A very rare teratological observation in *Monachoides incarnatus* (O. F. Müller, 1774) (Gastropoda: Hygromiidae), a "unicorn snail"

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ABSTRACT. In April 2017, a double teratological case in an adult *Monachoides incarnatus* (Müller, 1774) was discovered in Liège (Belgium). The specimen constitutes a "unicorn snail", where the snail owns only one central ommatophore (eye-stalk) with two eyes at the top of the tentacle, and a supernumerary small eye close to the right eye. The unique upper stalk is probably due to a trouble in its early development, where the upper ommatophores were abnormally merged. However, the cause and explanation of the third eye remains unexplained. Except for the upper part of the head, this specimen has all the normal characteristic of its species. Even if the specimen has not lost its sense of vision entirely, the visual field could be different. We can suspect a potential handicap to detect the direction of odors. Named 'Cosmo', it was able to produce eggs, unfortunately none have hatched. A succinct review of teratological cases in the soft part of the head in Stylommatophora is introduced and discussed. As far as we know, only one other case of "unicorn snail" was reported from literature in *Helix pomatia*. Another case in *Cornu aspersum* was recently detected in California the same year as our specimen.

INTRODUCTION

Teratological cases are abnormalities of the physiological development in a living being, which can lead to morphological malformation. The causes of these abnormalities are various, with intrinsic (genetic, trouble in ontogeny) and/or extrinsic causes (ex. dietary deficiency, radioactivity, thermal shocks). If these new characteristics are sometimes just cosmetic (ex.: polydactyly in humans) or adaptive [ex.: melanism in butterfly in industrial region (van't Hof et al., 2011; Cook & Saccheri, 2013)], numerous cases can induce severe consequences on the lifestyle and even on the survival of the individual. In the latter case, it can cause a weak adaptation to the normal life of the species (ex.: weak capacity to forage or to avoid predation) or a lethal malformation in the embryonic stage. If in a relatively ancient past, these "monsters" were exploited as an attraction, for Science, teratological cases are primarily an opportunity to better understand the developmental processes and the influences of the environment and of intrinsic factors on these processes.

Among Mollusks, numerous teratological cases were reported. The most famous case is at the origin of the genus name *Cornu* in the Brown garden snail (von Born, 1778). This species was described by Otto Friedrich Müller (1774) as *Helix aspersa* Müller, 1774, and by Jean de Charpentier (1837) as *Helix (Cryptomphalus) aspersus* (*Cryptomphalus* was used as a subgenus). However, before them, Ignaz von Born (1778) described a "horn of plenty" form (an impressive scalariform shell) of the brown garden snail. Thinking to have discovered a new species, he gave the name of *Cornu copiae*. So *Cryptomphalus* Charpentier 1837 is a junior synonym of *Cornu* Born 1778. So today, the teratological name is currently used as the referent to describe this species, despite being in breach of the International Commission on Zoological Nomenclature (Altaba, 2011; Banks, 2012). Numerous other teratological cases were reported in mollusks, mainly concerning the shell shape (e.g. sinistral in dextral species, abnormal color, or again aberrant coiling shape). The "freak" shells, by their rarity and curiosity, have a lot of success among shell collectors. However, other malformations were

