MarLIN
Marine Information Network
Information on the species and habitats around the coasts and sea of the British Isles

Slipper limpet (*Crepidula fornicata*)

MarLIN – Marine Life Information Network
Biology and Sensitivity Key Information Review

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2008-04-17

A report from:
The Marine Life Information Network, Marine Biological Association of the United Kingdom.

Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/species/detail/1554]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

This review can be cited as:
Rayment, W.J. 2008. *Crepidula fornicata* Slipper limpet. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. DOI https://dx.doi.org/10.17031/marlinsp.1554.1

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***Crepidula fornicata* at Oreston Spit.**
Photographer: Keith Hiscock
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See online review for distribution map

Distribution data supplied by the Ocean Biogeographic Information System (OBIS). To interrogate UK data visit the NBN Atlas.

Researched by	Will Rayment	**Refereed by**	Dr Frédérique Viard
Authority	(Linnaeus, 1758)		
Other common names	-	**Synonyms**	-

Summary

Description

The shell is oval, up to 5 cm in length, with a much reduced spire. The large aperture has a shelf, or septum, extending half its length. The shell is smooth with irregular growth lines and white, cream, yellow or pinkish in colour with streaks or blotches of red or brown. Slipper limpets are commonly found in curved chains of up to 12 animals. Large shells are found at the bottom of the chain, with the shells becoming progressively smaller towards the top.

Recorded distribution in Britain and Ireland

In Britain, it is present on the east coast south of Spurn Head, the length of the south coast and northwards along the west coast to Cardigan Bay. It has been introduced accidentally to several locations in Ireland but a population has never persisted.

Global distribution

Originally found on the east coast of the Americas between Canada and Mexico. Now also introduced to British-Columbia, Washington state, Japan and Europe, where it is found on the

Atlantic coast between Denmark and Spain, in Sicily and the Adriatic Sea.

Habitat

Crepidula fornicata is typically found attached to shells and stones on soft substrata around the low water mark and the shallow sublittoral. It is often attached to the shells of mussels *Mytilus edulis* and oysters *Ostrea edulis*.

Depth range

Low water mark to 60m

Identifying features

- Spire set posteriorly.
- Shell slightly curled dextrally.
- Shell smooth with irregular growth lines.
- Aperture elongate and oval.
- Septum extends from beneath spire for approximately half length of shell.

Additional information

Crepidula fornicata is a non-native species. The modern British population is known to have been introduced to Essex between 1887 and 1890 in association with oysters, *Crassostrea virginica*, imported from North America (Fretter & Graham, 1981; Eno *et al.*, 1997).

Listed by

Further information sources

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Biology review

Taxonomy

Phylum	Mollusca	Snails, slugs, mussels, cockles, clams & squid
Class	Gastropoda	Snails, slugs & sea butterflies
Order	Littorinimorpha	
Family	Calyptraeidae	
Genus	Crepidula	
Authority	(Linnaeus, 1758)	
Recent Synonyms	-	

Biology

Typical abundance	High density
Male size range	up to 50mm
Male size at maturity	
Female size range	Small-medium(3-10cm)
Female size at maturity	
Growth form	Turbinate
Growth rate	0.04-1.11mm/day
Body flexibility	None (less than 10 degrees)
Mobility	
Characteristic feeding method	Active suspension feeder
Diet/food source	
Typically feeds on	Phytoplankton and particulate organic food
Sociability	
Environmental position	Epibenthic
Dependency	Independent.
Supports	None
Is the species harmful?	No Edible

Biology information

Abundance

In the Bay of Marennes-Oleron, France, *Crepidula fornicata* was found in a wide range of sediment grain sizes and depths. Maximum abundance and biomass reached 4770 individuals per m and 354 g of dry weight per m respectively in shallow muddy areas (De Montaudouin & Sauriau, 1999). *Crepidula fornicata* also occurs at "moderate" density, for example in the Arcachon Basin (De Montaudouin *et al.*, 2001).

Size at maturity

Due to the protandrous hermaphroditic life-cycle of *Crepidula fornicata*, size at maturity is difficult to ascertain. Warne(1956), cited in Fretter & Graham (1981), reported size at maturity to be 4 mm but it is unclear whether this referred to both sexes or males only. Under laboratory conditions, Nelson *et al.* (1983) reported that the mean female length at first larval release was 23.8 mm.

