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PTISANULA LIMNÆOIDES, A NEW ARCTIC OPISTHOBRANCHIATE MOLLUSC, ITS ANATOMY AND AFFINITIES

BY

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WITH ONE PLATE

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Ptisanula limnæoides, a New Arctic Opisthobranchiate Mollusc, its Anatomy and Affinities.

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In 1910 Professor G. DE GEER published a note on a fossil Gastropod from the Quaternary shell-deposits at Kapellbacken, Uddevalla. As it apparently belonged to a new genus, I decided upon giving a description of it later on and named it for the time being *Ptisanula limnæoides*.[1] It seemed to be identical with a recent species from Spitzbergen that I had already observed in the Riksmuseum collections, but I was unacquainted with its relations, they being only to be established by close investigation and research. The characters of the shell in evidence were not sufficient to enable me to state its systematical position, and the radula, obtained from the dried animals, which vere fortunately present in the shells, exhibited a peculiar shape but afforded no basis for drawing conclusions on its affinities. In the Riksmuseum collections, however, I did find some further specimens of the new form, preserved in alcohol, and they enabled me to make an examination of the exterior morphology of the soft parts as well as of the inner anatomy of one

[1] *Ptisanula limnoides* in DE GEER 1910.

specimen cut into sections. From this examination it was evident that the new mollusc is an opisthobranchiate gastropod most closely allied to the northern and arctic genus *Diaphana*.

Localities. The recent specimens of *Ptisanula limnæoides* belonging to the Riksmuseum, were dredged by TORELL in 1858, partly in Bel Sound at 5—12 fms, stones, algæ (6 sps), at 30—40 fms, stones with Hydrozoids[1] (1 sp., sectioned), and at 30 fms, fine clay (1 sp.), and partly in Horn Sound, at 40—60 fms, clay, stones (1 sp.). The fossil shells from Kapellbacken were found in four different horizons of a layer, belonging to »the finiglacial transgression». At 22, 24, 25 and 26 m above the sea there were collected 1, 3, 3 and 1 specimens respectively.

Description of the Shell.[2] It is of an elongate ovate shape with an elevated blunt-tipped spire and high, slightly convex whorls, tabulated at the oblique, channel-shaped sutures. The colour is semi-hyaline white with a shining surface, covered, in a fresh state, by a thin, straw-coloured, feebly gleaming cuticula with some longitudinal stripes of darker brown. The aperture contains half the length of the shell and has an oblong or rounded rectangular form with an obtuse upper angle; the outer margin issues at right angles from the body-whorl, bends immediately down, is in its middle-part somewhat concave or else feebly convex, strongly and uniformly bowed below, and then directly passing into the columellar margin; the pillar is in its lower part sinuous and furnished in the middle with a distinct convexity that is not sharply marked as a fold; in its upper part again it is slightly concave or nearly straight. The columellar and outer margins are connected on the parietal wall by a fine calcareous lamella. The columellar margin is reflected in its whole length, thus forming a narrow but deeply protruding umbilicus. The apex is twisted regularly with a somewhat depressed nuclear whorl. The surface is smooth with the exception of fine irregularly placed lines of increase. Besides them very feeble traces of a few distant opaque spiral lines

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[1] Chiefly *Campanularia integra* Mc GILL and *Sertularella tricuspidata* ALDER.

[2] The Description of the shell and its variation has been published in Geologiska Föreningens i Stockholm Förhandlingar Bd 35, H. 5, Maj 1913.

are observable on the middle-part of the whorls. No special apical sculpture is present.

Measurements in millimetres. The largest specimen from Bel Sound (Fig. 2): Height 2.7; breadth 1.6; h. of aperture 1.3; br. of ap. 0.7; h. of last whorl 2.1; number of whorls $3^2/_3$. The specimen from Horn Sound (Fig. 3): H. 2.6; br. 1.5; h. of ap. 1.4; br. of ap. 0.7; h. of last whorl 2; number of whorls $3^1/_2$. The largest specimen from Kapellbacken (Fig. 4): H. 3.1; br. 1.7; h. of ap. 1.5; br. of ap. 0.9; h. of last whorl 2.4; number of whorls 4; another shell (Fig. 1): H. 3; br. 1.5; h. of ap. 1.5; br. of ap. 0.7; h. of last whorl 2.3; number of whorls $3^3/_4$.