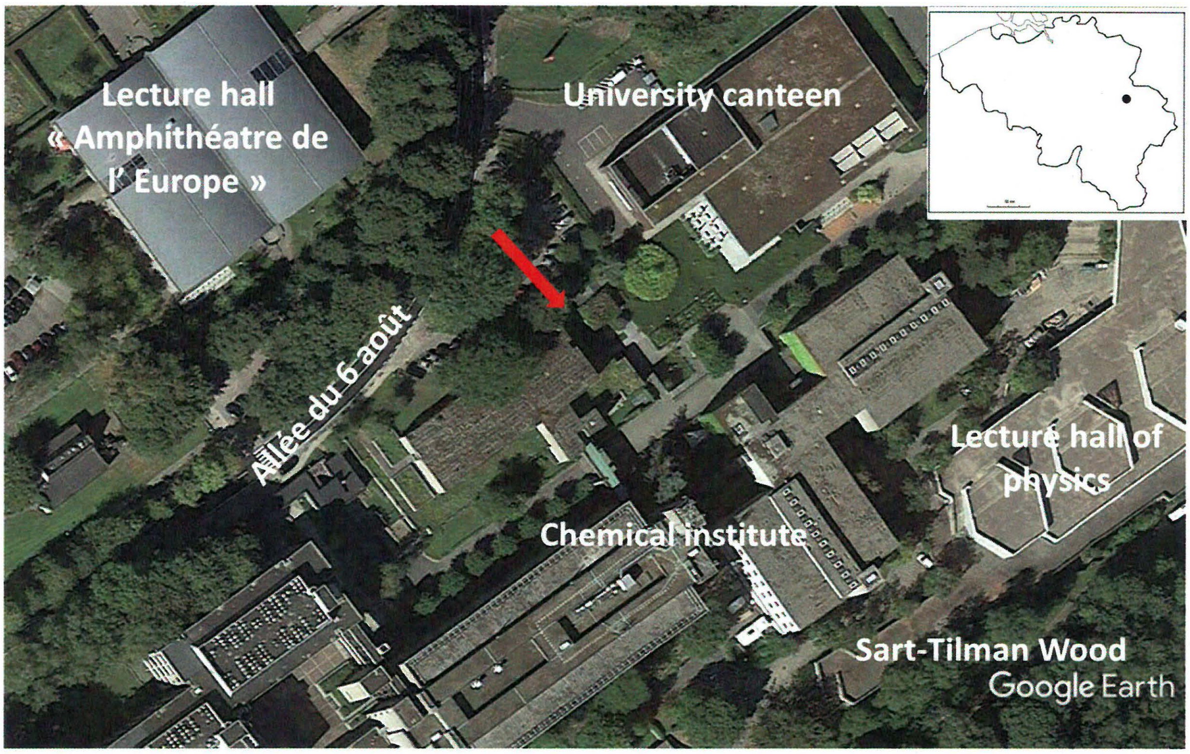

Figure 1. Satellite image (Google Earth 2017) of the south-western part of the Agora District (Campus of Sart-Tilman, University of Liège, Belgium). The red arrow shows the localization where the teratological specimen was discovered.

reported in the soft body (Varga 1993, Mitov et al. 2003: two tails in *Limax punctulatus* Sordelli, 1870), sexual organs [ex. 3 penis in *Rumina decollata* Linnaeus, 1758 (Schmidt, 1855)] and in the shape of the radula (Bor et al. 1994).

CONTEXT OF THE NEW OBSERVATION

On 27th April 2017, the biologist student M. Leclercq discovered in the Sart-Tilman campus (Agora District) of the University of Liège (ULiège, Belgium – Fig.1) a curious gastropod on a step of an outside concrete staircase (50°35'08''N – 5°24'03''E). Her attention was drawn by the curious look of the animal; the gastropod had only one central thick ommatophore. M. Leclercq collected the specimen alive. For the record, M. Leclercq nicknamed the specimen "Cosmo" due to its 'extraterrestrial-like' appearance (in her mind).

DESCRIPTION OF THE SPECIMEN

The specimen was described as a *Monachoides incarnatus* (Müller, 1774), Hygromiidae, living in temperate forests and moist hedges (Welter-Schultes, 2012). It is a very common species in Belgium (Adam, 1960; Vilvens et al. 2012). A recent study on the Sart-Tilman campus (Léonard et al., 2013) have forward that this species is the second more prevalent species observed in the nearby forest after *Discus rotundatus* (Müller, 1774), in term of number as well as spatial abundance. The specimen has a completely developed adult shell (complete aperture) which is 13 mm wide and 8.5 mm high. This is a relatively small size, but still in the normal range of this species [13-16 mm wide and 9-10 mm high (Welter-Schultes, 2012; Kerney & Cameron, 1999)]. Except for the ommatophores, the individual has all the normal external characteristic of the species.

