Boreochiton ruber (Linnaeus, 1767)

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Synonyms: *Chiton ruber* Linnaeus, 1776; *Chiton ruber* var. *oblonga* Jeffreys, 1865; *Tonicella rubra* (Linnaeus, 1767).
Vernacular: Northern red chiton; Lleuen goch y graig (Welsh); Chiton rouge du nord (French); Rote Käferschnecke (German); Rødleddsnegl (Norwegian); Rød skallus (Danish).

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

Shell Description

Usually 10 to 15 mm long and 6 to 9mm wide, occasionally 21mm long. In dorsal view, outline is elliptical; width about 60% of length. 20 to 30% of animal width occupied by girdle (Jones & Baxter, 1987) (fig. 1), but in lateral view, because of inclination of valves and perspective, girdle appears to take up about 50% of animal's width (fig. 2).

figure 1(left) https://flic.kr/p/qKt38T Length 12 mm. Outline elliptical, width about 60% of length. Girdle occupies 32% of width in this perpendicular view. Leg. P. Lightfoot

figure 2 (right) https://flic.kr/p/r2LAhK . Lengths 12 & 14.5 mm. Head valve i on right of image. Distinct backward pointing beak on valves ii –vii. Vibrant colours as alive and in good condition. Thin pale bands on girdle are roughly in line with shell sutures; bands very fragmentary on lower specimen. Leg. P. Lightfoot.

Eight overlapping **valves** (figs. 3 & 4) principally made of
a) tegmentum: outer coloured layer of aragonite permeated and weakened by canals,
b) articulamentum: thick inner layer of white and (sometimes on jugal tract) pink aragonite,
c) properiostracum: outermost proteinaceous layer,
d) myostracum: thin discontinuous innermost layer; only visible in section under microscope.
Head valve (i) semicircular, with wide V posterior edge when viewed in situ on living specimen (fig. 1). Intermediate valves (ii –vii) rectangular, slightly keeled, with low smoothly-convex to straight side slopes when viewed from posterior (fig. 5). Almost semicircular tail valve (viii) has antemedian mucro with almost straight, steep postmucronal slope. Antemucronal area resembles jugal area of intermediate valves (fig. 3). Distinct beak on each of intermediate valves (ii –vii) visible in lateral view (fig. 2), and mucro on tail valve viii resembles beak.
Canals permeate tegmentum and terminate on its dorsal surface as minute stipple of caps on pores (at magnification over X30), and as open pores on margins of tegmentum; some canals penetrate the articulamentum to form holes on its ventral surface, especially near the posterior edge and in the slit ray and jugal tract (fig. 4).

figure 3 https://flic.kr/p/q68Hjk Colour vibrancy lost at death or if in poor condition. Pigment stability varies; reds persist while pale greens soon fade, as on this one (same as live specimen in fig.1).
1: semicircular head valve i. **2**: valve i (enlarged), concentric growth lines centred on origin on posterior edge.
3: tail valve viii, almost twice as wide as long. **4**: valve viii enlarged & tilted forwards to reveal insertion plates.
5: antemedian mucro, origin of surrounding concentric growth lines. **6**: steep, slightly convex, postmucronal slope.
7-7-5: central antemucronal area resembles triangular jugal area (**8-8-8**) of intermediate valves. Leg. P. Lightfoot.