Growth rate
Reported growth rates vary according to age. Pechenik *et al.* (1996) recorded juvenile growth rate for the 9 days after metamorphosis as varying between 15-225µm per day (mean 110.5µm per day). Thouzeau(1991) recorded mean juvenile growth rates over 1 month following settlement as 38-48µm per day with a maximum of 90µm per day.

Mobility
Immediately after settlement, juvenile *Crepidula fornicata* are capable of slow crawling and locate a suitable site for attachment and growth. This is either a stone or a chain of other *Crepidula fornicata* (conspecifics). The shell then grows to fit the substratum and consequently most animals are incapable of further movement at the age of about 2 years (Fretter & Graham, 1981).

Nutrition
Following laboratory experiments, Thain (1984) deduced that, for optimum growth and reproduction, an individual *Crepidula fornicata* being fed with the alga *Phaeodactylum tricornutum* requires 5 x 10^8 algal cells per gram of flesh wet weight per day.

Habitat preferences

Physiographic preferences	Open coast, Strait / sound, Estuary, Enclosed coast / Embayment
Biological zone preferences	Lower circalittoral, Lower infralittoral, Sublittoral fringe, Upper circalittoral, Upper infralittoral
Substratum / habitat preferences	Coarse clean sand, Cobbles, Fine clean sand, Gravel / shingle, Mixed, Mud, Muddy gravel, Muddy sand, Other species, Pebbles, Sandy mud, Small boulders
Tidal strength preferences	Moderately Strong 1 to 3 knots (0.5-1.5 m/sec.), Very Weak (negligible), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered, Sheltered, Very sheltered
Salinity preferences	Variable (18-40 psu)
Depth range	Low water mark to 60m
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

Although *Crepidula fornicata* is a cosmopolitan species, which can tolerate a wide range of environmental conditions, populations are particularly well developed in wave protected areas such as bays, estuaries or sheltered sides of wave exposed islands (Blanchard, 1997). Similarly, the species is found on a variety of substrata but is most abundant in muddy or mixed muddy areas (De Montaudouin & Sauriau, 1999).

Life history

Adult characteristics

Reproductive type	Protandrous hermaphrodite
Reproductive frequency	Annual protracted
Fecundity (number of eggs)	10,000-100,000
Generation time	See additional information
Age at maturity	see additional information
Season	February - October
Life span	5-10 years

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	Planktotrophic
Duration of larval stage	1-2 months
Larval dispersal potential	Greater than 10 km
Larval settlement period	Insufficient information

Life history information

General

Crepidula fornicata is a protandrous hermaphrodite. This means that the animals start their lives as males and then subsequently may change sex and develop into females. Although breeding can occur between February and October, peak activity occurs in May and June when 80-90% of females spawn. Most females spawn twice in a year, apparently after neap tides. The spat settle in isolation or on top of an established chain. If the individual settles alone, it becomes male briefly, passing rapidly on to a female, especially if another animal settles on it to initiate chain formation. Sex change can only occur to the bottom-most male in a stack and takes approximately 60 days, during which the penis regresses and the pouches and glands of the female duct develop. If a juvenile settles on an established stack it develops and may remain as a male for an extended period (up to 6 years), apparently maintained by pheromones released by females lower in the stack (Fretter & Graham, 1981).

Age at maturity

Due to the protandrous hermaphroditic lifecycle of *Crepidula fornicata*, age at maturity is difficult to ascertain. Warne(1956), cited in Fretter & Graham (1981), reported size at maturity to be 4mm but it is unclear whether this refers to both sexes or males only. A size of 4mm would be achieved approximately 2 months after settlement. Under laboratory conditions, Nelson *et al.*(1983) report that the mean time from being spawned to first larval release for females was 300 days, *i.e.*. maturity is reached approximately 10 months after settlement.

Generation time

Generation time is complicated by the hermaphroditic life-cycle of *Crepidula fornicata*. Incubation of the eggs takes 2-4 weeks and the duration of the larval phase is 4-5 weeks (Fretter & Graham, 1981; Thouzeau, 1991). Using the ages at maturity quoted above, it would appear that males are capable of breeding as little as 4 months after fertilization. Under laboratory conditions, Nelson *et al.* (1983) reported the female generation time to be 300 days. However, *in situ* females were not reported to spawn until their third year (Deslou-Paoli & Heral, 1986).