The curiosity of this specimen is clearly the head (respectively the tentacle) (Figs 2-5). If the individual has a small lower pair of stalks as expected, the upper part of the head is totally abnormal. First, the upper pair of eye-stalks (ommatophores) is replaced by a unique merged stalk. This ommatophore is central on the head, and is able to be retracted and to be spread like a normal tentacle. This ommatophore is thicker seen from above (Figs 3 & 4) than in side view, which seems normal in this last point of view (Figs 2 & 4). The animal retains a capacity to angle its ommatophore (at least around 75° from the head axis in horizontal plan, and at least from -45° to 85° in vertical plan) (Fig. 4).

The second interesting characteristic is that two evident eyes are present at the extremity of the eye stalk. Each eye seems connected with a separate optical nerve. However, as this was observed by translucence, we cannot be certain that what was observed was indeed an optical nerve and not a

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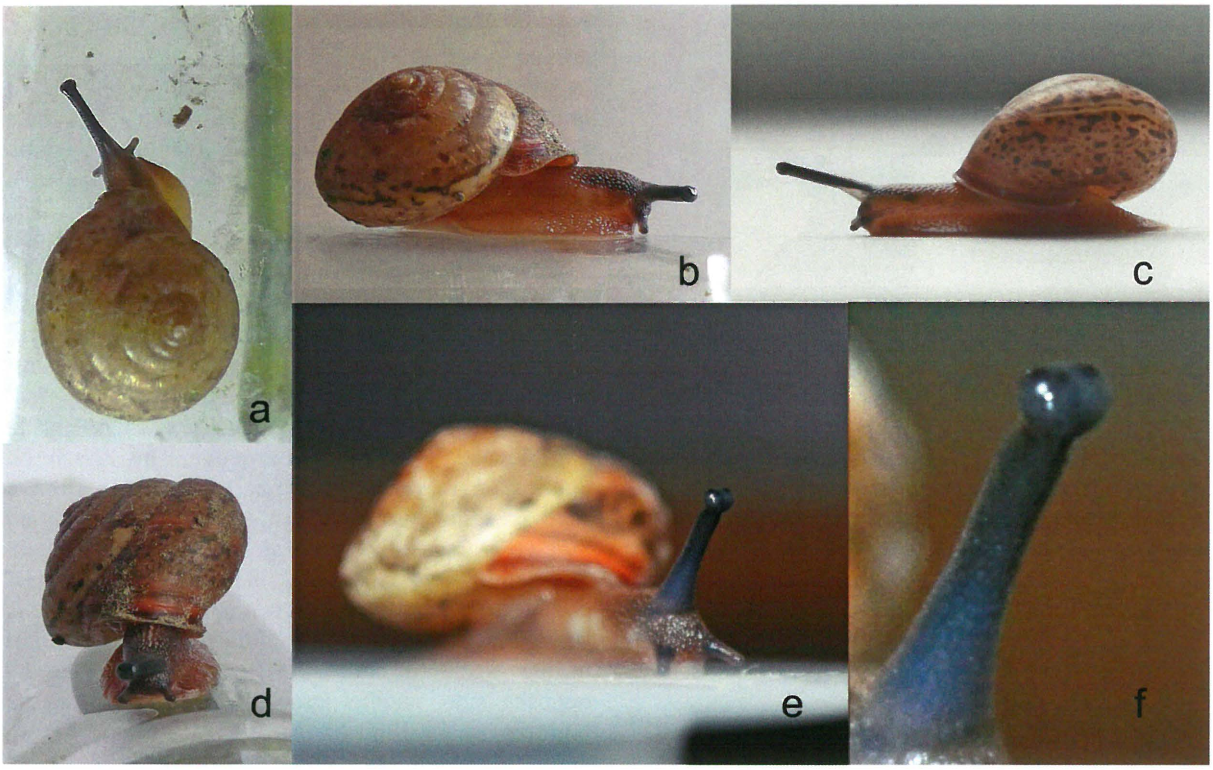

