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Leptochiton cancellatus (G.B. Sowerby II, 1840)

Synonyms: *Chiton cancellatus* G.B.Sowerby II, 1840; *Lepidopleurus cancellatus* (Sowerby II, 1840);

Vernacular: Arctic cancellate chiton.

GLOSSARY, BELOW, uses the standardised terminology for chitons proposed by Schwabe (2010). Some Jones & Baxter (1987) terms are indicated in the glossary as a.k.a.

Preface

This small species may be overlooked as a juvenile, pale *Lepidochitona cinerea* (Linnaeus, 1767). The single specimen used to illustrate this account was found during examination of several *L. cinerea*. It shows some deviation from the features of *Leptochiton cancellatus* described in Kaas (1981) and Kaas & Belle (1985). On balance, and until molecular studies of the *Leptochiton* species can be compared, its features, location and habitat appear to support an identification of *L. cancellatus*. The text conforms to Kaas & Belle's description and figures, any deviations are mentioned in the image captions. Other specimens of *L. cancellatus* are on Nature22 website of marine life from Brittany, whence Kaas and Belle took specimens for their figures. <http://nature22.com/estran22/mollusques/polyplacodentale/chitons.html>

Shell Description

figure 1 (left). <https://flic.kr/p/NiCR5L> Black manganese and rusty ferrous deposits. **1:** Girdle narrow, valves 80 - 90% of width. **2:** Head valve less than a semicircle, posterior widely V shaped. Closely packed, oval granules in chainlike lines running **longitudinally** in front (**3**) of mucro on tail valve and in the jugal (**4**) and pleural (**5**) areas of valves ii to vii, and **radiating** on head valve (**2**), behind (**6**) mucro on tail valve and on lateral areas (**7**) of valves ii to vii. Granules eroded on this large (8.6mm long) specimen. **8:** Peripheral ribbed, pointed spicules 0.1mm long.

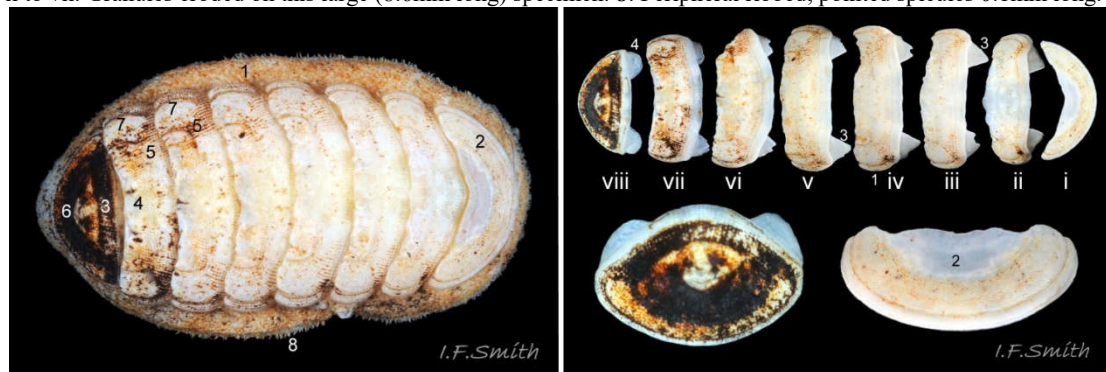


figure 2 (right). <https://flic.kr/p/NZJYuu> Eight thin, white or cream valves with mineral staining.

1: No lateral insertion plates. **2:** Tegmentum layer eroded from central area of head valve, exposing underlying ungranulated articulamentum layer. Articulamentum projects beyond tegmentum as apophyses to underlie next valve, triangular on intermediate valves (**3**), but rounded trapezoidal on tail valve viii (**4**).

Up to c. 8mm long and 4mm wide, often smaller. Smallest chiton species in British waters, apart from *L. scabridus*. In dorsal view, outline elliptical; width about 50% of length when extended (fig. 1). **Girdle** narrow, so intermediate shell valves (ii to vii) occupy 80 to 90% of chiton's width. Eight overlapping, thin, fragile, white or cream **valves** (fig.2) principally made of **tegmentum**: dorsal layer of aragonite (fig.3) permeated and weakened by canals; and **articulamentum**: ventral layer of aragonite. Also **properiostracum**: outermost proteinaceous layer and **myostracum**: microscopically thin discontinuous innermost layer. Dorsal surface of valves often stained in patches or streaks with black manganese and/or rust coloured ferrous deposits (fig. 1). Head valve (i) less than semicircle, posterior margin widely V shaped; approximately crescentic on live animal (fig. 1). Intermediate valves (ii to vii) have gently

curving, almost parallel, anterior and posterior edges, with somewhat obliquely truncated anterior corners, and they lack any sign of a beak (fig.3 & fig.4).

figure 3 (left). <https://flic.kr/p/NiCQw1> Ventral & dorsal views of intermediate valve v. 1: Tegmentum; dorsal layer permeated and weakened by canals. 2: Articulamentum: ventral layer; has triangular apophyses (3) protruding to underlie next valve. Valve has gently curving, almost parallel, anterior (4) and posterior (5) edges, with somewhat obliquely truncated anterior corners (6), and no beak (7).

