Further observations on the carnivorous slug *Testacella haliotidea* Draparnaud, 1801

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Abstract

A population of the shelled slug *Testacella haliotidea* Draparnaud, 1801 is known to exist in the Drury Road allotment site, Colchester, Essex. During the years 2018-2022 specimens were found throughout the year on a particular plot, mostly under a landscape fabric used to mulch between rows. A total of 61 finds were made, some individuals being recaptured several times. Shell size and body mass were recorded for approximately half the sightings. Interesting observations were made in the field regarding their feeding habits; their behaviour was also studied in captivity. Mortality in the field was significant, 9.8% of individuals were found to be injured at the body extremities, probably by a ground beetle.

Introduction

Following some recent new observations of *Testacella* spp. (Gastropoda, Pulmonata, Testacellidae) in Essex, ST summarised the taxonomic situation regarding the genus in the U.K. at that time and the history and distribution of the various species in Essex (Taylor 2015). This work included reference to several observations of *Testacella haliotidea* Draparnaud, 1801 from allotments in Colchester (Bowdrey 2008), including some discovered at the Drury Road allotment site. This site is the fourth Colchester allotment site with records for this elusive shelled slug, which often inhabits cultivated land close to human habitation. All records noted by Taylor (2015) were in such habitat, a trend supported by Rowson *et al*. (2014). A further recent observation by ST of the species in Tiptree was also in a cultivated garden, while another documented example is provided by Van Nieulande (2011) and De Winter & Van Nieulande (2011) detailing a healthy population of the species in a relatively small domestic garden. This paper concerns the study of the population of *T. haliotidea* in the Drury Road site.

The Drury Road allotment plot

This study is entirely based on a plot in the Drury Road allotment site. The site is triangular in shape, surrounded by three roads - Maldon, St Helena and Drury - and covers a total area of approximately 6,300m^2 which was originally divided into over 50 plots, now sub-divided. Mapping evidence indicates the site has been used as allotment gardens for around 100 years, prior to which it was farmland. The soil is a sandy loam underlain by clay.

The study plot, centroid grid reference TL98512415, measures 136m^2 and has been cultivated by MF since 1998 (Plate 1). Over the years, organic matter has been recycled in the site, plus repeated loads of cow and horse manure have been added to the soil. With the exception of regular use of slug pellets, no other inorganic compounds have been added. The site has a thriving population of snails (primarily *Cornu aspersum*) and slugs: *Ambigolimax nyctelius*; *Arion hortensis*; *A.* cf. *rufus*; *Deroceras reticulatum*; *Limacus maculatus*; *Limax maximus*; *Tandonia sowerbyi*; and *T. budapestensis*.

Throughout MF's cultivation of the plot, Plantex, a permeable dark grey fibrous geotextile material (hereafter referred to as "membrane"), has been preferentially used to mulch between rows and it is underneath these membranes where the bulk of the *T. haliotidea* were found (Plates 1 and 2a).

Plate 1. Habitat where most sightings occurred. Note the grey membrane.
Photograph © Maria Fremlin

Plate 2. (a) *Testacella haliotidea*, common snails and worm under a membrane; (b) three *T. haliotidea* specimens with distinct shell markings, at rest; (c) foraging *T. haliotidea* with unusual skin pigmentation; (d) same specimen at rest. Photographs © Maria Fremlin

No other recent sightings of *T. haliotidea* have been reported for any other plots on this allotment site, despite efforts to raise peoples' awareness of the species. The late Peter Wilson, who was very knowledgeable about slugs, cultivated a large plot there between 1982 and 2018, but only saw a specimen once and that was in Maldon Road by a front garden (pers. comm.).

Sightings and biometric data

During the period May 2018–February 2022, 61 sightings were recorded, all during daylight hours. They occurred throughout all months of the year (Fig. 1).