Figure 2. Pictures of “Cosmo”, a “unicorn” snail (*Monachoides incarnatus*), in different points of view in day light. Picture ‘f’ is a magnification of the picture ‘e’ showing the unique ommatophore with three black ocular spots (a-c: pictures: J.D; d-f: pictures: M.L.).

retractor muscle. So we can assume than this unique central stalk could be a result of a problem in the development of the head, where the two eye-stalks were merged together. However, we are not in the presence of a cyclops case where the fusion is so complete that the eyes are merged in one. Clearly, the extremity of the stalk has a ‘horizontal eight’ shape like two merged balls, corresponding to the two ocular balls. A closer examination reveals another very uncommon feature: the number of eyes is not two but three! The two main eyes show a normal size for the species, and a smaller third eye is located close to the right eye, slightly under it and in a more central localization (Fig. 5). This third eye also seems to have an optical nerve, but again without being sure that this is not a retractor muscle. We cannot see by translucence whether this structure is connected to or completely independent from the similar one of the right eye.

With one stalk and three eyes, this double teratological case was able to survive with its malformation until the adult age; its handicap was not so severe as to become noxious. Its vision is functional as it shows to retain the capacity to avoid important lighting during our photographic session, notably by contraction of the stalk. However, we can assume that the visual range can differ from that of a normal snail. A normal upper stalk pair has also an olfactory function, and is able to detect the orientation of an olfactory source (tropotaxis) (Chase & Croll, 1981). This capacity is based on the detection of a gradient of olfactory stimulus between the two stalks, the stalk closer to olfactory source perceiving stronger the odor more efficiency. In our specimen, the stalk pair is merged, and remains in central location despite some degree of movement. This specimen could potentially be less performant in detecting the direction of an odor; but suggesting that Cosmo suffered from this handicap remains speculative without histological and olfactive detection experiments. The lower stalk pair, having tactile and olfactory functions, is probably fully functional and carries out the more specific function of analysing stimuli closer to the ground, often by direct contact. We think that the specimen’s mouth, and so its capacity to feed, is normal. M.L. was clearly able to feed the specimen with vegetables like slices of cucumber and radish. We have made the choice to not kill the specimen for any dissection.

M. Leclercq has maintained Cosmo in a terrarium with another individual of the same species in the hope that they would pair and produce offspring. If no copulation was observed, Cosmo has spawned the 17th May, around 25 eggs buried by itself in the soil. After four weeks, unfortunately, none hatched. Cosmo died on September 7th, probably in its second year, a normal life span for *M. incarnatus* (Welter-Schultes, 2012).

Figure 3. Comparison between "Cosmo" (picture J.D.) and a normal lived adult specimen of *Monachoides incarnatus* (picture C.V.) seen from above.

DISCUSSION

Teratological cases of snail-heads in literature

If malacological literature is rich in teratological cases concerning the shell, few are reported concerning the head and tentacle/ommatophore (reviewed in Table 1 with references). In these rare occurrences, none were reported as lethal embryonic cases. It is logical that a lethal form has few chance to be observed due to the fact that the soft parts of mollusks decompose rapidly, and that the mortality occurs at an early age (the embryos are generally very small and so the malformation remain largely under-detected). Some cases are also reported in snail-breeding forums, but without official scientific reports. An interesting point is the diversity of cases observed in Stylommatophora group, reviewed in Fig. 6 and Table 1.