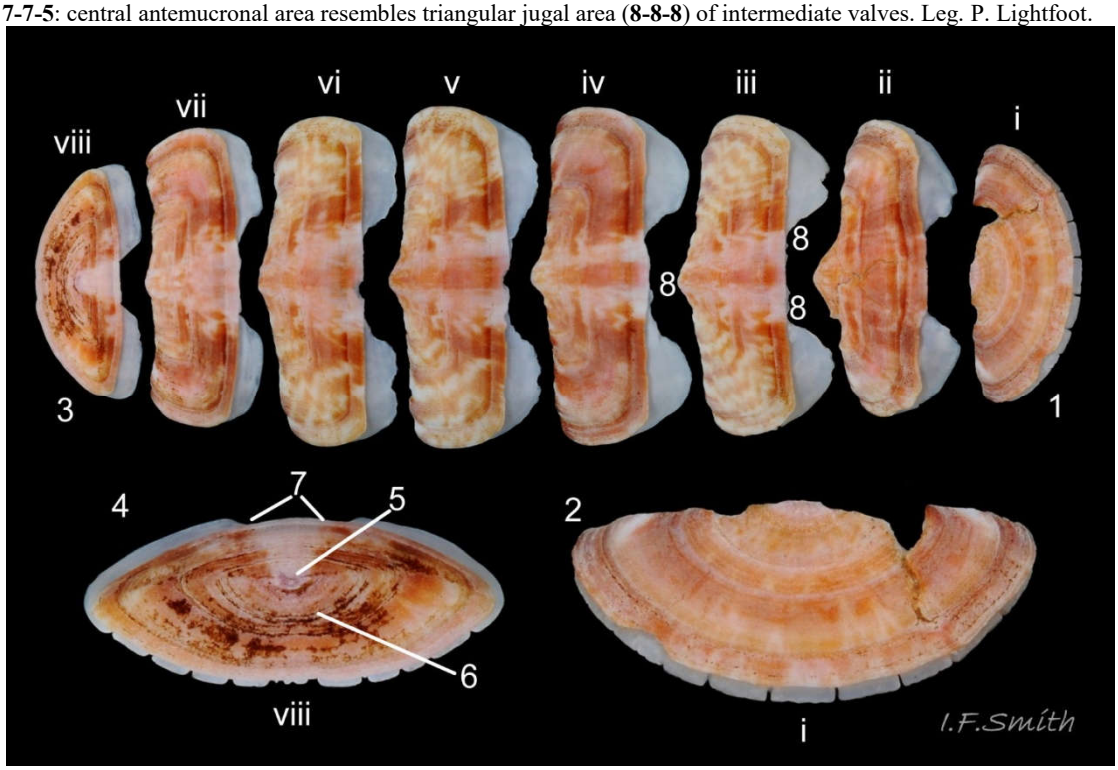


figure 4 (left) https://flic.kr/p/r2Lz28 **1**: tegmentum: outer layer weakened by permeating canals.
2-3-3: jugal area. **2-4**: barely visible ridge, separating lateral area (above ridge in image) from pleural area.
5: almost-rectangular, concentric, distinct growth lines; origin at **2** on valve-posterior.
6: caps on aesthetes, visible at X30. **7**& **14**: apophysis, extension of articulamentum, almost a semicircle.
8: articulamentum: white and, on jugal tract, pink; has few canals, hard and brittle.
9-9: slit ray: row of openings to canals that penetrate articulamentum. **10**: slit separating insertion plates.
11: openings of aesthete canals in articulamentum near posterior edge and, at **12**, in jugal tract, and at **13** on posterior margin of tegmentum. **15**: piece of muscle that connected apophysis to body. Leg. P. Lightfoot.

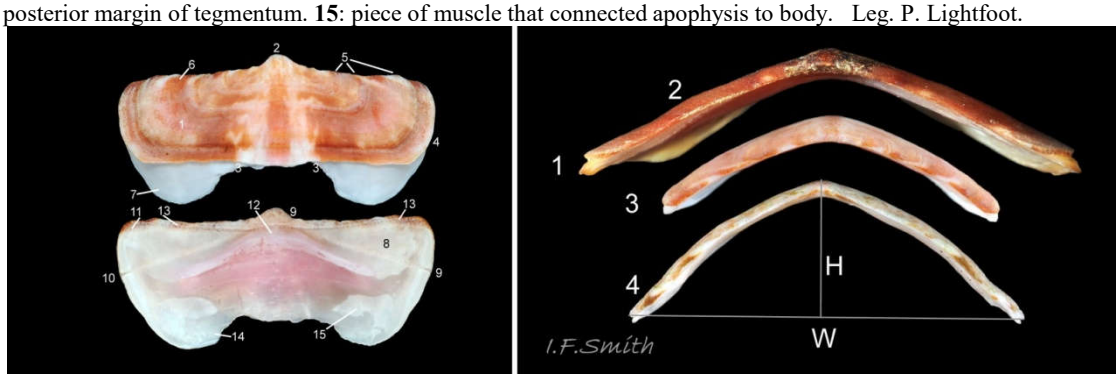
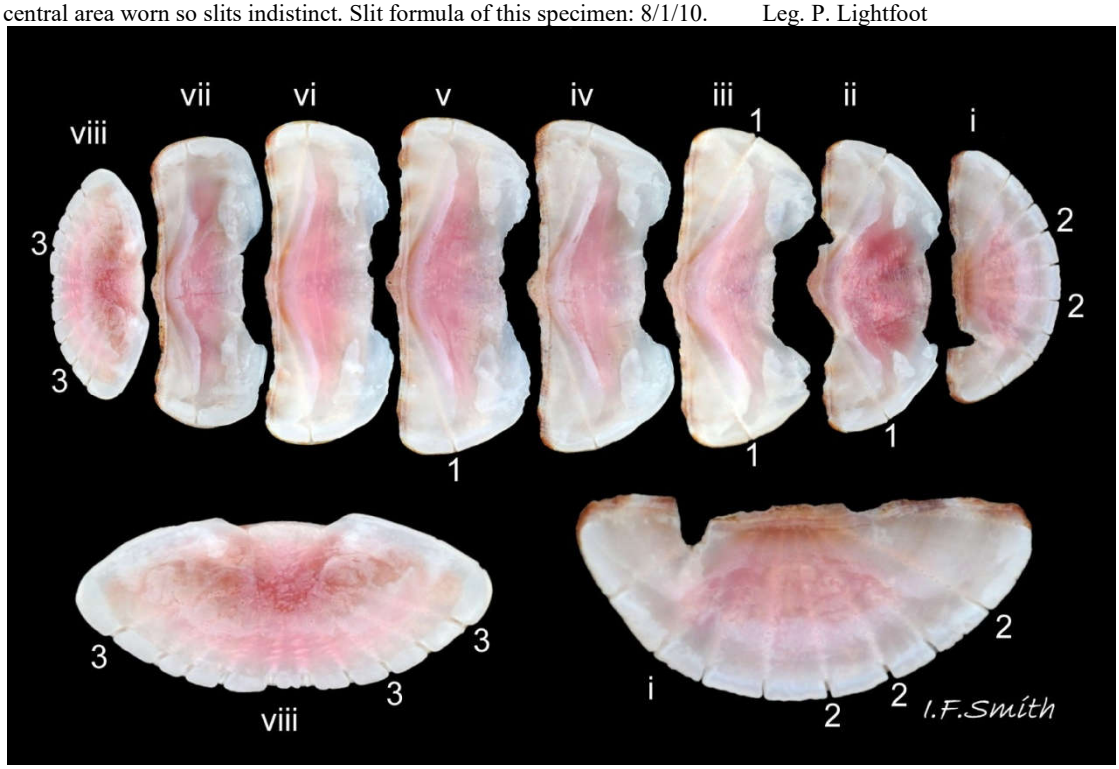


figure 5 (right) https://flic.kr/p/r2VB4v Species comparison. **1:** *Tonicella marmorea*, keeled,low arch, H/W20% , varies 20% to 44% so overlaps with *B. ruber*. Often partly flat and slightly convex in part (at **2**).
3: *B. ruber*, low smoothly-convex arch-profile, elevation 23% (h/w) with moderate keel. Sometimes flatter.
4: *Lepidochitona cinerea*, moderately-high arch-profile, elevation 32% (h/w) with keel. Elevations vary within each species and overlap between species so cannot be used alone to separate them. Leg. P. Lightfoot.