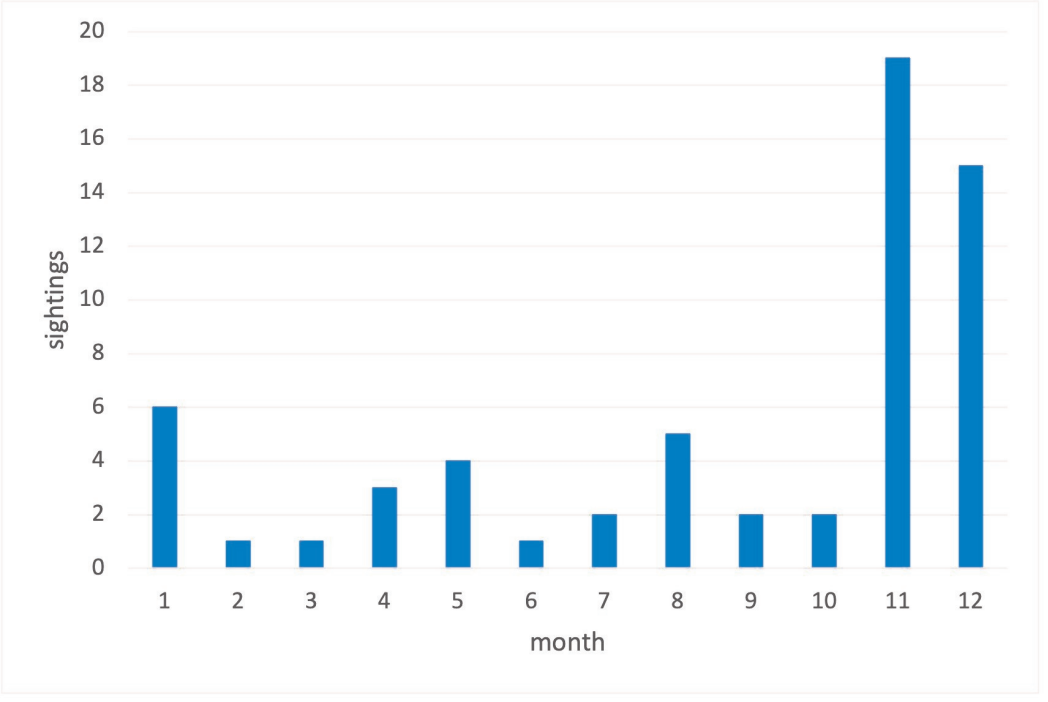

Fig. 1. *Testacella haliotidea* sighting frequency throughout the year for the period 2018-2022.

The slugs were mostly sighted under the rolled-up membranes (n=53) together with worms, snails, other slugs and their eggs, woodlice, millepedes, ground beetles, etc. (Plate 2a). Specimens were also found in the area of a very old cow manure heap (four juveniles, May 2018), the vegetable patch and even by a grass verge. All individuals had a pale cream sole and when not active can easily be mistaken for a pebble.

During November 2020 - January 2021, specimens were actively searched for on a regular basis under three rolled membranes where they were particularly abundant (n= 34). During this period MF noticed that some individuals had characteristic growth lines in the shell and sometimes even body markings (Plates 2b-d & 4a). The slugs seemed to remain along the length of an individual membrane; sometimes two to three specimens could be found there in one day. As time went on this led to the identification of at least 14 recaptures, indeed one individual was recaptured eight times.

Wherever possible, biometric data was taken of the shell dimensions (MF used digital callipers accurate to 0.01mm; ST used callipers accurate to 0.1mm) and the mass of the entire animal (in the field with a Salter electronic diet scale, model 1250, to 0.1g; otherwise with a Scalix CB-310 electronic scale, accurate to 0.01g). Two shell measurements were taken: maximum length and maximum width. Measurements were taken for 31 sightings; the results, with trendline, are plotted in Fig. 2. Even though sometimes three measurements were taken they were somewhat variable, demonstrated by cases where the same individuals were recaptured on separate occasions (Fig. 2, marked orange and green). The measurements are difficult to take in live individuals because the shell is level with the skin and difficult to grab with the callipers. Nevertheless, the data demonstrates a correlation between the shell length and width, as might be expected for individuals of the same species. Juveniles' shells averaged ca. 2.6 x 1.7mm and the shell of the largest specimen was ca. 7.4 x 4.7mm, slightly larger than