We can underline a first group of anomalies concerning atypical formation on one eye-stalk, the second one being normal. In this case, an undetermined structure or perhaps an incomplete eye-stalk or tactile stalk can be observed budding from a normal eye-stalk (Fig. 6d-e, Table 1 lines 1, 3, 6-10). In some cases, the eye-stalk can be completely split into two new stalks. In these cases, the snail has three complete eyes. Some pictures in literature seem to show that forked stalks with two eyes are smaller in length than a normal stalk, but others as in Varga (1993) show that this is perhaps just because of a more contracted stalk during a short time, forked stalks retaining the ability to be fully extended as a normal stalk. Another group of anomalies are the 'tricorn' snails (Fig. 6c, Table 1 line 11). Contrarily to the last three-eyed cases, these snails have two normal external eye-stalks, but also develop a central stalk. Unfortunately in our knowledge, no scientific publication reported this case, but pictures from a snail breeding forum suggest a case in *Lissachatina fulica* (Férussac, 1821) with an additional central stalk representing two additional merged ommatophores, and so probably, four eyes in total. This situation is perhaps a case of a partial conjoined twin where a part of the heads of both twins was merged. On the opposite side, another group of anomalies are the 'unicorn' snails (Fig. 6a, table 1 lines 5, 12, 13). In these specimens, only one central stalk is observed. Rotarides (1930) reports in *Helix pomatia* Linnaeus, 1758 a case of such 'unicorn' snail, with two complete eyes at the end of only one larger stalk with two retractile muscles and two optical nerves inside of it. This is clearly a case of coalescence of the two ommatophores very similar to our specimen. In our knowledge, we have not found another case of 'unicorn snail' in literature. However, a recent case has been reported in a *Cornu aspersum* found in a private garden in 2017 in California (USA) (Unpubl. Data, reported on Reddit: https://www.reddit.com/r/mildlyinteresting/comments/77n0rq/a_oneeyed_snail/).

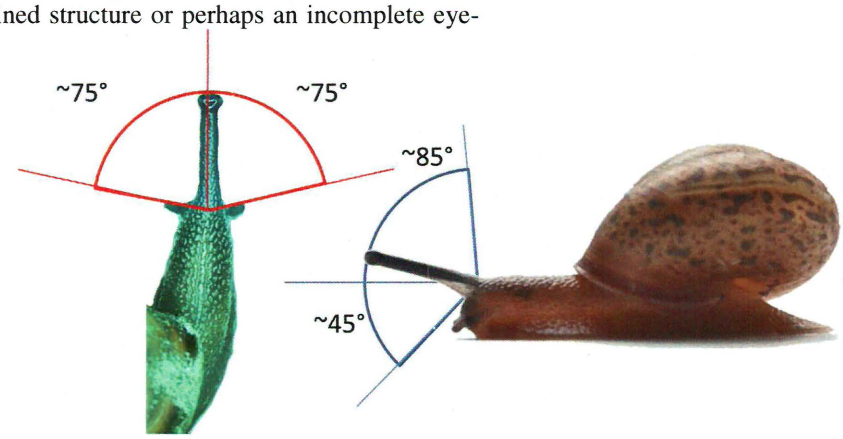

Figure 4. Degree of observed movement of the unique ommatophore in our unicorn snail specimen (*Monachoides incarnatus*). Left: in the horizontal plane, right: in the vertical plane.