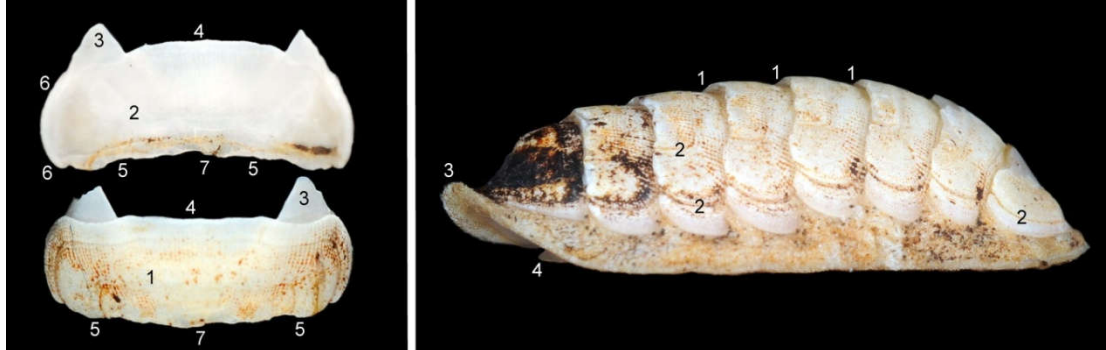


figure 4 (right). <https://flic.kr/p/NZJXR5> 1: No beak on intermediate valves. 2: A few strong growth lines on all valves. 3: Girdle flexed up at posterior for release of faeces, excreta and ova or sperm. 4: Rare glimpse of foot.

Smooth curved profile with no sign of a keel when intermediate valve viewed from posterior (fig. 5). Tail valve (viii) quite large, roughly triangular (fig. 6), and slightly concave (fig. 7) to posterior of slightly swollen mucro which is positioned to posterior of centre when extracted valve viewed from above (fig. 6).

figure 5 (left). <https://flic.kr/p/NiCQm1> Posterior of valves iv & v. Arch is moderately high curve with no keel. Elevation of these arches; height/width 45% & 47%. (Kaas & Belle state 39% for *L. cancellatus*; 48% for *L. sarsi*).

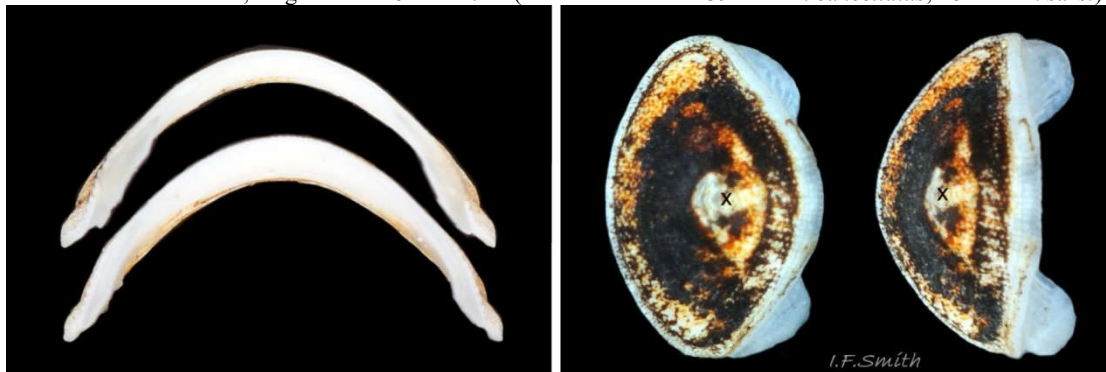


figure 6 (right). <https://flic.kr/p/NZJXy1> Two views of tail valve, a) anterior tilted down to expose full surface. b) in approximately life position as for following description: Tail valve roughly triangular; mucro (X) behind the centre, swollen but not prominent (Kaas & Belle, 1985). Length of tail valve 45% of width (Kaas, 1981). This specimen differs from Kaas & Belle as outline is almost semicircular, and length of valve is 51% of width.

Canals permeate the tegmentum and terminate on its dorsal surface in small oval granules with a cap (megalaesthete) at anterior of granule, and a few smaller subsidiary caps (micraesthetes) in posterior part of granule (Jones & Baxter, 1987).

Intermediate valves ii to vii each have two widely separated, small, triangular **apophyses** (fig.3) on anterior edge that extend under next valve forwards (fig. 8). Tail valve viii has rounded trapezoidal apophyses. *L. cancellatus*, like others in family Leptochitonidae, lacks **insertion plates** that most chitons have at ends of intermediate valves, at anterior of head valve and posterior of tail valve.

Dorsal surface cancellated by closely packed, almost touching, oval granules in chainlike lines running a) longitudinally in front of mucro on tail valve and in the jugal and pleural areas of valves ii to vii, and b) radially on head valve, behind mucro on tail valve and on lateral areas of valves ii to vii (figs. 1 & 9). Lines of granules may be eroded on large old specimens. Lateral and pleural areas slightly differentiated by slight elevation of lateral area and difference in orientation of granules. Usually, a few strong growth lines are clearly visible on all valves (fig.4).

figure 7 (left). <https://flic.kr/p/Pv3nHG> Posterior of *L. cancellatus*, and comparative silhouettes of three species based on Kaas & Belle (1985). X = mucro.