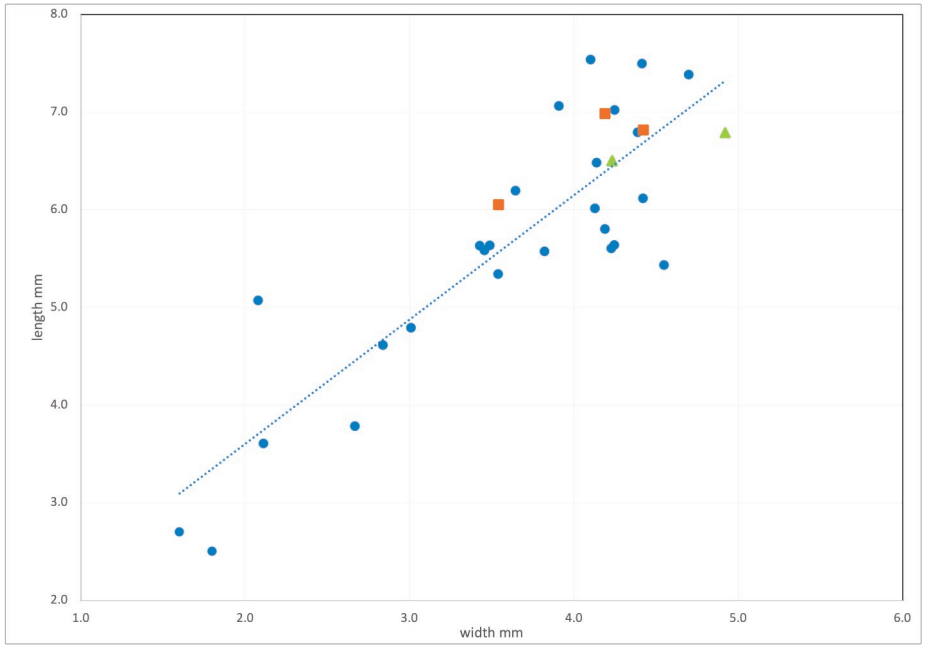

Fig. 2. *Testacella haliotidea* shell dimensions: length versus width, plus trendline. Green and orange points indicate measurements of recaptured individuals.

the biggest specimen from the Dutch study at ca. 6.4 x 4.2mm (De Winter & Van Nieulande 2011).

Individual animal mass varied a great deal: max 3.8g, min 0.1g (n=32). One individual, which was weighed on seven different days, showed considerable variation: from 1.1g to 2.8g. This is largely linked to diet (discussed below). As expected, a plot of individual mass against maximum shell length was more scattered (Fig. 3).

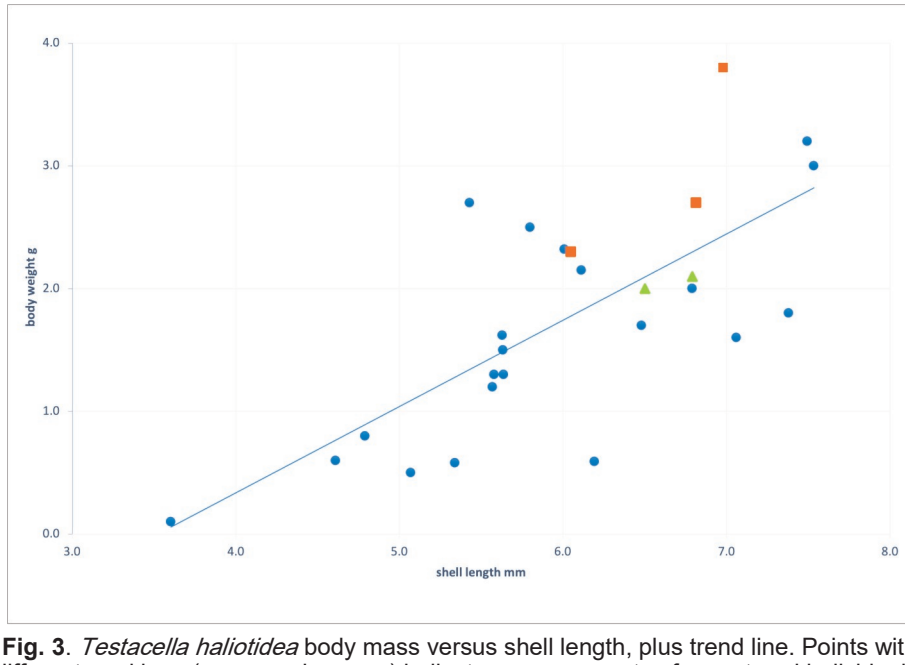

Fig. 3. *Testacella haliotidea* body mass versus shell length, plus trend line. Points with different markings (green and orange) indicate measurements of recaptured individuals.

Behavioural observations in the allotment habitat

When found, the slugs were mostly on the surface of the soil, resting under cover, although one observation was of a partially buried individual with the shell just visible. Foraging was observed only on three occasions (Plate 2c).