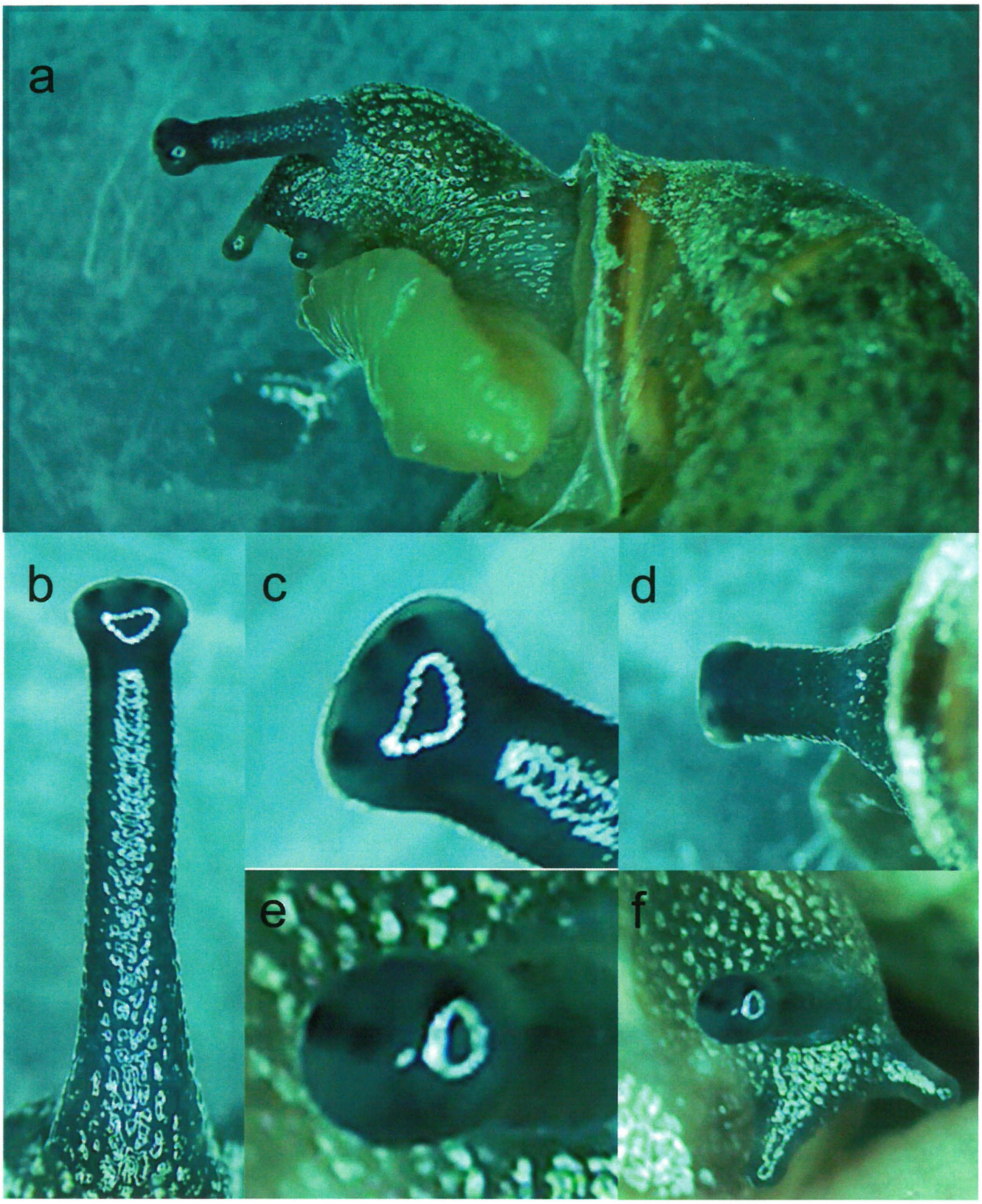

Figure 5. Details of the ommatophore of the "unicorn snail", pictures taken from a binocular microscope. (a): the snail is getting out its shell, (b) above view of the fully extended ommatophore; detail of the extremity of the eye-stalk in upper view (c) and in front view (e & f) and (e) being a magnification of (f). (d): half-contracted ommatophore. (pictures: J.D.).

This garden land snail has exactly the same teratology as our 'Cosmo', but with two normal eyes at the extremity of the merged stalk. The discoverers have kept it as a pet and have given it the name of 'Cyclop'. A similar case was however reported in a *Cepaea nemoralis* (Linnaeus, 1758) where the upper pair are conjunct for half their length, thus forming a fork, like the letter Y (Arkell, 1915) (Fig. 6g, Table 1 line 4). A fourth category of anomalies resides in an abnormal number of eyes without supernumerary tentacles

(Fig.6f, Table 1 line 2). Wiegmanns (1905) reported a snail *Helicella itala* (Linnaeus, 1758) (historically known as *Helix ericetorum* Müller, 1774) with two eyes in one stalk at the level of the ocular globe, with for each one an independent optical nerve.

Potential causes of these teratological cases

Most teratological cases are most probably a consequence of genetic (and/or epigenetic) anomalies having a direct impact on organ ontogeny, or anomalies during regeneration processes after injuries. Other cases resulting from fusion or partial separation such as conjoined twins and chimera will not be discussed here.