Variation of the Shell.[1] The dimensions given above and the Figures 1—4 denote a formal variation, that finds expression in a stretched or a somewhat inflated body-whorl, owing to which the aperture is lengthened or somewhat wider while the umbilicus is narrow or more conspicuous. Such variations are present in both the fossil and the recent shells. Besides this, there seems to be a constant difference between the recent form from Bel Sound and the fossil shells, the apical whorls of the first-named being somewhat more depressed and broad, those of the last-named comparatively high and narrow. The post-nuclear whorls are a little higher and broader in the recent shells than in the fossil ones. This circumstance produces a somewhat smaller size in the fossil shell, compared with a recent one with the same number of whorls. The specimen from Horn Sound approaches in this respect the fossil ones. In the sculpture no difference can be observed, the fossil shells too exhibiting indistinct opaque spiral lines and fine lines of increase; in other parts they are smooth.

The difference in size named is too slight to be considered as a phenomenon of dwarfing of the fossil specimens, such as I have shown to exist in other forms, *e. g. Margarita helicina* and *Natica clausa* from Bohuslän and in *Velutina undata* from Finmark,[2] as well as in terrestrial molluscs, *e. g. Pupa arctica* in Sweden.[3] It leaves, however, the question open, whether

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[1] The Description of the shell and its variation has been published in Geologiska Föreningens i Stockholm Förhandlingar Bd 35, H. 5, Maj 1913.

[2] ODHNER 1912 and 1913.

[3] ODHNER 1910. See list of literature.

the fossil specimens lived in a more arctic or a more temperate climate than that prevaling nowadays in Bel Sound. The presence of *Mytilus* in the same layer might perhaps indicate a somewhat warmer sea, but the fact of the presence alone of one species must be used with caution when conclusions as to the climate are to be drawn; often it is only a more detailed examination of the stage of development attained and of the variation of the fauna or some characteristic portions of it that can give us certain criteria for judging in such problems. The small or young forms present in the *Ptisanula*-bearing layer were not suitable for a comparison with recent ones, but perhaps it might be possible, from further collections, difinitely to solve this question.

Description of the Radula (Figs. 6—8). The formula of the radula is 1.1.1. It contains 26 complete and 3 rudimentary series of teeth. The median tooth is strong and high, the sides of its base are produced in wing-like processes with a deep sinus between them; a short collum separates the basal portion from the apex, which itself is a little narrower than the base and is spoon-formed with the concave surface to the front and a slight concavity behind; its margin is erect and serrated into 7—9 strong denticles. The median teeth are placed close together and in articulation with each other (Fig. 8). The lateral teeth are lamelliform (Fig. 8) and very thin; they are placed with their basal edges in the longitudinal direction, and thus they cover the median teeth (Fig. 6) and have a concave outer surface. They have the shape of a meniscus with a strongly convex anterior margin and a less sinuous posterior one. Their upper ends rise beyond the median apices (Fig. 6) and are deflected laterally owing to the concaveness of their surface (Fig. 7). The median teeth have a dark brownish colour, that of the lateral ones being lighter.

The Animal is capable of withdrawing completely into the shell (Fig. 3). In the retired position the foot-sole is expanded, not folded, and fills the aperture like that of a *Limnæa*, owing to the fact that it lacks an operculum. The foot has a broadly oval form with an unbroken regularly rounded, and tapering margin all around. In the median line of the sole there runs a longitudinal furrow. On transversal sections this is seen to protrude very deeply in the

middle-part of the sole and to receive in its fundus the efferent duct of the foot-gland (Fig. 5).[1] The head is covered with a large cephalic disc, somewhat sinuous in front but without any trace of tentacles and without any median furrow. The disc is abruptly terminated behind. In the outer and hind parts of the disc the superficial eyes are visible. The colour of the animal is a darkish brown.