Fecundity

Females can lay around 11000 eggs at a time contained in up to 50 egg capsules (Deslou-Paoli & Heral, 1986). Laboratory experiments by Thain (1984) revealed that following incubation, approximately 4000 larvae were released per female.

Sensitivity review

This MarLIN sensitivity assessment has been superseded by the MarESA approach to sensitivity assessment. MarLIN assessments used an approach that has now been modified to reflect the most recent conservation imperatives and terminology and are due to be updated by 2016/17.

Physical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Substratum Loss	High	High	Moderate	High

Stacks of adult *Crepidula fornicata* live attached to the substratum and are incapable of moving. Removal of the substratum would remove the resident population and intolerance is therefore recorded as high. Ismail (1985) demonstrated that following suction dredging of the top few centimetres of sediment on oyster grounds in Delaware Bay the *Crepidula fornicata* population was removed. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

	Intolerance	Recoverability	Sensitivity	Confidence
Smothering	Low	Very high	Very Low	Low

Stacks of adult *Crepidula fornicata* live attached to the substratum and are incapable of moving. They are active suspension feeders, generating a water current through the mantle cavity by ciliary action and trapping food particles on a mucous sheet lying across the front surface of the gill filament. Smothering with a 5cm layer of sediment would be expected to clog the feeding and respiration structures. However, it has been demonstrated that *Crepidula fornicata* is capable of clearing its feeding structures at some energetic cost (Johnson, 1972). Furthermore, areas with large *Crepidula fornicata* populations do tend to become silted up through deposition of pseudofaeces, apparently with little effect on the species (Thouzeau *et al.*, 2000) and the fact that *Crepidula fornicata* lives in chains of up to 12 individuals means that at least some of the chain would avoid the effects of smothering. Therefore, although there may be some energetic cost as a result of smothering, probably resulting in decreased growth and reproductive output, there is unlikely to be mortality and an intolerance result of low is recorded. Following the smothering event, growth and reproduction should quickly return to normal and hence a recoverability of very high is recorded.

	Intolerance	Recoverability	Sensitivity	Confidence
Increase in suspended sediment	Low	Very high	Very Low	Moderate

Crepidula fornicata is an active suspension feeder, trapping food particles on a mucous sheet lying across the front surface of the gill filament. An increase in suspended sediment is therefore likely to interfere with the feeding and respiration structures. Johnson (1972) transplanted individual *Crepidula fornicata* to environments of varying turbidity and measured their shell growth rates. Growth rate was found to decrease as turbidity increased. These observations were verified in laboratory conditions by measuring water filtration rate at different turbidities. Filtration rate was found to decrease as turbidity increased with the greatest reduction in filtration occurring between 140-200 mg l^{-1}. Decreased filtration rate was associated with increased production of pseudofaeces in order to keep the filtering mechanism clear of debris. Increased pseudofaecal production coupled with decreased food intake would lead to increased energy consumption which is likely to impair the survival of the species. Hence, intolerance is recorded as low. When suspended sediment returns to normal levels, feeding and respiration will return to normal and the only likely lag will be in reproductive output, *i.e.* it will take a period of time to replenish food reserves, during which reproductive output will not be at maximum levels. A recoverability of very high is therefore recorded.

Decrease in suspended sediment Low Very high Very Low Moderate

Crepidula fornicata is an active suspension feeder, feeding on phytoplankton and particulate organic food. A decrease in suspended sediment would decrease food availability and therefore may impair growth rates. However, over a one month period (the benchmark) it is unlikely that survival would be affected. Hence, intolerance is recorded as low. When turbidity returns to normal levels, growth rate should soon return to normal and hence recoverability is recorded as very high.

Dessication Low Very high Very Low Very low

The majority of the population of *Crepidula fornicata* inhabit the subtidal zone and therefore desiccation is not relevant. However, some individuals are found at the level of low water spring tides and are therefore likely to be intolerant of desiccation. *Crepidula fornicata* has the ability to attach firmly to its substratum and is thus completely enclosed within its shell. The benchmark for desiccation is exposure to the air for one hour. It is likely that *Crepidula fornicata* would be able to survive this exposure with only some loss of water. During the period of exposure it would not be able to feed and respiration would be compromised and so there is likely to be some energetic cost. Intolerance is therefore recorded as low. However, it should be noted that *Crepidula fornicata* does not colonize the intertidal zone and therefore must be prevented from doing so by some factor or combination of factors. This may be desiccation, but it seems more likely to be temperature stress and/or wave exposure. On immersion, metabolic activity should soon return to normal so recoverability is recorded as very high.