Insertion plates of valves ii – vii embedded in girdle have a single slit; valve i has about eight slits and valve viii has about ten (fig. 6). Typical slit formula 8/1//10. Weakly developed **slit rays** run from slits to posterior edge of valves i – vii (fig. 4) and from slits to mucro on valve viii (fig. 6). Two almost semicircular **apophyses** on anterior of each intermediate valve are separated by a jugal sinus about same width as one apophysis (fig. 17). Apophyses extend under next valve forwards. Valve viii has short, wide, near-trapezoidal apophyses (fig. 4).

figure 6 https://flic.kr/p/r2LyBv **1**: single slit between insertion plates at end of slit ray on intermediate valve. **2**: eight slits in insertion plate at end of slit rays on head valve i. **3**: ten slits in insertion plate on tail valve viii; central area worn so slits indistinct. Slit formula of this specimen: 8/1/10. Leg. P. Lightfoot



Dorsal surface of valves smooth apart from near-rectangular, distinct, growth lines (faint stippling of caps on canals may be visible at over X30 magnification); colouring differentiates jugal area, but lateral and pleural areas very weakly defined as separating diagonal ridge poorly developed (fig. 4). Shell growth is outwards from posterior margin of all valves, except concentrically outwards from mucro on tail valve viii (fig. 3). **Properiostracum** has consistency like collagen, may become loose and easily rubbed off if animal loses condition in captivity.

figure 7 (left) https://flic.kr/p/q5V3Dj Same specimen a) live,in good condition with greenish-cream and vibrant brick-red/orange and b) still alive but in poorer condition and properiostracum lost. Leg P. Lightfoot.

figure 8 (right) https://flic.kr/p/qKkM7o Same specimen a) in good condition, with vibrant colours and girdle with coloured granules and b) after rotting in water; vibrancy and greenish tints lost, flesh of girdle rotted away and most surface granules lost, leaving just the yellowish chitinous surface layer on right of animal. Leg P. Lightfoot.

Dorsal **shell-colour** brightest on live specimens in good condition (fig. 7), vibrancy lost immediately upon death, or even before if in poor condition or injured (figs. 3 & 8). When alive, principal colours of shell and girdle lie in range of brown, brick-red, orange, pink and purple-pink in various combinations arranged in streaks and blotches, with intervening areas

of cream or greenish-cream (figs. 2 & 9) chemical stability of pigments varies; reds persist after death, while greens soon fade.

figure 9 (left) https://flic.kr/p/r2VxtV 10 mm long. **1**: girdle fringed by spicules (124 X 22µm), often tinted as girdle. **2**: dark viscera visible through translucent sole. Leg P. Lightfoot.

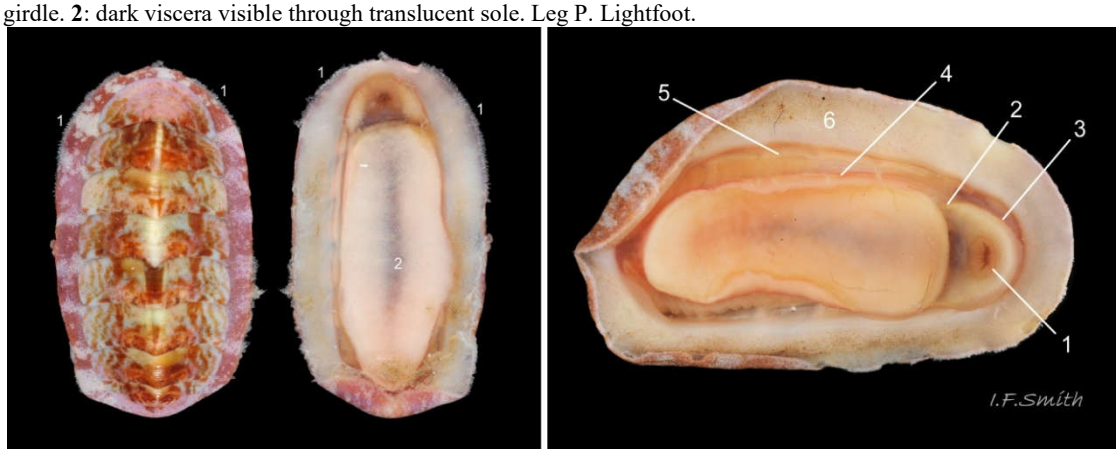


figure 10 (right) https://flic.kr/p/q7bjCs Length 14.5 mm. 1: transverse slit-mouth with wrinkled lips. 2: distal tip of mouth lappet extending laterally from crescent-moon shaped head; no eyes or sensory tentacles. 3: pink border around head. 4: pink border around foot. 5: mantle-fold between mantle-cavity and girdle (6). Leg P. Lightfoot.

Body Description

Head and foot rarely protrude into view naturally on live animal, can only be seen if animal removed from substrate, or placed on glass. **Head** shaped as crescent moon with concave edge fitting round anterior of foot and extending laterally as mouth lappets (fig. 10). Much of head is occupied by large transverse slit-mouth with wrinkled lips; no eyes or sensory tentacles. Pink (fig. 10) or brownish-pink (fig. 11) border around head when viewed ventrally (fig. 12).

figure 11 (left) https://flic.kr/p/q7oUhr length12mm. Brownish-pink border around head (1) and foot (2). Dark viscera (3) visible, but no medial line. Girdle deflected (4) to form exhalent channel. Leg P. Lightfoot.