When the teratological case has a genetic source, for example a mutated gene, this feature can be transmitted to the next generation. For instance, in *Radix labiata* (Rossmäller, 1835) [(formerly known as *Radix peregra* (O.F.Müller, 1774)], the determination of dextral (normal) and senestral (rare) forms, is based on some genes where determined by maternal effects of a dominant dextral (D) allele and a recessive sinistral (s) allele (Okumora et al. 2008). When the reproduction is based on self-fertilization (land mollusks often being hermaphrodite), the frequency of dextral and sinistral coiling follows the laws of Mendel, but in case of sexual reproduction, with an exchange of gametes from two individuals, the genetic material of the egg is preponderant on the one coming from the spermatozoid.

The sinistral case in gastropods is very interesting because the chirality often induces a reproductive isolation of the mutant population, sinistral and dextral individuals being unable to copulate with each other. This isolation can lead to the creation of new species or sub-species (Okumora et al., 2008). The discovery of teratological mutants can be demonstrated by transmission of this feature to the next generations, which can be observed directly in the next generation if it constitutes a dominant allele.

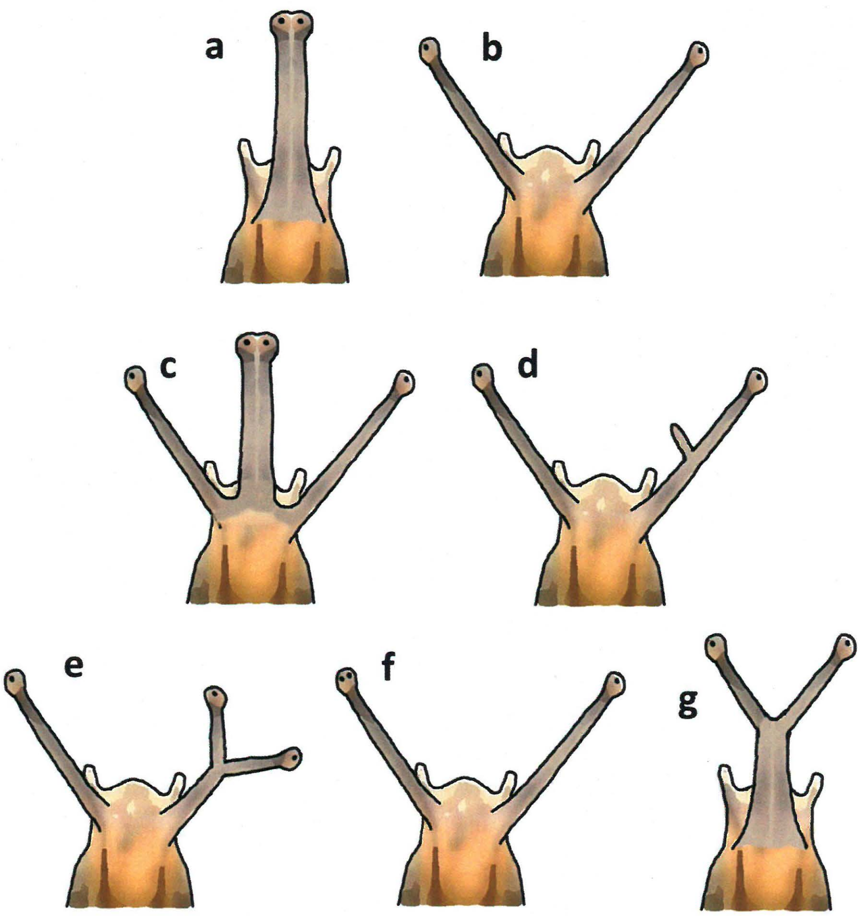

Figure 6. Different types of anomalies observed for the soft part of the head in Stylommatophora. (a) 'unicorn' snail (one thick eye-stalk, two eyes), (b): normal head with an upper pair and lower pair of stalks, (c) 'tricorn' snail (three stalks, two normal external eye-stalks and one central thicker with potentially two eyes), (d) additional body structure on a stalk (can be also a structure similar to a small lower stalk), (e) bifurcation of eye-stalk (with a total of three eyes), (f): supernumerary eyes in one stalk, and (g) 'Y-shaped ommatophore' snail (drawings J.D.).