L. cancellatus: “Tail valve mucro behind the centre when seen from above, swollen but not prominent, posterior slope a little concave directly behind the mucro.”

L. sarsi: “Tail valve mucro not prominent, central or a little anterior, posterior slope only slightly concave directly behind the mucro.”

L. scabridus: “Tail valve mucro about central, somewhat swollen, postmucronal slope concave.” (Kaas & Belle, 1985).

Measured horizontally, mucro on the photo appears to be anterior of the centre because part of its anterior is concealed below the next valve. The Kaas & Belle text of *L. scabridus* says mucro is about central but on silhouette it is well to posterior.

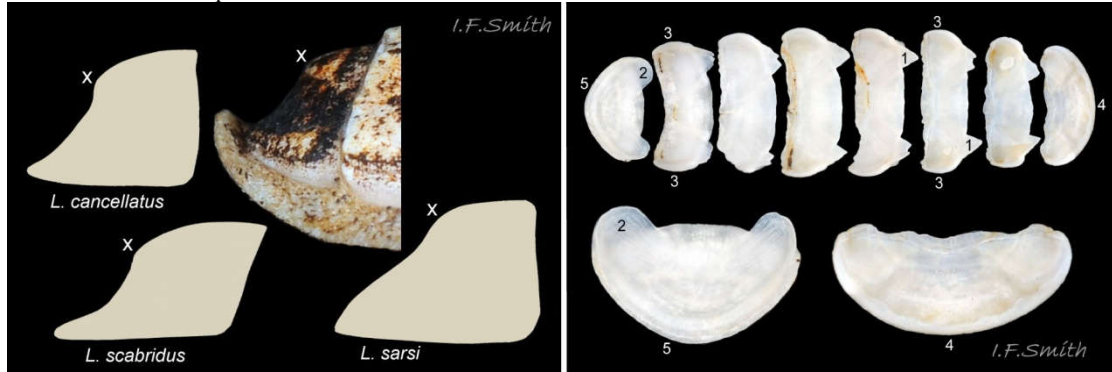


figure 8 (right). <https://flic.kr/p/NiCOcy> Small, triangular, widely separated apophyses (1) on intermediate valves ii to vii extend under next valve forwards. Rounded trapezoidal apophyses (2) on tail valve viii. No insertion plates with intervening slits at ends of intermediate valves (3), at anterior of head valve (4) or posterior of tail valve (5).

Body Description

Head and foot rarely protrude into view naturally on live animal (fig.4), can only be examined if animal removed from substrate, or placed on glass. Most of **head** occupied by large transverse slit-mouth with wrinkled lips, surrounded by white hood (fig. 10); no eyes or sensory tentacles.

figure 9 (left). <https://flic.kr/p/Pv3nCw> Dense, oval granules in chainlike lines running: longitudinally in the jugal (1) and pleural (2) areas and radially on lateral area (3) of valve vii.

4: Girdle raised at posterior for exhalant water current carrying excreta, faeces and ova/sperm.

5: Dorsal surface of narrow, whitish girdle has no pattern; some individual scales stained with mineral deposits. Scales squarish with rolled tips; give surface a rough appearance.

6: Ventral surface of girdle, whitish stained by minerals; has imbricated, flat scales (microscope required).

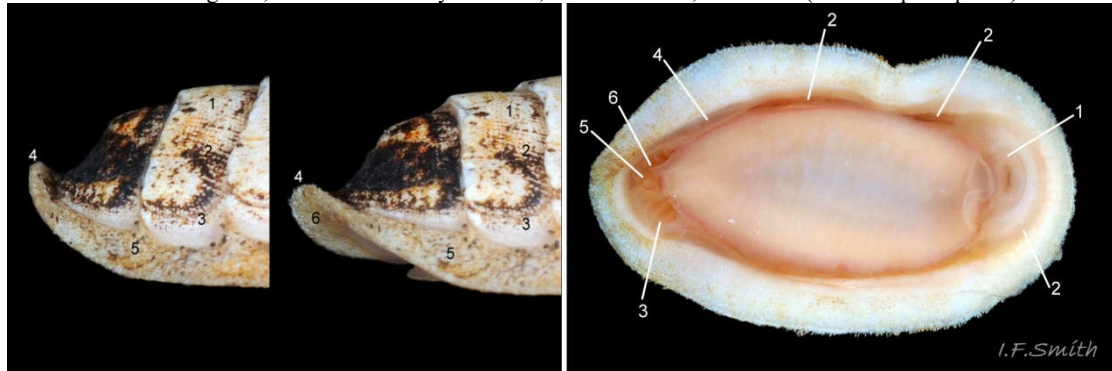


figure 10 (right). <https://flic.kr/p/NZJWUf> Head has large transverse slit-mouth (1) with wrinkled lips, surrounded by white hood, no eyes or sensory tentacles. Narrow mantle cavity (2) runs around whole animal; contains gills (3) at posterior (merobranch arrangement). Between foot and girdle, the mantle fold (4) is unobtrusive but can seal the mantle cavity and conceal gills when in place. Anus (5) on papilla opens into mantle cavity at posterior. Foot, elongate ellipse with small projection (6) either side of anal papilla. Sole whitish pink centrally, becoming reddish pink towards periphery, no medial dividing line. Foot spreads widely, concealing mantle cavity with help of mantle fold (4) when gripping substrate.