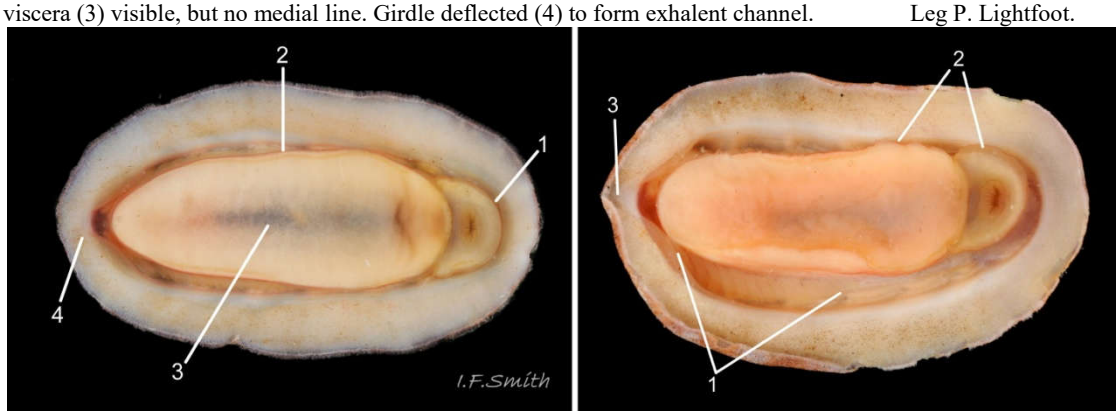


figure 12 (right) https://flic.kr/p/r1TGKm length 14.5mm. Specimen, anaesthetised to allow foot to be pressed aside to reveal thirteen gills (1) in posterior half of right mantle-cavity (merobranch arrangement). Pink border around foot and head (2). Girdle deflected (3) to form exhalent channel. Leg P. Lightfoot.

As on chitons generally, broad **radula** with extremely strong hard teeth of chitin mineralized with magnetite in rows of seventeen. Teeth pale when formed at rear of radula, darken and harden with magnetite as moved forwards. In each row, a pair of major lateral teeth, the principal scrapers, are the largest and darkest (fig. 16).

Aesthetes (sensory tissue) fill canals that permeate the tegmentum and parts of articulamentum; terminate on fine stipple that may be visible at over 30X magnification (fig. 4) as sense organs on dorsal surface of valves.

Immediately below the valves, **mantle** is a tough thin translucent epidermis (fig. 13), but greatly thickened where reflected around periphery to form a fleshy **girdle** into which ends of valves deeply embedded (fig. 14). Girdle has cream or yellowish-white flesh with tough transparent yellowish epidermis that survives when flesh rotted away (fig. 13).

figure 13 (left) https://flic.kr/p/r42Rex Ventral view with soft parts rotted away. Thin, translucent, yellowish, chitinous epidermis of mantle within shell (**1**), and its extension as girdle-surface (**2**). Leg. P. Lightfoot.

figure 14 (right) https://flic.kr/p/qLCoTs **Lower**: packed heads of club-shaped girdle-granules have a mealy appearance. Girdle fringed by straight spicules. **Upper**: girdle after immersion in NaOH solution. Leg. P. Lightfoot

Ventral surface of girdle is paved with elongate oval, strongly ribbed, colourless scales (20X16µm to 44x18µm), often some stained brownish (fig. 15). Dorsal surface of girdle has densely-packed, elongate (50 - 60µm), club-shaped granules with packed, touching heads giving a mealy appearance (fig. 14); granules coloured similarly to valves with, often-fragmentary, pale, narrow bands roughly in line with shell sutures (fig. 2). Edge of girdle fringed by straight, abruptly pointed, longitudinally finely striate spicules (124 X 22µm) when fresh and unworn, often tinted as girdle (fig. 9). Ventral surface of girdle can be flexed to form channel at posterior for release of faecal pellets, ova or sperm (figs. 11, 12 & 15).

figure 15 (left) https://flic.kr/p/r4bSE4 **1**: girdle spread to grip substrate; paved with colourless scales, some stained. **2**: mantle-lappet partly concealing gills. **3**: girdle turned out to form channel at posterior for exhalent water with faecal pellets, excreta, sperm or ova. **4**: foot spread to grip substrate; partly concealing pallial cavity. **5**: posterior of pericardium containing heart. **6**: white articulamentum of tail valve visible through transparent tissue; narrow grey marks are muscle bundles attached to tail valve. Leg. P. Lightfoot.

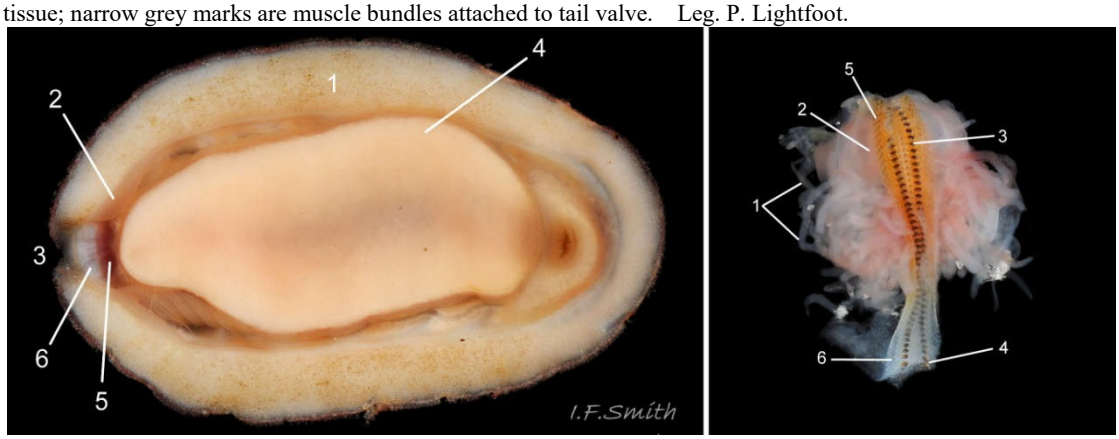


figure 16 (right) https://flic.kr/p/r1TF3d Radula resting on odontophore. Muscles (**1**) to operate mouth parts and radula. Hyaline shield (**2**) overlying cartilaginous pink odontophore. Major lateral teeth, black at anterior of radula **(3)** permeated with extremely-hard magnetite; paler at posterior of radula (**4**) as recently formed and not fully mineralized. Marginal teeth, golden as mineralized at anterior of radula (**5**); colourless as not yet fully mineralized at posterior of radula (**6**). Leg. P. Lightfoot.