On one occasion in 2021, while being handheld for the measurement of biometric data, a slug started behaving in a strange way. Soon something started to emerge from its mouth and took more than one minute to emerge completely (Plate 3a). It had regurgitated a worm which was approximately 8.5cm long; the mass of the empty skin fitted perfectly with the slug's loss: 0.3g. An identical regurgitation behaviour was noted by Cavadino (2016) in *T. maugei* when a slug was being handled. It regurgitated an earthworm sufficiently intact as to be identified as a member of the genus *Eisenia*. Liberto *et al.* (2011) show a feeding sequence of *T. scutulum* ending with the regurgitation of bloodless empty worm skin which had superficial lacerations; in this case there had been no handling.

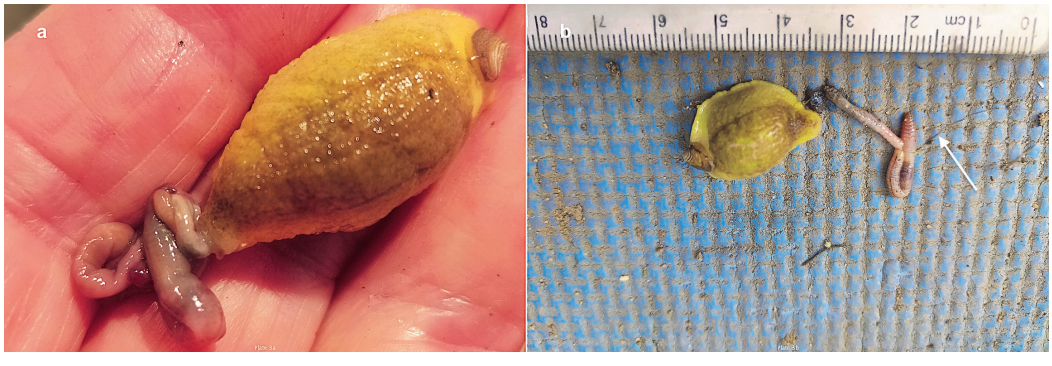

Plate 3. (a) *Testacella haliotidea* with freshly regurgitated worm; (b) *T. haliotidea* next to a manually extruded worm which was strangled by a membrane filament, arrowed.
Photographs © Maria Fremlin

Subsequent to this incident, a slug was found on 14th August 2021 with something sticking to its mouth: a thread from the membrane. It was pulled gently and out of the slug came part of the body of a worm that had been caught in that thread (Plate 3b). Subsequent microscopic examination of the worm by ST showed the anterior (head) end to be undamaged as far as just beyond the clitellum (saddle), after which the worm became little more than a hollow skin, before terminating at a broken end which was plugged with what appeared to be fine soil.

Seven days later during the afternoon, a slug was observed for several minutes with a bloodless portion of a worm sticking out of its mouth; three quarters of an hour later the slug had abandoned it and moved away.

There are various documented reports of feeding behaviour in *Testacella* and all agree that the principal means is by complete ingestion of earthworm prey. Crampton (1975) notes (albeit her observations were made on *T. maugei*) that the slugs' mouthparts are adapted for grasping and drawing in the prey rather than severing a portion of it, suggesting that in cases where worms are severed it is a result of the prey's struggling against the grasp of the slug's mouthparts rather than any particular action by the predator.

Taylor (1902-1907) suggests that disturbance during feeding may prompt testacellids to

regurgitate partially digested prey, an observation supported by the current study and by Cavadino (2016), while Barnes (1950) also reported observations of partial digestion of earthworms. Crampton (1975) notes that in some cases where large prey is taken, the ingested portion may be at least partially digested even while a significant length of the worm remains outside of the slug, although she reports no first-hand observations of regurgitation of partially digested prey.

Behavioural observations in captivity

A small number of specimens were retained by ST for periods in captivity. Testacellid slugs are notoriously difficult to keep in captivity however it was found that a 3-litre plastic tub, partly filled with garden soil and with small ventilation holes pierced in the lid, if kept outdoors in a cool dark place and regularly stocked with immature earthworms, served as a suitable temporary habitat at least during periods of temperate weather. Individual slugs were kept in the hope of observation of feeding behaviour while for a period in 2020 a pair were held to see if they might breed.

