie," but it does not occur south of southeastern Alaska; Kafanov (1980) restricted the type locality to Kodiak Island, Alaska.

Point Barrow, Alaska (71.4°N) [CAS], throughout the Bering Sea, and south to Petersburg, Alaska (56.8°N) [LACM, CAS], and southwest to the Sea of Okhotsk, Kamchatka, and Korea, in 2 - 80 m. Recorded as early as the Pleistocene in Alaska.

Literature: Fischer-Piette (1977: 84), U. S. Grant and Gale (1931: 314), Kafanov (1980: 319), Noda (1961: 225-226), Okutani et al. (1989: 110), Scarlato (1981: 348).

Subgenus **Yagudinella**
Kafanov, 1975

Yagudinella Kafanov, 1975. Type species (OD): *Cardium (Serripes) notabile* G. B. Sowerby III, 1915. Northwestern Pacific.

More quadrate than *Serripes*, *s. s.*, with more prominent, prosogyrous beaks. Anterior lateral teeth in both valves extending from subumbonal ridges.

Recorded as early as the Miocene.

Serripes (Yagudinella) notabilis
(G. B. Sowerby III, 1915)

OBLIQUE SMOOTHCOCKLE

Cardium (Serripes) notabile G. B. Sowerby III, 1915: 169; *Serripes n. nomurai* Otuka, 1943: 56.

Plate 74

Shell more quadrate than *Serripes (S.) groenlandicus*, produced ventrally, with narrower anterior end and broadly truncate posterior end. Beaks more prominent, very inflated, prosogyrous. Radial sculpture more prominent than in *S. (S.) groenlandicus*, particularly evident on anterior and posterior ends. Anterior lateral teeth set off by deep cleft. Externally with brown zigzag markings, especially in juvenile specimens; interior white. Length to 92 mm.

This species which has been known previously only from the western Pacific, from the Bering Sea south to Japan, also occurs from the Pribilof Islands (56.5°N) [LACM], south to the Alaska Peninsula (55.2°N) [LACM], and eastward to Cook Inlet (59.2°N) [LACM] and Prince William Sound (60.8°N) [LACM], Alaska, in 50 - 216 m.

Literature: Noda (1961: 227-228), Okutani et al. (1989: 111, as "*Serripes groenlandicus*"), Scarlato (1981: 348-349).

Subfamily **FRAGINAE** Stewart, 1930

Shell thick, strongly inequilateral. Sculpture of numerous, wide radial ribs with some imbricated scales. Thin, easily eroded chalky outer layer (intritacalx) in some. Interspaces smooth or with commarginal lirae. Posterior slope set off by radial ridge. Hinge plate short, angulate.

The subfamily arose in the Oligocene and contains six living genera, generally limited to warm, tropical shallow seas, one penetrating the northeastern Pacific.