This is rarer and more complex to observe if the anomaly is due to a recessive allele or due to several different genes, because in this case, several generations can hold the mutant gene without an individual with an abnormal phenotype, as it requires the individual to possess either two recessive alleles if the phenotype is determined by a lone gene, or the correct combination of genes if the anomaly is caused by multiple genes. Another phenomenon is the impact of epigenetics: molecular mechanisms which can control the expression of genes, notably in responses to environmental parameters. In this case, a specific form could appear only in certain environmental conditions due to the activation or inactivation of an epigenetic regulation, and not in other situations despite having the same genome. With all genetic or epigenetic, intrinsic or extrinsic causes, the consequence is a modification of the normal development of organs which can create an aberrant phenotype for the species. Some environmental elements (teratogen agents) can be the source of these modifications: for instance radioactivity or chemical substances can induce mutations in the genome, and/or perturbations in epigenetic regulation, thus creating teratological anomaly.

All the teratological cases are not genetically transmissible. Sometimes, a snail can be observed with a partially or totally absent tentacle. This disappearance is probably the consequence of injury following, for example, predation events. Interestingly, snails are able to regenerate amputated tentacles with the complete and correct morphology (ganglions, muscles and eyes) (Eakin and Ferlatte, 1973; Chase and Kamil, 1983; Flores et al., 1992; Moffet, 1995; Matsuo et al., 2010a,b; Matsuo & Ito, 2011). For a forked stalk, we can imagine that an amputation of this abnormal tentacle can regenerate a new normal one with only one trunk and one eye. On the other hand, when an injury occurs, the regenerative processes can sometimes not work correctly, and an aberrant structure or the duplication of an organ can occur (Mitov et al., 2003).

For our unicorn snail, we have no information as to the cause of its anomalies. It is difficult to imagine an injury event concerning a large part of the head followed by its regeneration. It is more probable than this possesses a genetic (and/or epigenetic) origin during ontogeny, probably in an early developmental stage where the two tentacles were not correctly separated. Unfortunately, we have no explanation concerning the supernumerary right eye.

Table 1. Review of reported teratological cases of the soft part of the head in Stylommatophora

	species	location	type	year and references
1	***Cepaea hortensis***	?	bifurcation (e?)	Hesse 1895 in Varga 1993
2	***Helicella itala***	?	double-eye	Wiegmanns, 1905
3	***Helix pomatia***	?	bifurcation (e?)	Young 1907 in Simroth 1908
4	***Cepaea nemoralis***	England	Y-shaped ommatophore	Arkell, 1915
5	***Helix pomatia***	?	unicorn	Rotarides, 1930 (see also Varga, 1993)
6	***Helix pomatia***	Hungary	bifurcation "d"	Varga, 1993
7	***Helix pomatia***	Bulgaria	bifurcation "d"	Mitov et al. 2003
8	***Cornu aspersum***	California (USA)	bifurcation "e"	2016, unpubl.data nhm.org/nature/blog/mutant-snail
9	***Eobania vermiculata***	?	bifurcation "e"	2016, Unpubl.data youtube.com/watch?v=uuPQllpbOf4
10	***Helix pomatia***	?	bifurcation "e"	Unpubl.data Helix-pomatia.de recited on www.gireaud.net/maladies.htm
11	***Achatina fulica***	?	tricorn	Unpubl.data https://www.petsnails.co.uk/care/breeding.html
12	***Monachoides incarnatus***	Liège, Belgium	unicorn	2017, present study
13	***Cornu aspersum***	California (USA)	unicorn	2017, unpubl.data, comm.pers. reddit.com/r/mildlyinteresting/comments/77n0rq/a_oneeyed_snail/

Comments: "d" & "e" correspond to the different types of bifurcation introduced in Figs 6d & 6e respectively. Most recent access to the website sources: 10th September 2019.

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