Aesthetes (sensory tissue) fill canals that permeate the tegmentum and parts of articulation; terminate in oval granules as sense organs on dorsal surface of valves. Dorsal surface of **girdle**, whitish but often stained rusty colour with mineral deposits; densely packed, squarish scales with curled tips give a rough appearance (fig. 9). Ventral surface of

girdle, whitish variably stained with mineral deposits; has imbricated, bluntly pointed, flat scales (microscope needed to see detail). Girdle has peripheral fringe of ribbed, pointed spicules about 0.1mm long (fig. 1). Girdle can be flexed up at posterior to allow release of faeces, excreta, ova or sperm (fig.4).

Open, narrow **mantle cavity** runs around whole animal; contains gills close to anus at posterior (merobranch arrangement) (fig. 10). Between foot and girdle, the mantle fold is unobtrusive but can seal the mantle cavity and conceal gills when in place. **Anus** on papilla opens into mantle cavity at posterior where girdle deflected dorsally for expulsion of faeces. Nephridiopores and gonopores open laterally into posterior quarter of cavity. No **penis** as external fertilization. **Foot**, elongate ellipse with small projection either side of anal papilla, sole whitish pink centrally, becoming reddish pink towards periphery, no medial dividing line (fig. 10). Foot spreads widely, concealing pallial cavity with help of mantle fold when gripping substrate.

Key identification features

Leptochiton cancellatus

- 1: Small; maximum length 8mm (illustrated specimen slightly larger). Valves whitish or cream, often stained in patches or streaks with black manganese and/or rust coloured ferrous deposits. No lateral insertion plates or slits (fig. 2).
- 2: Only at LWS and sublittorally. All round Britain. Probably overlooked.
- 3: Narrow whitish girdle has no pattern, may be stained with rust coloured ferrous, and/or blackish manganese deposits. Dorsal girdle scales squarish with rolled tip (fig. 9).
- 4*: Arch of valves is moderately high, smooth curve with **no sign of a keel**. Elevation of arch valves iv & v; height/width 39% (Kaas & Belle), but illustrated specimen 46% (fig. 5).
- 5: No posterior beak on intermediate valves (fig.4).
- 6: Cancellated by closely packed, almost touching, oval granules in chainlike lines running radially on valves i & viii, and on lateral areas of valves ii to vii (sometimes obsolete on lateral areas). Lines longitudinal on central areas of valves ii to vii (fig. 9).
- 7: Sole whitish pink centrally, becoming reddish pink towards periphery (fig. 10).
- 8: Gills close to anus at posterior (merobranch) (fig. 10).
- 9: Tail valve shorter than on *L. sarsi*; length 45% of width in life position (51% on illustrated specimen) (fig. 6).
- 10: Mucro slightly swollen and to posterior of centre of extracted valve viii; part of anterior concealed on live specimens (fig. 6). Postmucronal slope entirely concave (fig. 7).

figure 11 (left). <https://flic.kr/p/Pv3ny3> If displaced from substrate, *L. cancellatus* can roll into a ball.



figure 12 (right). <https://flic.kr/p/NZJWg1> Comparison images of *Lepidochitona cinerea*; has diversely coloured valves, including whitish (1) resembling *Leptochiton cancellatus*. Distinct posterior beak (2) on valves ii - viii.

Similar species

* indicates principal distinguishing features.

Lepidochitona cinerea (Linnaeus, 1767).

1*: Maximum length 28mm. Valves diversely coloured and patterned, including whitish resembling *Leptochiton cancellatus* (fig. 12). Lateral insertion plates separated by single slit on each end of valves ii to vii.

- 2: Midshore level and below. All round Britain. Commonest littoral chiton.
- 3*: Girdle has a unique (in N.W. Europe) lozenge pattern (fig. 13), sometimes indistinct, especially on whitish specimens which are easily confused with *L. cancellatus* (fig. 14).
- 4*: Arch of valves is keeled (fig. 15).
- 5*: Distinct posterior beak on intermediate valves (fig. 12).
- 6: Dorsal surface of valves has densely packed rounded granules, not in straight lines.
- 7: Sole pinkish white to orange pink, usually with grey viscera showing centrally.
- 8*: Usually 16 to 19 gills each side for whole length of foot (holobranch).

figure 13 (left). <https://flic.kr/p/Pv3mKj> Girdle of *Lepidochitona cinerea* has a unique (in N.W. Europe) pattern of dark and light, tessellating lozenges with (1) narrow waist on dark band interlocking with bulging waist of pale band (sometimes colours interchanged); (2) central dark spot on pale band, and white spot somewhere on dark band; (3) pale grey (or whitish or pale brown) longitudinal line often runs across, or near to, the waists of bands. Markings are indistinct on pale specimens and easily confused with *Leptochiton cancellatus*.