As the slugs live mostly within the soil, any observations were somewhat hit and miss. Similarly, as with many carnivores which eat relatively large prey compared to their own body size, the slugs are understood to feed infrequently, Stokes (1958) having reported an average 1.75 worms per week predated by *T. haliotidea* during her study. During the current study one slug specimen was deprived of worms for a week and then placed in a tray with several worms of various sizes. The slug was observed to attempt feeding on several occasions by everting the white-coloured feeding apparatus from inside the mouth and attaching it to earthworms. None of the feeding attempts were successful, perhaps due to the fact that the activity was taking place in a non-subterranean environment, allowing the potential prey much greater freedom of movement.

Although *T. scutulum* has been found to breed readily in captivity - to the extent that specimens kept together will mate almost immediately (Stokes 1958) - *T. haliotidea* is less reliable, hence it was not practical to attempt to observe actual mating in captivity. The slugs are, however, known to produce distinctive eggs which are white, rugby-ball shaped and relatively large (up to 7mm long (Rowson *et al*. 2014)) so weekly checks were made of all the soil in containers housing slugs, even if only a single specimen was present, as Stokes' observations suggest *T. haliotidea* is capable of self-fertilisation. Despite a pair of slugs being housed together for a period of two months, no eggs were observed at any time and no slug hatchlings were seen either. In Stokes' experiments the animals were thought to have mated in late winter as oviposition occurred between May and September. In the current study the slugs were paired over the period of December 2020 to March 2021. One died during the spring but the other survived well into the summer so why it did not oviposit is a mystery, possibly linked to the captive conditions. Interestingly, when Stokes reared some of the eggs they were observed to take over a year to hatch.

During the current study, in the period during which captive specimens of *T. haliotidea* were under observation, although no regurgitations were observed, on two separate occasions what appeared to be an empty skin of an earthworm was found in a tub occupied by a slug. This, the allotment observations detailed above and those made by others which are referenced above all suggest there is scope for further research on the regurgitation behaviour of the testacellid slugs.

Mortality

The discovery of fatally injured *T. haliotidea* specimens during this study was not uncommon: out of 61 sightings, six were of mortally injured slugs. The observed injuries were seen to occur mostly at the tips of the body, in particular around the shell.

One victim had its shell missing. Another individual, exhibiting a distinct body pigmentation possibly from an earlier injury, was sighted nine times during a period of 6th December 2020 to 29th January 2021. The last observation was post-mortem with an injury below its shell (Plates 4a-b). Another slug had a somewhat unusual body shape, perhaps due to an early injury, and was captured four times, the last time unfortunately post-mortem, apparently due to an injury at the head (Plates 2c-d and 4c).

Plate 4. (a) *Testacella haliotidea* individual with distinct scar tissue; (b) corpse of the same individual with a shell injury, upside down; (c) corpse of an individual with head injuries; (d) *Nebria brevicolis* under a membrane, next to a burrow. Photographs © Maria Fremlin

From the apparent scarring marks, it seems the slugs are capable of sometimes surviving injury. When fatally injured, the observations suggest they may also take a while to die; over a few days they lose a lot of weight, the body darkens and becomes cigar shaped, later developing an intensive odour resembling that of stale seafood (Plate 5).

Other potential slug prey species were available under the membranes in vast numbers (eight species in total; see above), but their predation was rarely observed. Ground beetles are known to be significant predators of slugs (Barker 2004; Rowson *et al*. 2014) and the ground beetle *Nebria brevicolis* (determined by Nigel Cuming) was frequently found under the membranes either foraging or going into their burrows (Plate 4d). A study of predation by the ground beetles *Pterostichus madidus* and *N. brevicollis* on the slug *D. reticulatum* showed these generalist beetle species were unable to overcome the defence mucus production of healthy slug specimens (Mair & Port. 2002). The shelled slug is not slimy thus it could present an easier prey to a ground beetle, but to the authors' knowledge there are no specific studies of *Testacella* predators. Despite making 21 sightings, mostly under paving stones, the Dutch study makes no mention of injury or predation (De Winter & Van Nieulande 2011; Van Nieulande 2011).