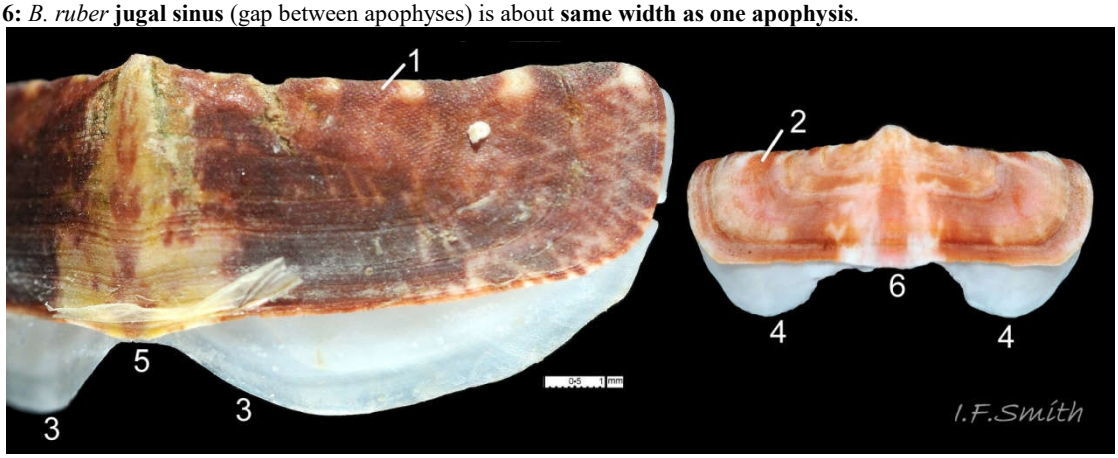
Open narrow **mantle-cavity** runs around whole animal; contains about twelve small **gills** (range 10 – 15) on each side in the posterior half only ;merobranch arrangement (fig. 12). Number of gills increases with age. Between mantle-cavity and girdle the **mantle-fold** is unobtrusive (fig. 10) except where it widens near the posterior into a **mantle-lappet** (fig. 15) and may partly conceal gills. **Anus** opens into mantle-cavity at posterior by channel formed by deflection of girdle (fig. 15). Nephridiopores and gonopores open laterally into posterior quarter of cavity. No **penis** as external fertilization. **Foot**, elongate ellipse, has cream or yellowish-white sole with dark viscera sometimes visible medially (fig. 11), but no medial dividing line. Foot has pink (fig. 10) or brownish-pink border (fig. 11) around sole. Foot spreads widely, concealing pallial cavity when gripping substrate (fig. 15).

Key identification features

Boreochiton ruber.

1. At LWS and sublittorally. Usual maximum length 15mm, occasional ones to 21mm can be mistaken for *Tonicella marmorea* (fig. 19).
2. Dorsal surface of valves smooth apart from growth lines. Faint stippling may be visible at X 30 magnification (fig. 17); more distinct in N. Pacific, may be a distinct species.
3. Apophyses on intermediate valves are prominent and rounded, often **almost semicircular. Wide jugal sinus** (gap between them) is about **same width** as one apophysis (fig. 17).
4. Dorsal surface of girdle has densely-packed, elongate (50 - 60µm), club-shaped granules with packed touching heads giving a mealy appearance (figs. 14 & 19).
5. Girdle usually has alternating dark and pale transverse bands. Pale bands, sometimes fragmentary, usually thinner than dark bands, and aligned with shell-sutures (figs. 2 & 19).
6. Dorsal surface of valves ii – vii makes an arch with smoothly-curved or flattish sides when viewed in profile from posterior (fig. 5). Arch distinctly lower than that of *Lepidochitona cinerea*, but similar to that on *T. marmorea*.
7. About 12 gills each side (range 10-15), arrangement merobranch (fig. 12).
8. All around Britain and Ireland except Liverpool Bay and Flamborough to Kent.