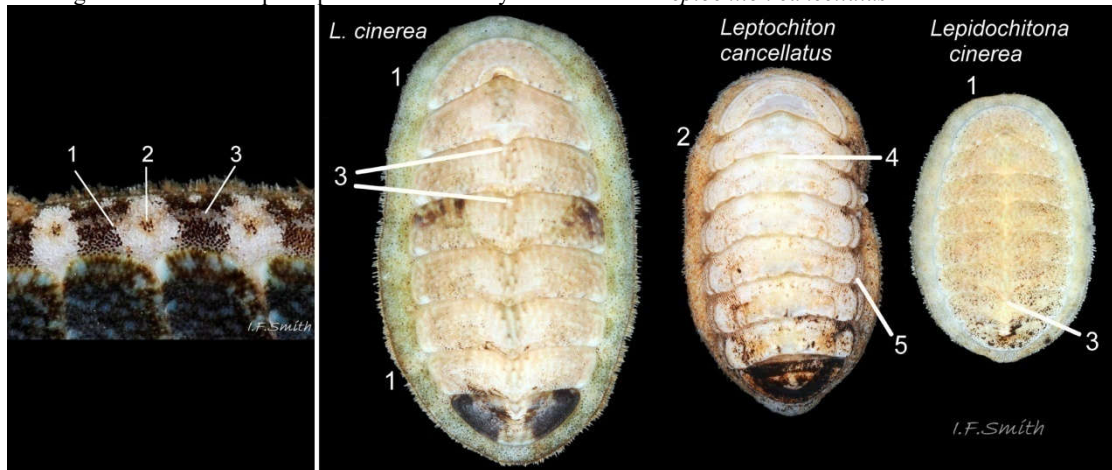


figure 14 (right). <https://flic.kr/p/NZJTtY> Pale *Lepidochitona cinerea* comparison with *Leptochiton cancellatus*.

- 1: *Lepidochitona cinerea* faint trace of girdle pattern.
- 2: *Leptochiton cancellatus* whitish girdle, no pattern, but rusty staining from ferrous deposits.
- 3: *Lepidochitona cinerea* beak on intermediate valve.
- 4: *Leptochiton cancellatus* no beak on intermediate valve.
- 5: *Leptochiton cancellatus* strong growth line.

figure 15 (left). <https://flic.kr/p/NZJSEd> 1: Keel on high arch of *L. cinerea*. 2: Smoothly rounded, high arch of *L. cancellatus*. H/W 46%. 3: Slight keel on low arch of *L. scabridus*. H/W c.31%.



figure 16 (right). <https://flic.kr/p/NjS8yz> Disarticulated *L. asellus* for comparison (dorsal and ventral views). Valves whitish, with distinct dark longitudinal streaks. Apophyses (1) broader and less pointed than on *Leptochiton cancellatus*.

Leptochiton asellus (Gmelin, 1791)

- 1*: Maximum size 18mm x 10mm. Valves whitish, sometimes with distinct black/dark brown longitudinal streaks (fig. 16) or general staining by black or rust coloured mineral deposits (fig. 17). No lateral insertion plates or slits.
- 2: Only at LWS and sublittorally. All round Britain; probably commonest sublittoral chiton.
- 3: Whitish girdle has no pattern, may be stained with rust coloured ferrous, and/or blackish manganese, deposits. Dorsal girdle scales elongate, bluntly pointed (fig. 18).

- 4*: Arch of valves is quite high with **distinct keel** and straight side slopes (fig. 18). Elevation, height/width, of arch on valves iv & v is 36%.
- 5: Often a slight beak on intermediate valves, especially valves ii & iii.
- 6: Roughly oval granules in slightly disjointed lines, orientated as on *L. cancellatus*
- 7: Sole whitish pink centrally, becoming reddish pink towards periphery.
- 8: Eight to thirteen gills in posterior half of pallial groove (merobranch).
- 9: Tail valve length less than 50% of width in life position.
- 10: Mucro not swollen and slightly anterior of centre of valve viii.

figure 17 (left). <https://flic.kr/p/NZJRQN> *L. asellus* for comparison. Valves whitish, stained by ferrous mineral, except newest growth at ends of valves (1). No pattern on whitish girdle (2), but dorsal surface mineral-stained (3).