Conclusion

This study demonstrated that in the Drury Road site there is a very healthy population of this elusive shelled slug, albeit concentrated in just one plot. Probably the habitat under the membranes, not used on other plots, has created a suitable micro-climate for

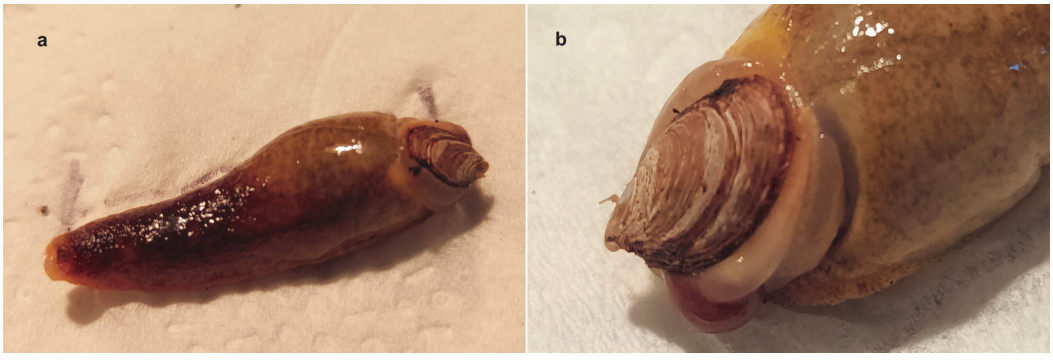

Plate 5. (a) corpse of a *Testacella haliotidea* with shell injuries; (b) close up of the injured area. Photographs © Maria Fremlin

molluscs along with all kinds of other invertebrates, from worms to centipedes and woodlice: low light and high humidity. This fortunate occurrence allowed a unique insight into *T. haliotidea* behaviour and mortality in the field.

Acknowledgments

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References

BARKER, G.M. ed. (2004) *Natural enemies of terrestrial molluscs*. CABI Publishing, Wallingford, UK.

BARNES, H.F. (1950) Worm eating slugs in Bedford gardens. *Bedfordshire Naturalist* **4**: 24-26.

BOWDREY, J. (2008) Allotments are the stronghold of the shelled slug (*Testacella haliotidea* Draparnaud) (Mollusca: Testacellidae) in Colchester. *Nature in North East Essex* **2008**: 51-52.

CAVADINO, I. (2016) *A Spooky Slug Filled October*. Available at: https://blogs.tcv.org.uk/natural-talent/2016/11/21/october/ (Accessed: 1st July 2022).

CRAMPTON, D.M. (1975) The anatomy and method of functioning of the buccal mass of *Testacellamaugei* Ferussac. *Journal of Molluscan Studies* **41** (6): 549-570.

DE WINTER, A.J. & VAN NIEULANDE, F.A.D. (2011) *Testacella haliotidea* Draparnaud, 1801 in the Netherlands (Gastropoda Pulmonata, Testacellidae). *Basteria*, **75** (1/3), 11-22. Available at: https://natuurtijdschriften.nl/pub/597391 (Accessed 8th July 2022).

LIBERTO, F., RENDA, W., COLOMBA, M.S., GIGLIO, S. & SPARACIO, I. (2011) New records of *Testacella scutulum* Sowerby, 1821 (Gastropoda, Pulmonata, Testacellidae) from Southern Italy and Sicily. *Biodiversity Journal* ***2***: 27-34.

MAIR, J. & PORT, G.R. (2002) The influence of mucus production by the slug, *Deroceras reticulatum,* on predation by *Pterostichus madidus* and *Nebria brevicollis* (Coleoptera: Carabidae). *Biocontrol Science and Technology* **12** (3): 325-335.

ROWSON, B., TURNER, J., ANDERSON, R. & SYMONDSON, B. (2014) *Slugs of Britain and Ireland*. Field Studies Council.

STOKES, B.M. (1958) The worm-eating slugs *Testacella scutulum* Sowerby and T. *haliotidea* Draparnaud in captivity. *Proceedings of the Malacological Society of London* **33**: 11-20.

TAYLOR, J.W. (1902–07) *Monograph of the Land and Freshwater Mollusca of the British Isles. 2. Testacellidae, Limacidae, Arionidae*. Taylor Brothers, Leeds, UK.

TAYLOR, S. (2015) The carnivorous shelled slug family Testacellidae in Essex. *Essex Naturalist (New Series)* **32**: 235-238.

VAN NIEULANDE, F. A. D. (2011) De eerste populatie van de land naaktslak *Testacella haliotidea* Draparnaud, 1801 in Nederland. *Spirula* **382**: 105-106.