Increase in emergence regime Intermediate High Low Low

Crepidula fornicata is found at the level of low water spring tides and so an increase in emergence will expose some individuals to desiccation stress. The benchmark is an additional one hour of emergence every tidal cycle. During this time, exposed individuals will not be able to feed and respiration will be compromised. Over the period of a year, the resultant energetic cost may cause the mortality of individuals exposed for the longest time. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Decrease in emergence regime Tolerant Not relevant Not sensitive High

Crepidula fornicata thrives in the subtidal and so individuals on the lower shore which are only exposed rarely anyway would not be affected by a decrease in emergence. It is possible that a decreased emergence regime would result in *Crepidula fornicata* colonizing further up the shore.

Increase in water flow rate Intermediate High Low Low

Crepidula fornicata is a cosmopolitan species but is found in greatest numbers in wave protected areas (Blanchard, 1997) where water flow is typically moderately strong or weaker (see glossary). An increase in water flow rate of 2 categories for one year would place some individuals in areas of strong or very strong flow. These areas are outside the species' habitat preferences and some mortality is likely, probably due to interference with feeding and/or respiration, although this is not well understood. Intermediate intolerance is therefore recorded. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Decrease in water flow rate Tolerant Not relevant Not sensitive High

Crepidula fornicata thrives in areas of low water flow (Blanchard, 1997) including the lowest category on the water flow scale ("very weak"). It is an active suspension feeder and is able to maintain a feeding and respiration current independently of ambient water flow. Thus, it would probably tolerate decreases in water flow regime. However, it should be noted that decreased water flow rate could result in deoxygenation and increased settlement of suspended sediment. These factors are covered in their relevant sections.

Increase in temperature Low Very high Very Low High

Crepidula fornicata is distributed over a wide temperature range. On the east coast of the Americas it is found as far south as Mexico and therefore it must be able to tolerate higher temperatures than it experiences in northern Europe. The effect of temperature on larval development was investigated by Lucas & Costlow (1979). Larvae were found to tolerate daily temperature cycles of 5°C between 15°C and 30°C with little mortality. Over a 12 day period there was 0% mortality at 30°C but 100% mortality occurred by day 6 at 35°C. Thus, it seems that adults are able to tolerate chronic change over time and larvae are able to tolerate acute change in the short term. Intolerance is therefore recorded as low. The ability of larvae to tolerate acute change also contributes to the species' very high recoverability.

Decrease in temperature Intermediate High Low High

During the severe winter of 1962-63 the British population of *Crepidula fornicata* was subjected to an acute decrease in temperatures. Waugh (1964) recorded 25% mortality of *Crepidula fornicata* from the south coast and east coast of England where the recorded temperatures were 5-6°C and 3-4°C respectively below normal for a period of 2 months. These temperature changes are in line with the benchmarks and hence the intolerance is recorded as intermediate. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Increase in turbidity Low Very high Very Low Low

Crepidula fornicata does not require light and therefore is not directly affected by an increase in turbidity for the purposes of light attenuation. The consequent effects that increasing the suspended sediment may have on clogging feeding and respiration structures is covered in 'suspended sediments'. An increase in turbidity may affect primary production in the water column and therefore reduce the availability of phytoplankton food. However, phytoplankton will also immigrate from distant areas and so the effect may be decreased. As the turbidity increase only persists for a year, decreased food availability would probably only affect growth and fecundity and an intolerance of low is recorded. As soon as light levels return to normal, primary production will increase and hence recoverability is recorded as very high.

Decrease in turbidity Tolerant Not relevant Not sensitive High

Crepidula fornicata does not require light and therefore is not directly affected by a decrease in turbidity for the purposes of light attenuation. The consequent effects that decreasing the suspended sediment may have on feeding is covered in 'suspended sediments'.