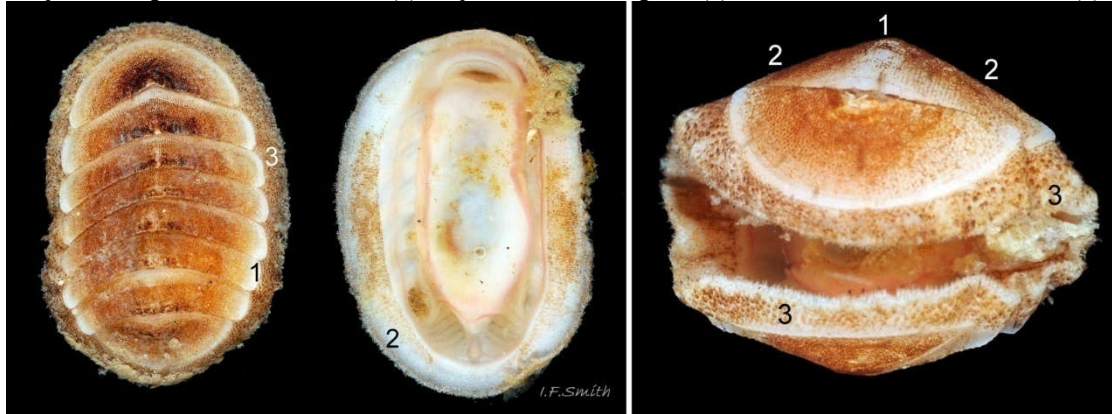


figure 18 (right). <https://flic.kr/p/NjS7oD> . *L. asellus* for comparison. Arch of valves has distinct keel (1) and straight side slopes (2). Elevation of arch valves iv & v; height/width 36%, Kaas & Belle. Dorsal girdle scales elongate, bluntly pointed (3); not like rough appearance of *Leptochiton cancellatus*.

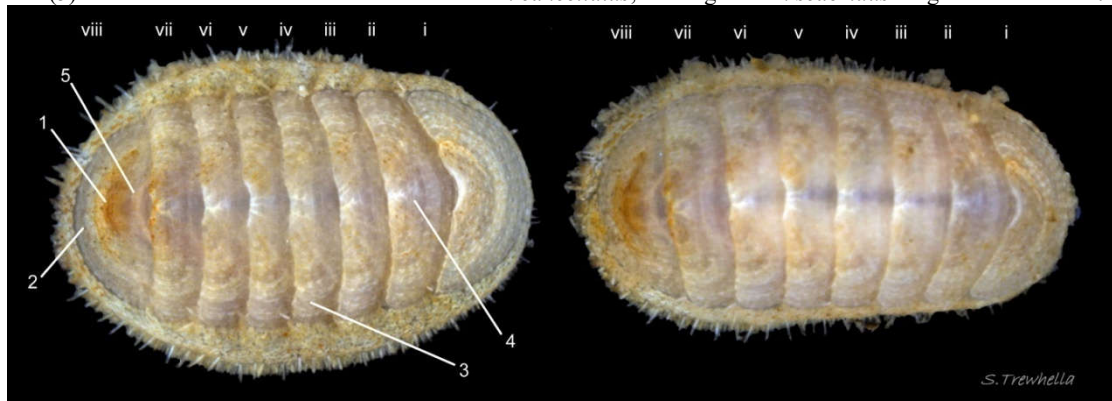
Leptochiton scabridus (Jeffreys, 1880). (fig. 18.2).

- 1*: Small; length often 4 or 5mm, max. 8mm x 4mm. Valves whitish to dull orange, sometimes stained by black or rusty mineral deposits. No lateral insertion plates or slit.
- 2*: Only at LWS and sublittorally. Rare, only SW England, Channel Islands & Brittany.
- 3: Narrow whitish girdle has no pattern, may be stained with rust coloured ferrous, and/or blackish manganese, deposits.
- 4*: Arch of valves has a **slight keel** and a lower profile than on *L. cancellatus* (fig. 15).
- 5: No posterior beak on intermediate valves, but anterior of valve ii tends to be angulated.
- 6*: Rows of raised, round granules on valves, orientated as on *L. cancellatus*, but coarser.
- 7*: Whole **sole strikingly bright red** (fig. 18.1)
- 8: Gills confined to posterior half (merobranch).
- 9: Tail valve length about 55% of width in life position.
- 10: Mucro swollen and near centre of valve viii. Postmucronal slope entirely concave.

figure 18.1 (left). <https://flic.kr/p/2iizGVC> *Leptochiton scabridus*. Carmine red sole and gills (1). Mantle fold (2). (right) Length 4.1 mm. Sole expanded so red less intense. Mantle fold (1). Leg. S. Trehwella.



figure 18.2 <https://flic.kr/p/2iiRa54> Comparison *L. scabridus*. Central mucro (1). Granules vary from rounded bosses to angular; arranged radially on head valve, postmucronal area (2) of tail valve and the lateral triangles (3) of intermediate valves. Arranged in longitudinal lines on central areas (4) of intermediate valves and antemucronal area (5) of the tail valve. Granules orientated as on *L. cancellatus*, but larger on *L. scabridus*. Leg. © S. Trewhella.



***Leptochiton sarsi* Kaas, 1981**

Very similar and closely related to *L. cancellatus*. All Scandinavian specimens previously recorded as *L. cancellatus* that were examined by Kaas (1981) were considered by him to be *L. sarsi*. No British records on NBN, but one from Guernsey (1922) and others from Mediterranean (Dell'Angelo et al, 2009), so, if these correctly identified, possibility that *L. sarsi* may be in British waters unrecognised.

1: Maximum size 10mm X 5mm.

2*: Western Sweden to northern Norway at depths 40m to 700m.

3: Narrow girdle. Dorsal scales elongate, conical.

4: Arch of valves is high and rounded to slightly keeled. Elevation of arch of valves iv & v; height/width 48%.