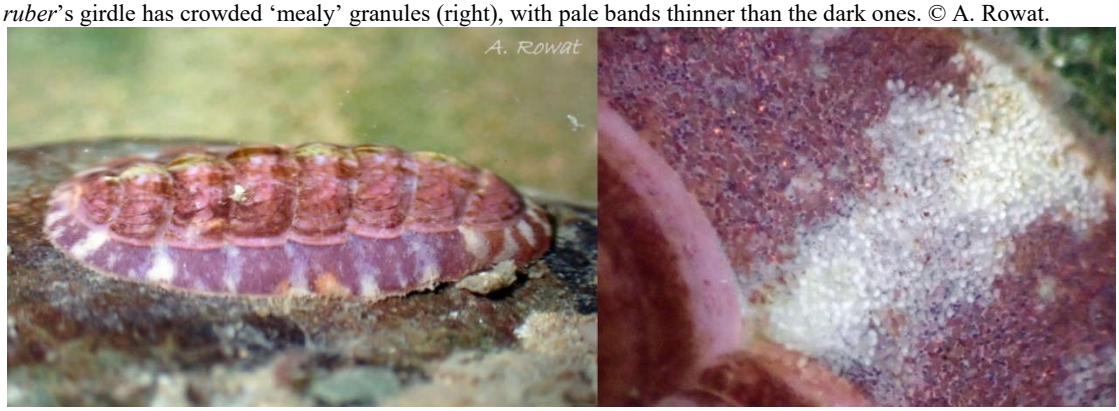
figure 17 https://flic.kr/p/qLJk3i Comparison of valve iv, *T. marmorea* (left), *B. ruber* (right), at same scale. Leg. D. M. McKay & S. Taylor, and P. Lightfoot. Apart from growth lines, both appear to have smooth valves, but both have caps/granules that become visible at about 3X (*T. marmorea*) and X30 (*B.ruber*).
1: *T. marmorea* caps/granules visible if viewed on 50 cm monitor.
2: *B. ruber* caps/granules almost or entirely invisible if viewed on 50 cm monitor.
3: *T. marmorea* apophyses are, relative to valve size, short (anterior-posterior), wide and gently curved.
4: *B. ruber* apophyses are prominent and rounded, often almost semicircular.
5: *T. marmorea* **jugal sinus** (gap between apophyses) is about **quarter width of one apophysis**.
6: *B. ruber* **jugal sinus** (gap between apophyses) is about **same width as one apophysis**.



The shapes of apophyses vary depending on position. For example, apophyses on valves vii and viii on *B. ruber* are much less prominent and rounded than above. For consistency, it is suggested that comparisons of chiton spp. are made with undamaged valves iv or v, the central largest ones. On a freshly dead specimen, the retaining muscles are very tough so it is impossible to cut out the brittle apophyses without damage. If the chiton is left standing girdle-deep overnight in 10% NaOH solution, it should be possible to disarticulate the valves intact. (CAUTION: solution burns human flesh and can cause blindness.) The valves may sometimes be pulled out with forceps from preserved specimens after storage.

figure 18 https://flic.kr/p/r1TEKj Length 14.5mm. North Yorkshire, England. Leg. P. Lightfoot. If displaced from the substrate, *B. ruber* can roll into a defensive ball.

figure 19 https://flic.kr/p/2iUvW7K Large *B. ruber* (length 20mm) often resemble *Tonicella marmorea*, but *B. ruber*'s girdle has crowded 'mealy' granules (right), with pale bands thinner than the dark ones. © A. Rowat.



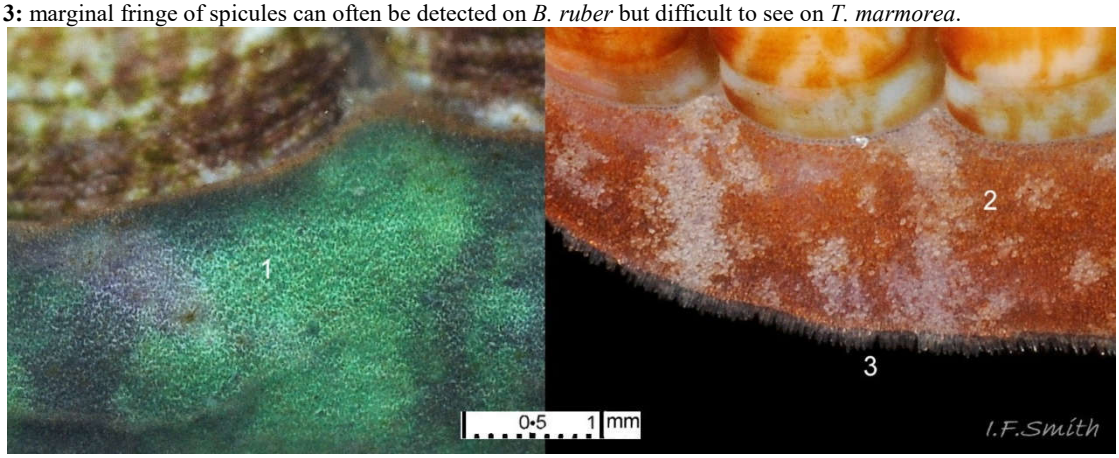
Similar species

For distinguishing from small (length < 21mm) *T. marmorea*, underwater photographs of *B. ruber* may not be sufficient; counting of gills, careful disarticulation of specimen and/or examination under magnification may be required.

Tonicella marmorea (O. Fabricius, 1780).

1. At LWS and sublittorally. Maximum length 45mm (in Europe).
2. Dorsal surface of valves has growth lines and, at c. X3 magnification, numerous distinct small granules (fig. 17). (Granules usually indiscernible in underwater images or on specimens before deposits and properiostracum removed.)
3. Apophyses on intermediate valves short (i.e. anterior-posterior), wide and gently curved (fig. 17). [Apophyses in fig.64 in Kaas & Belle (1985), appear to be worn into a stronger curve. Fig.19 in Jones & Baxter (1987) shows undamaged apophyses more accurately.]
4. Dorsal surface of girdle has sparse minute granules (c.27µm long) that do not touch each other (fig. 20). (Girdle usually looks smooth in photographs.)
5. Girdle variably coloured; deep purple-red to green and usually with yellow/orange bands about as wide as dark bands; some may resemble *B. ruber* but pale bands on it are narrower and sometimes fragmentary.
6. Dorsal surface of valves ii – vii flat or weakly convex upper slope, separated by hip from slightly concave lower slope (fig. 5) but both species vary. Low arch, similar height/width ratio to *B. ruber*.
7. 17 – 26 gills each side, arrangement merobranch.
8. Not found in Britain further south than North Wales or Northumberland. (Many doubtful records on mapping schemes as easily confused with *B. ruber*.)

figure 20 https://flic.kr/p/2iPCi3Q *T. marmorea* (left), *B. ruber* (right), same scale. Leg. Mc & T and P. Lightfoot.
1: dorsal surface of girdle on *T. marmorea* has widely spaced, minute granules, often imperceptible in images.
2: girdle on *B. ruber* has club-shaped spicules with densely-packed, touching heads giving a mealy appearance.
3: marginal fringe of spicules can often be detected on *B. ruber* but difficult to see on *T. marmorea*.