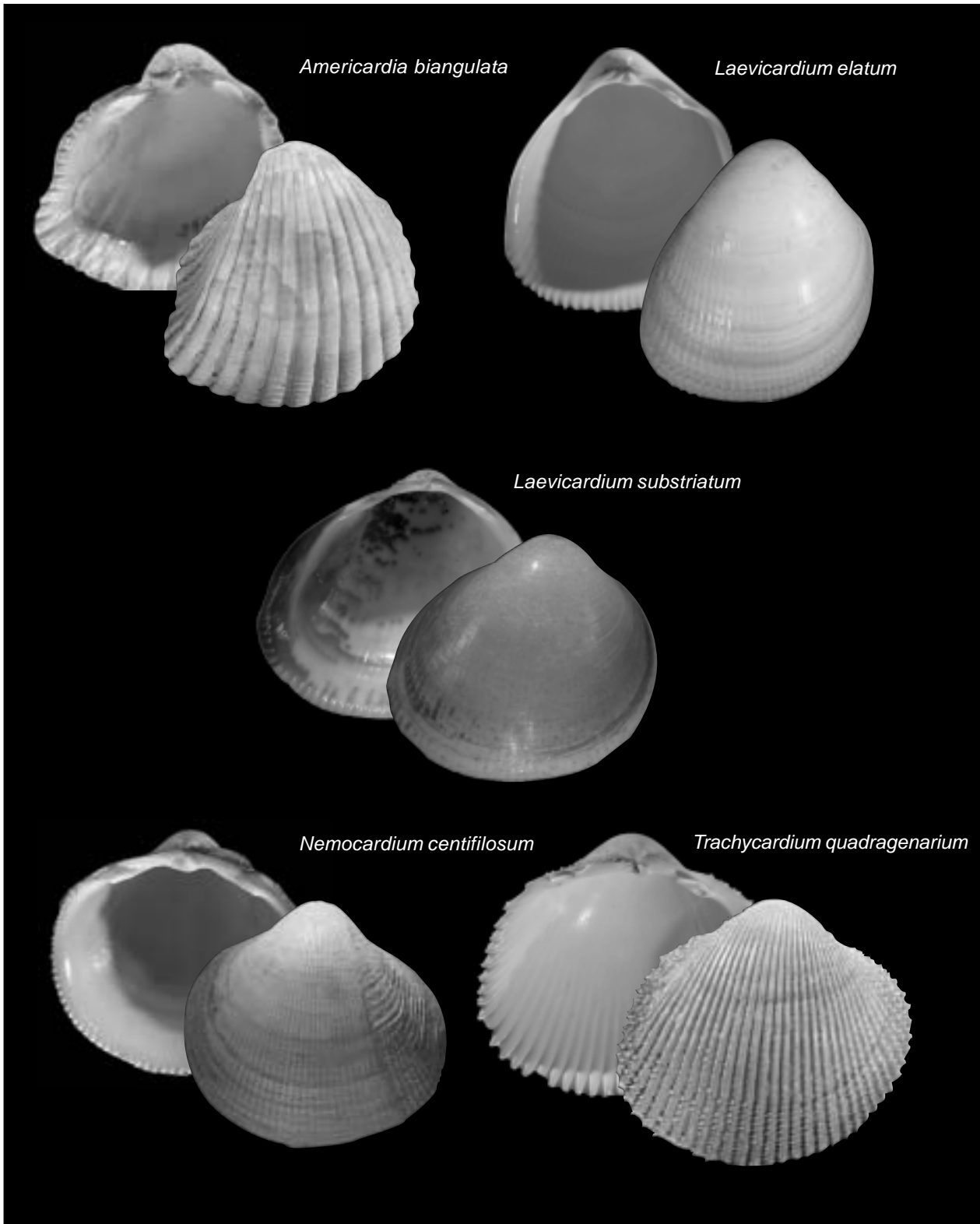


Plate 75. Family Cardiidae. *Americardia biangulata*, Sonoma, length 31 mm; *Laevicardium elatum*, Baja California, length 86 mm; *Laevicardium substriatum*; California, length 20 mm; *Nemocardium centifilosum*, Alaska, length 13 mm; *Trachycardium quadragenarium*, California, length 72 mm. See appendix for further specimen data.

Genus **Americardia** Stewart, 1930

Americardia Stewart, 1930. Type species (OD): *Cardium medium* Linnaeus, 1758. Recent, Caribbean.

Shell quadrate, with high, wide umbones. Ribs flat-topped; interspaces with commarginal striations. Intritalcalx with numerous arched commarginal threads on ribs, some stronger, scale-like. Cardinal teeth strongly unequal; anterior laterals a little closer to cardinals than are posterior laterals.

This genus is known at least to the Miocene and perhaps to the Oligocene. The name is a combination of America and the Greek *cardia*, a heart; the gender is feminine.

Americardia biangulata
(Broderip and G. B. Sowerby I, 1829)

Plate 75

WESTERN STRAWBERRY-COCKLE

Cardium biangulatum Broderip and G. B. Sowerby I, 1829: 367; *C. modestum* Conrad, 1855b: 11; 1857b: pl. 3, fig. 15, non R. A. Philippi, 1848, non A. Adams and Reeve, 1850; *C. magnificum* Carpenter, 1857b: 187, ex Deshayes MS, nom. nud.

Shell thick; posterior end truncate. Sculpture of about 26 broad, flat, imbricate radial ribs; interspaces with fine commarginal lirae. Exterior yellowish, generally variegated with brown; interior maculated with purple or red. Length to 45 mm.

Santa Cruz Island, California (34.0°N) [LACM], throughout the Golfo de California, south to Isla Salango, Ecuador (1.6°S) [LACM], in the intertidal zone to 100 m. Recorded as early as the Pliocene of Baja California.

Literature: Fischer-Piette (1977: 123-124), U. S. Grant and Gale (1931: 312), Hertlein and Strong (1947: 140), J. Hertz (1994a), Keen (1971: 157), Olsson (1961: 251).

Subfamily **LAEVICARDIINAE**
Keen, 1936

Shell higher than long. Sculpture of low, narrow radial ribs, sometimes stronger on posterior slope, not hollow within. Hinge plate long, arched. Cardinal teeth not equal in size. Anterior left lateral tooth lamelliform.

The subfamily first appeared in the Eocene and contains three genera with approximately 20 species. Two genera are represented in the northeastern Pacific.

Genus **Laevicardium**
Swainson, 1840

Laevicardium Swainson, 1840. Type species (SD Stoliczka, 1871): *Cardium oblongum* Gmelin, 1791. Recent, Mediterranean.