Increase in wave exposure High High Moderate Low

Crepidula fornicata is found in greatest numbers in wave protected areas such as bays, estuaries or sheltered sides of wave exposed islands (Blanchard, 1997). This suggests that it is intolerant in some way to wave exposure. The species' body form is robust and it attaches firmly to the substratum but in many cases the substratum is liable to be moved by strong wave action. Indeed, *Crepidula fornicata* is often found cast ashore following storms (Hayward & Ryland, 1997; F. Viard, pers. comm.). It is also likely that strong wave action will interfere with feeding and/or respiration, although this is poorly understood. A change of 2 categories on the wave exposure scale would place some of the population in the wave exposed category and it is expected that after a year, high mortality would result due to the considerations discussed above, hence an intolerance of high is recorded. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Decrease in wave exposure Tolerant Not relevant Not sensitive High

Crepidula fornicata is found in greatest numbers in wave protected areas such as bays, estuaries or sheltered sides of wave exposed islands (Blanchard, 1997). It is an active suspension feeder and is able to maintain a feeding and respiration current independently of ambient water flow. Thus, it would be likely to tolerate decreases in wave exposure.

Noise Tolerant Not relevant Not sensitive High

There is no evidence to suggest that *Crepidula fornicata* is sensitive to noise or vibrations caused by noise.

Visual Presence Tolerant Not relevant Not sensitive High

There is no evidence to suggest that *Crepidula fornicata* is sensitive to visual disturbance.

Abrasion & physical disturbance Intermediate High Low Very low

Crepidula fornicata has a robust body form and so individuals are likely to be resistant to the benchmark level of physical abrasion. However, the gregarious chain-forming characteristic of the species renders it susceptible to disturbance as chains are more likely to be broken up, leaving some individuals exposed to predation. Some mortality is expected and hence intolerance is recorded as intermediate. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.
De Montaudouin *et al.* (2001) (following Sauriau *et al.*, 1998) suggested that physical disturbance is a factor which could stimulate the presence of *Crepidula fornicata*. They noted that the species settles preferentially in the trails of trawl fishing gear, and that this may explain why *Crepidula fornicata* is not very abundant in the Arcachon Basin, France, as bottom trawling activities are prohibited here.

Displacement Intermediate High Low Moderate

Crepidula fornicata live in chains of up to 12 individuals, with the bottom individual being attached permanently to the substrate. Attachment is permanent as the shell takes on the shape of the substrate (Hoagland, 1979). Displacement would almost certainly lead to the mortality of the bottom individual in the chain as it would become very vulnerable to predation. However, other individuals in the chain would be unaffected by the displacement. Johnson (1972) demonstrated that transplanted individuals continue to grow normally. The low level of mortality suggests that intolerance to displacement is intermediate. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination	High	High	Moderate	Low

No evidence was found on the effects of synthetic compounds specifically on *Crepidula fornicata*. However, there is a wealth of evidence concerning effects on related molluscs. The effect of tri-butyl tin (TBT) from anti-fouling paints on gastropods is very well documented. Imposex, female mortality and the subsequent decline in population, has been described in *Nucella lapillus* (e.g. Bryan *et al.*, 1986), *Littorina littorea* (Bauer *et al.*, 1995), *Ilyanassa obsoleta* and *Urosalpinx cinerea* (Matthiessen & Gibbs, 1998). Limpets (Patellidae) are extremely intolerant of aromatic solvent based dispersants used in oil spill clean-up. During the clean-up response to the *Torrey Canyon* oil spill nearly all the limpets were killed in areas close to dispersant spraying. Viscous oil will not be readily drawn in under the edge of the shell by ciliary currents in the mantle cavity, whereas detergent, alone or diluted in sea water, would creep in much more readily and be liable to kill the limpet (Smith, 1968). For example, a concentration of 5ppm of dispersant killed half the limpets tested in 24 hours (Southward & Southward, 1978; Hawkins & Southward, 1992). Thus, although no evidence has been found specifically relating to *Crepidula fornicata*, the intolerance of species in the same class to synthetic chemicals suggests an intolerance of high with moderate confidence. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Heavy metal contamination Intermediate High Low Moderate