6*: Valve granules coarser than on *L. cancellatus* with wider gaps between them. Granule lines **not radial** on valves i & viii or lateral areas of valves ii to vii. Lines longitudinal on central areas of valves ii to vii; spaced wider than on *L. cancellatus* so fewer rows (12 rows match width of an apophysis, about 16 on *L. cancellatus*) (figs. 19 & 20) .

9: Tail valve long, length 60% of width.

10*: Mucro on tail valve viii not swollen and positioned slightly anterior of centre.

Postmucronal slope concave only to immediate posterior of mucro; changes to straight or slightly convex further towards posterior (fig. 7).

figure 19 (left) <https://flic.kr/p/Pv3tYC> Part of intermediate valve of *L. sarsi* for comparison. Leg. Det. P. Kaas.

SEM © J. Sigwart. Valve granules coarser than on *L. cancellatus* with wider gaps between them.

On lateral area (1), granules clumped in indistinct quincunxes, not in distinct lines (radial lines on *L. cancellatus*).

On pleural (2) and jugal (3) areas, granules in longitudinal lines; spaced more widely than on *L. cancellatus* so fewer rows (on this image 12 rows match width of apophysis (4), about 16 on *L. cancellatus*).

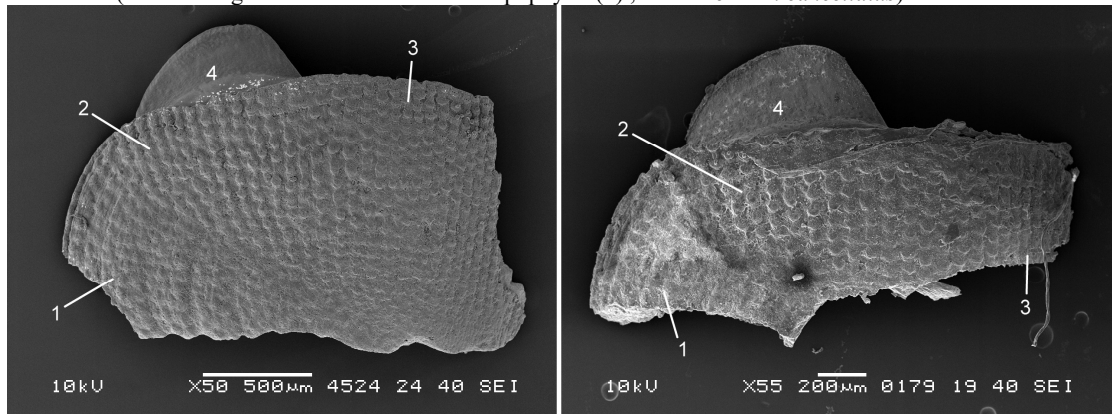


figure 20 (right) <https://flic.kr/p/NZJPRY> Caption as for figure 19, but on this image 11 rows of granules match width of apophysis (4), about 16 on *L. cancellatus*).

***Leptochiton rugatus* Carpenter in Pilsbury, 1892**

All Pacific specimens previously recorded as *L. cancellatus* that were examined by Ferreira (1979) were considered by him to be *L. rugatus*. It has a quite different radula.

Habits and ecology

Lives on and under stones and dead shells on silty sand at LWS and sublittorally to beyond 900 metres. When alarmed, can increase grip suctionally by raising part of girdle to form partial vacuum, and if displaced from substrate, can roll into a ball (fig. 11).

Respiration: cilia on gills and mantle create inhalent water-current entering pallial cavity wherever girdle is raised at anterior. Water current passes through gills and then along cavity as exhalent current to exit at posterior under raised girdle.

In absence of eyes or of tactile or chemoreceptor tentacles on head, *L. cancellatus* senses environment through aesthetes exposed on surface of shell.

Feeds by scraping micro algae and associated organisms from the rock surface using its hard radula of chitin mineralized with magnetite. Water current in pallial cavity carries excreta from lateral nephridiopores to posterior, where faecal pellets from anus join the flow; all expelled at posterior under raised girdle (fig. 9).

Travels by monotaxic, retrograde, compression waves on sole of foot.

Breeding: dioecious. Water current in mantle cavity carries sperm or ova from lateral gonopores to posterior and out through channel in deflected girdle (fig. 10). As fertilization is external, synchronised emission of sperm and ova needed to ensure success; trigger in many chiton species is moon-phase/ state of tides. Planktonic trochophore larvae hatch and metamorphose into small adult-form young without intervening veliger stage.