Lepidochitona cinerea (Linnaeus, 1767).
1. Only chiton species likely to be found higher than MLW on British shores. Has diverse colour forms (fig. 21), some similar to *B. ruber* (fig. 22). Usual maximum length 16mm, occasionally 28mm.
2. Dorsal surface of valves has numerous rounded, sometim**es** slightly elongated, granules visible at X5 magnification (fig. 23).
3. White apophyses on intermediate valves are gently curved. Wide jugal sinus (gap between apophyses) on intermediate valves is about same width as one apophysis (fig 17)
Dorsal surface of girdle has densely packed rounded granules (fig. 23)**.**
4. Girdle usually has alternating dark and light transverse lozenge-like bands of approximately equal size. Usually, dark bands have narrow waist, and light bands have a wide waist (fig. 24), sometimes colours interchanged. A thin paler longitudinal line often runs across the waist of bands. Usually a dark central spot on pale bands, and a white spot somewhere on dark band. Markings can be partial, indistinct, or absent on pale specimens.
5. Valves moderately highly arched; valve v height about 32% of width; distinctly higher than that of *Boreochiton ruber* (fig. 5).
6. Usually 16 – 19 gills each side, arrangement holobranch.

figure 21(left) https://flic.kr/p/2iXn6YV *L. cinerea* has diverse colour forms.

figure 22 (right) https://flic.kr/p/2iXpSkj Pink and red forms of *L. cinerea* are often misidentified as *B. ruber.* The diagnostic girdle pattern of *L. cinerea* easily differentiates them. © P. Lightfoot.

figure 23 (left) https://flic.kr/p/2iXpSik *L. cinerea* has 1: distinct, crowded, depressed granules on valve viii. Larger granules on other valves. 2: distinct, crowded, round granules on girdle. 3: girdle fringe of spines.

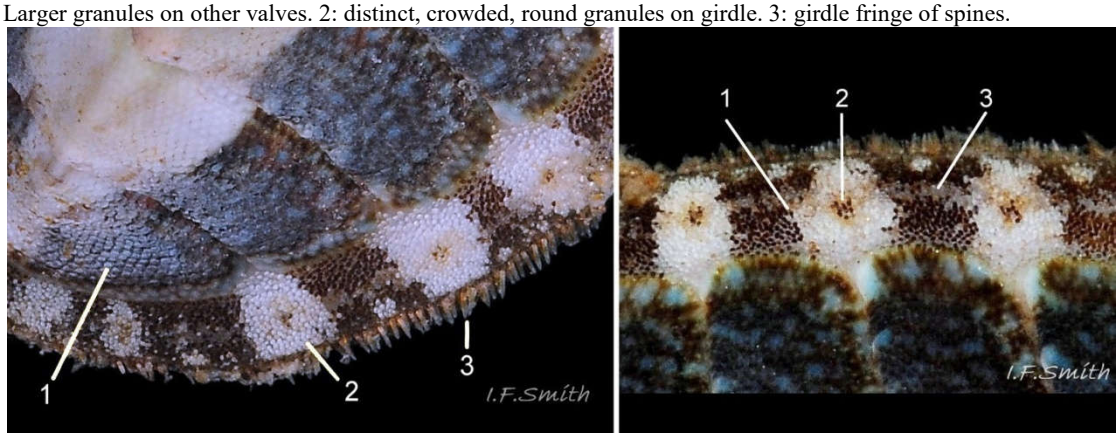


figure 24 (right) https://flic.kr/p/2iXpSho Girdle pattern of *L. cinerea*. 1: waist narrow on dark band; wide on pale band. 2: central dark spot on pale band, and white spot on dark band near margin. 3: pale line often across bands.

Habits and ecology

Lives on rock and under stones and old shells, including those resting on sand, at LWS and sublittorally to about 300 metres; commonest 10 – 40m. Shell articulates to conform closely to uneven rock surface; large foot and flat girdle grip surface firmly. When alarmed, can increase grip suctorially by raising part of girdle to form partial vacuum, and if displaced from substrate, can roll into a ball (fig. 18).

Respiration: cilia on gills and mantle create inhalent water-current entering pallial cavity wherever girdle is raised at anterior. Adjacent gills have interlocking cilia so all work as a unit (as in many bivalves). Water current passes through gills and then along cavity as exhalent current to posterior to exit through channel formed by deflection of girdle (fig. 15).
Circulation: blood travels from head sinus through longitudinal sinuses to the foot, viscera and mantle, then through the gills (fig. 12) for aeration before passing into the adjacent heart in the dark-red dorso-ventrally flattened pericardium below valves vii & viii; occasionally exposed on live specimens (fig. 15). From the heart the blood is pumped through the medial dorsal aorta to the head sinus, giving off some channels to the gonad and valve muscles on the way. In the absence of eyes and of tactile or chemoreceptor tentacles on head, it **senses** the environment through aesthetes exposed on surface of shell. Proposed aesthete functions include photoreception, chemoreception, mechanoreception, replenishment of properiostracum materials, and secretion of protective substances. There are also sensory organs on the girdle.
Feeds by scraping microalgae and associated organisms from hard surfaces using its hard radula of chitin mineralized with magnetite (fig. 16). Though 'primitive' in apperance, it has an elaborate digestive system with no trace of a primitive rotating style in the stomach. A long, coiled intestine compresses faeces into oval pellets. Water current in pallial cavity carries excreta from lateral nephridiopores to posterior, where faecal pellets from anus join the flow; all expelled at posterior through channel in deflected girdle (fig. 15).
Travels by monotaxic, retrograde, compression waves on sole of foot.
Breeding: dioecious. Water current in pallial cavity carries sperm or ova from lateral gonopores to posterior and out through channel in raised girdle (fig. 15). 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