Bryan (1984) suggested that gastropods are rather tolerant of heavy metals. In the Fal Estuary, *Crepidula fornicata* does occur in the Carrick Roads, an area where creek water polluted with heavy metals mixes with the open ocean (Bryan & Gibbs, 1983). In this area, concentrations of silver, cadmium, copper, lead and zinc were found to be higher than in 'control' estuaries (Bryan & Gibbs, 1983). This suggests that *Crepidula fornicata* is at least partially tolerant to heavy metal contamination. Laboratory trials have revealed specific responses to heavy metals. Thain (1984) investigated the effects of exposure to mercury. The adult and larval 96 hour LC_{50}s (concentrations at which half the organisms die after 96 hours) were 330 and 60 µg l^{-1} respectively. As a reference, levels of mercury in UK waters at the time of these experiments were 10^4 to 10^5 below the 96 hour LC_{50} for adult *Crepidula fornicata*. Furthermore, sub-lethal concentrations of mercury were shown to impair growth and condition of young adult *Crepidula fornicata* and impair reproductive capacity at 0.25µg l^{-1}. Nelson *et al.* (1983) investigated the effects of exposure to silver. Reproductive output was found to be impaired following exposure to the highest concentration of silver nitrate (10µg l^{-1}) for 24 months. The evidence suggests that high concentrations of heavy metals will cause mortality in *Crepidula fornicata* and therefore intolerance is recorded as intermediate. Lower concentrations, which could realistically occur *in situ* impair growth, condition and reproductive output and will therefore affect the long term health of the population. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Hydrocarbon contamination Intermediate High Low Low

No evidence could be found for the effect of hydrocarbons on *Crepidula fornicata* specifically. However, inferences can be drawn from closely related groups. Following the *Torrey Canyon* oil spill in 1967, total mortality of 3 *Patella* species was reported after one month of oil coming ashore at Porthleven reef (Smith, 1968). Other gastropod mortalities included *Nucella lapillus*, *Tritia incrassata* and *Gibbula* sp.. Bayne *et al.* (1982) reported that sublethal concentrations of petroleum hydrocarbons depressed the rate of feeding in gastropods and bivalves and increased the rates of oxygen consumption. Increased energy expenditure coupled with decreased feeding rates results in less energy available for growth and reproduction and has been demonstrated to translate to reduced growth rates in juveniles of the bivalve *Mercenaria mercenaria* (Keck *et al.*, 1978). The lethal effects on gastropods of exposure to high levels of hydrocarbons and the sub-lethal effects of chronic exposure to lower levels suggest that *Crepidula fornicata* is likely to have a high intolerance to hydrocarbons. However, account has to be taken of the fact that the majority of the population is subtidal and hence is unlikely to be affected by hydrocarbon pollutants. Therefore, the recorded intolerance is adjusted to intermediate. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Radionuclide contamination Intermediate High Low High

Greenberber *et al.* (1986) exposed larval *Crepidula fornicata* to doses of x-ray radiation between 500 and 20,000 rads in total. After 20 days, there was a dose dependent decrease in larval shell growth rate and a significant increase in larval mortality following doses above 2000 rads. These levels of radiation are extremely high compared to background levels in the environment. For reference, Polykarpov (1998) (cited in Cole *et al.*, 1999) describes the natural levels of background radiation being equivalent to a dose of 0.005 Gy per year (equivalent to 0.5 rads per year). Hence, high doses of radiation have been shown to significantly increase mortality while lower levels have sub-lethal effects on growth and reproduction. A value of intermediate intolerance is therefore recorded. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Changes in nutrient levels Not relevant Not relevant

Insufficient information found.

Increase in salinity Tolerant Not relevant Not sensitive High

Populations of *Crepidula fornicata* inhabit the open coast where sea water is at full salinity. They are clearly capable of thriving in fully saline conditions and hence probably relatively tolerant of increases in salinity. No information was found concerning the reaction to hypersaline conditions (>40psu).

Decrease in salinity Low Very high Very Low Moderate

Crepidula fornicata is described as euryhaline (Blanchard, 1997) and thrives in variable salinity environments such as estuaries. It would therefore be expected to be tolerant to changes in salinity. However, it is a marine organism and a drop in salinity to levels below 18 psu would be likely to cause water balance stress and therefore impair growth and reproduction. Hence, an intolerance of low is recorded. Recovery is likely to be rapid so a recoverability of very high is recorded.

Changes in oxygenation Intermediate High Low Very low

Crepidula fornicata is an aerobic organism and therefore will be intolerant in some degree to lack of oxygen. No evidence was found for specific effects of reduced oxygenation on *Crepidula fornicata* but inferences can be drawn from the effects on other species. Jorgensen (1980) recorded the effects of low oxygen levels on benthic fauna in a Danish fjord. At dissolved oxygen concentrations of 0.2-1.0 mg/l the gastropod *Hydrobia ulvae* suffered mortality unless able to crawl to areas of higher oxygen concentration and the bivalves, *Cardium edule* and *Mya arenaria*, suffered mortality between 2 and 7 days. As *Crepidula fornicata* is not mobile, it is expected that some mortality would occur within a week at 2 mg/l and an intolerance of intermediate is recorded. Due to its high reproductive potential (see additional information below), recoverability is recorded as high.