Distribution and status

Shetland to Spain, Madeira and Mediterranean. Not Baltic. GBIF map at <https://www.gbif.org/species/5193797> shows disputed Scandinavian and Pacific records, and images shown (2019) are not *L. cancellatus*. All around Britain and Ireland on suitable substrate, except scarce/absent in North Sea; NBN interactive distribution map at https://records.nbnatlas.org/occurrences/search?q=lsid:NHMSYS0021056576#tab_mapView

Acknowledgements

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Current taxonomy: World Register of Marine Species (WoRMS)
<http://www.marinespecies.org/aphia.php?p=taxdetails&id=138675>

Glossary

aesthete = one of complex of canals filled with sensory tissue that permeate tegmentum and parts of articulamentum. Occur in bundles of a large megalaesthete surrounded by several smaller radiating micraesthetes that open as sensory macropores and micropores on dorsal surface of valves. Some are photoreceptors; other functions uncertain, may include chemoreception, mechanoreception, propriostracum replenishment and/or secretion of protective substances.

a.k.a. = also known as.

apophysis (pl. apophyses) = anterior extension of articulamentum for muscle attachment which underlies preceding valve; on all valves except head valve.

aragonite = orthorhombic crystalline mineral form of calcium carbonate <http://www.minerals.net/mineral/aragonite.aspx> . Less common on land than calcite, but, currently, the more frequent mineral-form in oceans and living mollusc shells.

articulamentum = ventral shell-layer of chiton valves, usually hard, white, porcelaneous aragonite and often differently coloured in central part. (Partially overlain ventrally by inconspicuous myostracum layer.)

cancellated = lattice like pattern.

chemoreception = sensing of chemicals; “smell / taste”.

chitin = semitransparent flexible horny protein.

chitinous = (adj.) made of chitin.

ctenidium (pl. gills) = comb-like molluscan gill; usually an axis with a row of filaments either side.

dioecious = having separate male and female individuals, not hermaphrodite.

ELWS = extreme low water spring tide (usually near March and September equinoxes).

girdle (on chiton) = peripheral band of thickened, reflexed mantle that encloses ends of valves.

gonopore = opening through which eggs or sperm are released.

haemoglobin = oxygen-carrying substance in blood; scarlet when oxygenated.

holobranch = arrangement of gills that extends full length of foot in pallial groove.

insertion plate (on most chitons) = extension of articulamentum on lateral margin of intermediate valves, anterior margin of head valve and posterior margin of tail valve. Inserts into, and anchors valve to, the girdle muscle block.

intermediate valve = (of chiton) any valve (ii to vii), except head valve (i) and tail valve (viii).

imbricated = overlapping like roof tiles.

jugal area = triangular middle section of central area of intermediate valves, with apex pointing to posterior; discernible when defined by differences of colour and/or sculpture (dorsal surface).

jugal tract = triangular middle section of central area of intermediate valves, with apex pointing to posterior; discernible when defined by densely arranged aesthete pores (ventral surface).

jugum = triangular middle section of central area of intermediate valves. (See jugal area and jugal tract.)

lateral area (on intermediate valve of chiton) = triangular area with its base along lateral edge of valve and its apex near the centre of the posterior edge. a.k.a. lateral triangle.

LWS = low water spring tide, two periods of a few days each month when tide falls lowest.

magnetite = mineral of iron oxide, hardest material made by any living organism (Botelho, 2013).

mantle = sheet of tissue covering visceral mass of molluscs. Secretes shell. On chitons, forms mantle/pallial cavity and is toughened to form the girdle surrounding the shell valves.

megalaesthete = (see aesthete).

merobranch = (of chitons) gills in pallial groove only in posterior two-thirds of animal.

micaesthete = (see aesthete).

monotaxic = (of locomotion waves on foot) single series of waves across complete width of foot.

mucro = projection on tail valve (viii) demarking posterior from rest of valve. Varies in prominence and position.

myostracum = microscopically thin discontinuous innermost layer of chiton valve.

nephridium (pl. nephridia) = cilia-lined excretory/osmoregulatory tubule (kidney).

nephridiopore = opening of nephridium for excretion. a.k.a. nephropore, or renal pore.

odontophore = firm, approximately ellipsoid, structure of cartilage supporting radula. Protruded like a tongue to operate radula.

papilla (pl. papillae) = small nipple-like protuberance.

plankton = animals and plants that drift in pelagic zone (main body of water).

pleural area (on valves ii - vii) = triangular area with its base along anterior edge of valve and its apex near the centre of the posterior edge. a.k.a. median triangle.

porcelaneous = resembling vitreous glazed ceramic material.

postmucronal = situated to posterior of mucro on tail valve.

periostracum = proteinaceous material covering the shell. Different composition from periostracum of most other molluscs.

quincunx = pattern of five as on playing card.

radula = ribbon of chitin bearing chitinous teeth that is extruded on a tongue-like odontophore of cartilage to rasp food. On chitons and limpets, teeth are usually impregnated with magnetite, a hard magnetic mineral of iron. <https://en.wikipedia.org/wiki/Radula>

retrograde (of locomotion waves on foot) = waves travel from anterior to posterior.

SEM = scanning electron microscope.

sublittoral = below level of low water spring tide

trochophore = spherical or pear-shaped larvae that move with aid of girdle of cilia. Stage preceding veliger, passed within gastropod egg in most spp. but free in plankton for limpets, Trochidae and (with no veligers) chitons.

<http://192.171.193.133/detail.php?sp=Molluscan%20trochophore>

tegumentum = outer shell-layer of chiton valves, usually porous and relatively soft. (Covered by periostracum when live.)

valves = the eight dorsal, articulated shell plates.

veliger = shelled larva of marine mollusc which swims by beating cilia of a velum (bilobed flap).