Widespread but rarely abundant. Greenland, Iceland, N. Norway and White Sea to Brittany and New England (USA); most numerous in northern part of range. Not Baltic or southern North Sea. Also reported from N. Pacific, but some there have distinctly granulated valve surfaces in contrast to smooth (or finely pustulate at X30) surfaces on *B. ruber* in Atlantic, so some doubt about identity . GBIF map http://www.gbif.org/species/2306812 Galician records on GBIF uncertain as not in Trigo et al. (2018). All around Britain and Ireland except north-east Irish Sea and North Sea from Flamborough to Kent, NBN interactive distribution map at https://data.nbn.org.uk/imt/?mode=SPECIES&species=NBNSYS0000178410#4-14.597,52.754,10.715,59.837!092kEf

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Glossary

µm = 0.001 mm

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. Functions may include photoreception, chemoreception, mechanoreception, properiostracum replenishment and/or secretion of protective substances.

a.k.a. = also known as.

antemedian = (syn. antemedial) situated to anterior of middle.

antemucronal area = area situated to anterior of mucro.

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

aragonite = orthorhombic crystalline mineral-form of calcium carbonate

http://www.minerals.net/mineral/aragonite.aspx . Most frequent mineral-form in oceans and living mollusc shells.
articulamentum = inner shell-layer of chiton valves, usually hard, white, porcelaneous aragonite and often differently coloured in central part. (Partially underlain by inconspicuous myostracum layer.)
buccal mass = anterior of digestive system including an odontophore that supports anterior of radula, and a complex of muscles to operate them and other mouthparts. Usually red or pink.
chemoreception = sensing of chemicals; "smell / taste".
chitin = semitransparent, flexible, horny protein.
chitinous = (adj.) made of chitin.
cilia (pl.) = motile linear extensions of membrane used in locomotion, or to create water currents in feeding. ("cilium" singular).
coll. = in the collection of (named person or institution) (cf. legit).
dioecious = having separate male and female individuals, not hermaphrodite.
dorso-ventrally flattened = as if pressed flat from above.
epithelium = tissue forming outer layer of body surface, "skin".
girdle = peripheral band of thickened, reflexed mantle that encloses ends of valves.
gonopore = genital opening through which eggs or sperm are released.
holobranch = (of chitons) gills in mantle-cavity extend full length of foot.
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 = any valve (ii – vii), except head valve (i) and tail valve (viii).
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.
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.
leg. Mc&T = Leg. David M. McKay and Simon Taylor.
legit = (abbreviation; leg.) collected/ found by (cf. coll.)
LWS = low water spring tide, two periods of a few days each month when tide falls lowest.
magnetite = mineral of iron oxide, one of hardest materials made by any living organism.
major lateral teeth = largest two teeth in each row of seventeen on chiton radulae; principal scraping blades. Often darkened more than other teeth by high magnetite content.
mantle = sheet of tissue that secretes the shell, surrounds the viscera and forms a cavity for the gill in most marine molluscs.
mantle-cavity = (a.k.a. pallial groove) narrow groove around whole foot and head, roofed by mantle. Contains gills, nephridiopores and gonopores.
mechanoreception = sensing of touch, sound, pressure change and/or posture.
merobranch = gills in pallial groove only in posterior two-thirds of animal.
micraesthete = (see aesthete).
MLW = mean low water mark.
monotaxic = (of locomotion waves on foot) single series of waves; each wave extends across complete width of foot.
mucro = projection on tail valve (viii) of chiton demarking posterior from rest of valve. Varies in prominence and position.
myostracum = thin, inconspicuous, discontinuous, innermost layer of chiton shell.
nephridiopore = opening of nephridium for excretion. a.k.a. nephropore, or renal pore.
nephridium = tubular glandular excretory/ osmoregulatory organ. a.k.a. kidney.

odontophore = firm, approximately ellipsoid, structure of cartilage supporting radula. Protruded like a tongue to operate radula.
osmoregulation = regulation of osmotic pressure to keep organism's fluids from becoming too diluted or concentrated.
pericardium = membranous sac containing heart and start of aorta.
perinotum = dorsal surface of chiton's girdle.
phototactic = (adj.) of species that moves towards light (positively phototactic) or away from it (negatively phototactic).
plankton = animals and plants that drift in pelagic zone (main body of water).
pleural area = (on intermediate valve of chiton) 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.
postmucronal = situated to posterior of mucro on tail valve.
properiostracum = (on chitons) proteinaceous material covering the shell. Different composition from periostracum of most other molluscs.
radula = ribbon of chitin bearing chitinous teeth that is extruded on a tongue-like odontophore of cartilage to rasp food. On chitons, teeth are usually impregnated with magnetite, a hard magnetic mineral of iron.
rec. = recorded by (person who submitted record, may be different from leg. and coll. persons/institution).
retrograde = (of locomotion waves on foot) waves travel from anterior to posterior.
side slope = shape in profile view (from posterior or anterior) of lateral areas of intermediate valves; may be straight, convex, concave or a combination of these.
sinus = dilated channel or receptacle containing blood etc. or gap between apophyses.
slit ray = row of canal pores running diagonally from lateral slit to posterior edge on ventral surface of chiton valve. a.k.a. notch ray.
suture = line where two valves meet.
tegmentum = outer shell-layer of chiton valves, usually porous and relatively soft. (Covered by properiostracum when live.)
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, *Tricolia pullus* and (with no veligers) chitons.
veliger = shelled larva of marine gastropod or bivalve mollusc which swims by beating cilia of a velum (bilobed flap).