Biological Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of microbial pathogens/parasites	Low	Very high	Very Low	Moderate

No evidence was found concerning microbial infections of *Crepidula fornicata*. Pecenik *et al.* (2001) reported that *Crepidula fornicata* is not infected by trematode miracidia, while other gastropod species including *Littorina littorea* and *Illyanassa obsoleta* are highly intolerant. The gastropod ectoparasites *Odostomia bisuturalis* and *Odostomia seminuda* both parasitize *Crepidula fornicata* and the intestinal copepod parasite *Mytilicola orientalis* has been found in specimens of *Crepidula fornicata* from Puget Sound, USA, (Kinne, 1980) but there is no evidence concerning the effects. In view of the species' resistance to trematode infection, intolerance is assessed as low.

Introduction of non-native species	Tolerant	Not relevant	Not sensitive	High

Crepidula fornicata is itself an introduced species and has spread widely in Britain since its introduction at the end of the 19th century (see 'Distribution').

Extraction of this species	Intermediate	Moderate	Moderate	High

Crepidula fornicata is a serious pest on oyster beds (Fretter & Graham, 1981) and therefore extraction of the species has occurred in an attempt to reduce the negative impact on the shellfishery. Cole & Hancock (1956) reported that over 8 tonnes ha^{-1} of slipper limpets were removed from oyster beds by dredging and that it takes up to 10 years to return to pre-clearance levels. Intolerance is therefore recorded as intermediate and recovery as moderate.

Extraction of other species	Tolerant*	Not relevant	Not sensitive*	Low

Crepidula fornicata is often found attached to other commercially extracted shellfish, particularly oysters (Fretter & Graham, 1981). When the oyster catch is sorted, individuals of *Crepidula fornicata* are separated from the catch and thrown overboard. De Montaudouin *et al.* (2001) suggested that this process may favour the proliferation and dispersal of *Crepidula fornicata*, particularly at the expense of commercially extracted shellfish species. *Crepidula fornicata* is therefore assessed as not sensitive with the potential to proliferate.

Additional information

The mode of reproduction of *Crepidula fornicata* gives the species strong powers of recoverability. Adults spawn at least once a year, large numbers of eggs are produced, there is a long planktotrophic larval stage giving the species high dispersal potential and adults reach maturity within a year. The ability of *Crepidula fornicata* to colonize new areas has been demonstrated by its spread through Europe following introduction from North America at the end of the 19th century. In light of the above information, recoverability is recorded as high.

Importance review

Policy/legislation

- no data -

Status

National (GB) importance	-	**Global red list (IUCN) category**	-

Non-native

Native	Non-native		
Origin	Eastern Canada, North and Central Mexico, Northern America E	**Date Arrived**	1872

Importance information

Ecological Impact

High densities of *Crepidula fornicata* may modify the nature and texture of sediments in some bays (e.g. Ehrhold *et al.*, 1998). Where *Crepidula fornicata* stacks are abundant, few other bivalves can live amongst them. This is due to spatial competition, trophic competition and alteration of the substratum (the pseudofaeces of *Crepidula fornicata* smother other bivalves and render the substratum unsuitable for larval settlement) (Fretter & Graham, 1981; Blanchard, 1997). In this way, *Crepidula fornicata* has become a serious pest on oyster beds and has caused many traditional oyster fisheries to be abandoned (e.g. in the Norman Gulf, France) (Blanchard, 1997). However, there is no indisputable evidence that *Crepidula fornicata* competes trophically with other species (F. Viard, pers. comm.). De Montaudouin *et al.* (1999) showed that *Crepidula fornicata* had no major influence on the local density or diversity of smaller coexisting macroinvertebrates and did not affect the growth of 18 month old oysters.

Management

In response to the invasion of shellfisheries by *Crepidula fornicata*, some management has been attempted. Sauriau *et al.* (1998) and Cole & Hancock (1956) reported dredging operations to clear slipper limpets from oyster beds, but concluded that further spread of the species could not be prevented.

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