Exocardium Olsson, 1964. Type species (OD): *Cardium ecuadoriale* Olsson, 1932. Miocene, Ecuador.

Radial ribs weak, obscure on posterior slope, smooth or rarely nodulose.

This genus is known as early as the Eocene. The name is derived from the Latin *laevis*, smooth, and the Greek *cardia*, a heart; the gender is neuter.

Literature: E. M. Baker and Merrill (1965), Kafanov and Savitskii (1983), Loosanoff and Davis (1963: 107-108), Penchaszadeh and Salaya (1983).

Laevicardium elatum
(G. B. Sowerby I, in Broderip
and G. B. Sowerby I, 1833)

Plate 75

GIANT EGGCOCKLE

Cardium elatum G. B. Sowerby I, in Broderip and G. B. Sowerby I, 1833b: 84.

Shell thin, ovate to trigonal. Sculpture of very low, smooth radial ribs; anterior and posterior slopes smooth. Exterior color yellow to brown; interior white. Anterior and ventral margins finely crenulate; posterior margin smooth. Length to 190 mm.

Alamitos Bay, California (33.6°N) [LACM], throughout the Golfo de California, south to Panamá (9°N) (Keen, 1971), in the intertidal zone to 20 m. Not recently collected in California, where it is probably extinct since the 1930s because of

pollution and habitat destruction, with established populations not occurring north of Laguna Ojo de Libre, Baja California Sur (27.8°N). Recorded as early as the Pleistocene in southern California.

Literature: Fischer-Piette (1977: 20), U. S. Grant and Gale (1931: 304), Hertlein and Strong (1947: 145), Keen (1971: 160), Olsson (1961: 257), Poutiers (1995: 121), Villalejo-Fuerte et al. (1996).

Laevicardium substriatum
(Conrad, 1837)

Plate 75

PACIFIC EGGCOCKLE

Cardium substriatum Conrad, 1837: 228; *C. elenense* G. B. Sowerby II, 1840?: 6, fig. 58; 1841: 109; *C. cruentatum* A. A. Gould, 1855: 26; 1857: pl. 11; *Laevicardium apicinum* Carpenter, 1864b: 313; *L. pedernalense* Pilsbry and Olsson, 1941: 60.

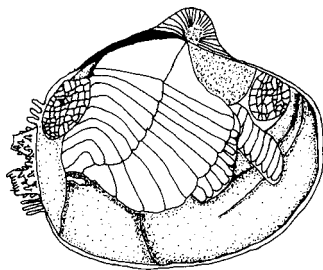
Shell ovate, somewhat longer posteriorly, more produced than young *L. elatum*. Sculpture absent, or with fine radial ribs along ventral margin. External color pale yellow or gray, flecked with brown. Interior with purplish-brown mottling. Length to 40 mm.

The Panamic *L. elenense* (G. B. Sowerby II, 1840) is said to differ from this species in being more inflated and more vividly colored, both externally and internally. However, we have not been able to reliably separate the two south of San Diego, and here regard them as synonyms. However, this problem clearly merits additional attention.

Mugu Lagoon, California (34.1°N) [LACM], certainly as far south as Bahía Santa Maria, Baja California Sur (24.8°N) [LACM], and, if *L. elenense* is indeed a synonym, throughout the Golfo de California, south to Máncora, Perú (4.1°S) (Olsson, 1961), in the intertidal zone to 40 m, in mud or sand. Recorded as early as the Pliocene in Baja California Sur.

Literature: Fischer-Piette (1977: 22), U. S. Grant and Gale (1931: 304-305), Haderlie and Abbott (1980: 371), Keen (1971: 160), Olsson (1961: 256-257).

Genus **Nemocardium** Meek, 1876



Nemocardium centifilosum
(after J. A. Schnieder, 1984)

Nemocardium Meek, 1876. Type species (SD Sacco, 1899): *Cardium semiasperum* Deshayes, 1858. Eocene, France.

Sculpture of radial ribs and striae, usually stronger on posterior slope; central slope sometimes nearly smooth; ribs on posterior slope often spinose; inner ventral margin crenulate.

The name is derived from the Greek *nema*, a thread, and *cardia*, a heart; the gender is neuter.

The subgenus *Nemocardium*, *s.s.*, in which the central slope is nearly smooth and the crenulations of the ventral inner shell margin are large posteriorly is not represented in the northeastern Pacific.

Literature: Poutiers (1992).

Subgenus **Keenaea** Habe, 1952

Keenaea Habe, 1952. Type species (OD): *Cardium samarangae* Makiyama, 1934, = *C. modestum* A. Adams and Reeve, 1850, *non* R. A. Philippi, 1848. Recent, East China Sea.

Shell thin, with discrepant sculpture; ribs on anterior and central slopes low, rounded, crowded; ribs on posterior slope higher, with wider interspaces and commarginal lirae.

Recorded as far back as the Oligocene. The genus is named in honor of the west American malacologist A. M. Keen; the gender is feminine.

**Nemocardium (Keenaea)
centifilosum** (Carpenter, 1864)

Plate 75

HUNDRED-LINE COCKLE

Cardium (?*modestum* var.) *centifilosum* Carpenter, 1864c: 611; 1866: 209; *C. richardsoni* Whiteaves, 1878: 468.

Shell ovate, thin, inflated. Sculpture of posterior slope cancellate, with about 20 radial ribs, separated from central slope by a raised radial rib. Central and anterior slopes with 40 or more fine, flat radial riblets. Umbones prominent, subcentral. Inner margin finely crenulate. Length to 25 mm.

Carpenter (1864c) proposed this taxon as a possible subspecies of *Cardium modestum* A. Adams and Reeve, 1850, *non* R. A. Philippi, 1849, = *Cardium samarangae* Makiyama, 1934, an Indo-Pacific species occurring from the East China Sea to southern Japan. However, this Asian species attains a larger size and has weaker, finer sculpture. The Panamic *N. (K.) pazianum* Dall, 1916, differs in having scaly ribs on the posterior slope.

Portlock Bank, Alaska (58.7°N) [LACM], to Punta Rompiente, Baja California Sur (27.7°N) [LACM], in 30 to 150 m. Recorded as early as the late Miocene in western North America.

Literature: Fischer-Piette (1977: 6), U. S. Grant and Gale (1931: 311), Hertlein and Grant (1972: 263-264), Hertlein and Strong (1947: 141-142), J. A. Schneider (1994), Valentich Scott (1998: 147).

Subfamily **TRACHYCARDIINAE**
Stewart, 1930

Shell ovate, inequilateral, subequivalve. Sculpture of radial ribs, usually with imbricated scales or spines. Hinge plate short, straight, occasionally oblique. Cardinal teeth unequal in size. Ribs forming indentations at shell margins that interdigitate valves posteriorly.

The elegant shells of shallow water, known since the Eocene, are mostly limited to warm seas. There are three living genera, one of which is present in the north-eastern Pacific.

Genus **Trachycardium**
Mörch, 1853

Trachycardium Mörch, 1853. Type species (SD von Martens, 1870): *Cardium isocardia* Linnaeus, 1758. Recent, Caribbean.

Shell robust, ovate, equilateral. Height greater than length. Sculpture of strong radial ribs, spinose on part or all of surface. Hinge plate strong, straight, short.

The name is derived from the Greek *trachys*, rough, and *cardia*, a heart; the gender is neuter.

The subgenus *Trachycardium*, *s.s.*, which has sculpture of imbricated scales over most of the surface but is nodose laterally, is not present in the northeastern Pacific.

Literature: Stanley (1981), Voskuil and Onverwagt (1991a).

Subgenus **Dallocardia**
Stewart, 1930

Dallocardia Stewart, 1930. Type species (OD): *Cardium quadragenarium* Conrad, 1837. Recent, northeastern Pacific.

Shell large, with strong radial ribs, spinose, sometimes frilled posteriorly. Spines on anterior slope on anterior sides of ribs, those on central and posterior slopes on posterior sides of ribs.

This genus is known back to the Oligocene.

**Trachycardium (Dallocardia)
quadragenarium** (Conrad, 1837)

Plate 75

SPINY PRICKLYCOCKLE

Cardium quadragenarium Conrad, 1837: 230; *C. luteolabrum* A. A. Gould, 1851: 91; 1853: 401; *C. xanthocheilum* Carpenter, in A. A. Gould and Carpenter, 1857: 201, *nom. nud.*; Carpenter, 1857b: 232, *ex* Gould MS, *nom. nud.*; *C. arenatum* Carpenter, 1857b: 93; *C. quadragenarium fernandoensis* R. Arnold, 1907a: 535.

Shell solid, inflated, ovate to rhomboidal. Sculpture of more than 40 sharp, strong, closely spaced, radial ribs, with small thorn-like spines, stronger on lateral and ventral parts of shell. Color pale yellow to brown, with brown maculations. Shell margins deeply crenulate. Length to 150 mm.

Monterey, California (36.6°N) [CAS], to Punta Rompiente, Baja California Sur (27.0°N) [LACM], in the intertidal zone to 50 m, in sand or mud of bays and offshore. Recorded as early as the Miocene of California.

Literature: Fischer-Piette (1977: 55), U. S. Grant and Gale (1931: 306-307), Haderlie and Abbott (1980: 370), Hertlein and Grant (1972: 259-260), Poutiers (1995: 125).