The Inner Anatomy. From the shape of the shell, the radula and the exterior morphology of the animal no definite conclusions as to the relations of the present form can be drawn. The presence of a cephalic disc gives rise to the supposition that it may belong to the group *Cephalaspidea* of the Tectibranchiate Opistobranchia; the shell reminds one more of *Actæon* than of anything else, but the radula and the absence of operculum as well as of parapodia at the foot-margins indicate affinity to the genus *Diaphana* of the family *Scaphandridæ*. In order to prove the correctness of this supposition, I have examined a specimen microscopically from sections. From the result the fact can be stated that no stomach-plates, which are much characteristic features of many of the genera of Tectibranchia, are present. In this respect too there is agreement with *Diaphana*. For comparison, therefore, I cut a specimen of *Diaphana hyalina* from Bohuslän and a specimen of its variety *glacialis* from Spitzbergen; these will also be dealt with and referred to in the following account.

The Intestinal Canal. The mouth of *Ptisanula* has no jaws, as is the case too with *Diaphana*. At the sides of the labial disc a pair of buccal glands debouch in both forms, just as in *Actæon*, *Hermæa* and other Nudibranchs. The pharyngeal cavity is furnished with a cylindrical epithelium that in *Diaphana* has cilia on its surface and a thin cuticula in *Ptisanula*. Further back in the expanded pharyngeal bulbus the epithelium becomes a cuticula, which in *Ptisanula* is remarkably thick. The walls of the bulbus are as usual muscular. In front of the radular sheath a pair of salivary glands debouch into the pharynx; these are very small in *Ptisanula*, larger in *Diaphana*. The oesophagus starts from the upper side of the pharynx, as usual; in *Ptisanula* it was bent back upon itself into a coil, the first bend of which was

[1] Cfr *Newnesia*, E. A. Smith, 1902.

furnished with a diverticulum pointing forwards;[1] in *Diaphana* the oesophagus was running straight backwards and had no diverticulum. The walls of the oesophagus have strong longitudinal folds, ciliated in *Diaphana*, cuticularized in *Ptisanula*. In the last-named form the section of the oesophagus is circular; further back it widens, the folds grow more numerous and become a thicker cuticula, and, exteriorly, a circular muscular layer. The stomach has a triangular section (Fig. 12) and its outer or left side is especially strongly cuticularized; here also the basal part of the epithelium is chitinoid and the cells of the stomach epithelium are flattened. The triangular section and the armed walls of the stomach seem to indicate a primary stage of the conditions found in other genera of Tectibranchia, where 3 chitinoid or calcareous plates are situated in the walls. The stomach gradually passes into the intestine, which is narrower and oval in section; it is furnished with only a thin cuticula and a feeble muscular layer.

In *Diaphana* no cuticularization of the stomach walls has taken place; the epithelium is like that of the oesophagus and of the intestine, consisting of cylindrical ciliated cells; in the stomach, however, the cilia are fused to a basal membrane. No muscular fibres surround the walls on the exterior.

In *Ptisanula* the stomach and the intestine were filled with a mass of partly masticated matter, that had been devoured. It consisted chiefly of small elongate cells apparently arising from some animal food that had probably been absorbed from the small hydroids among which the specimen was living when it was taken. The stomach of *Diaphana* was empty in both specimens, a circumstance indicating that they may be carnivorous like *Buccinum*, *Nassa* and other Gastropods, where the intestine is usually observed to be devoid of food (PETERSEN 1911).

The Genital Apparatus. On the right side of the head of *Ptisanula*, just in front of the eye and somewhat behind the mouth, a canal debouches under the head-lobe; this appears to belong to the male genital apparatus. If the canal is followed backwards, it will be found to lie above and to the right of the pharynx and to stretch somewhat

[1] Cfr *Newnesia* in the anatomical account given by ELIOT (1906).

behind the oesophagus, where it is widened and furnished with a coecal appendage, running forwards and upwards. Further back the canal grows narrower and terminates blindly (Figs. 5 and 9).

Within this canal or sheath the penis projects like a small bud from the walls, which at this point are strongly muscular. Before the glans penis, *i. e.* in the front part of the sheath, the walls are furnished with strong circular folds projecting into the lumen; towards the aperture the sheath widens sufficiently to cover the upper and right side of the pharynx. Behind the glans a ciliated epithelium lines the walls; further on it gives place to large bladder-like cells in irregular order, evidently with secretary function.

In *Diaphana* similar features prevail on the whole, though the sheath of the penis is longer and more winding and the glans is also more perfected (Fig. 10). In the distal part the sheath grows narrower and the walls become muscular and the canal very fine; this widens and opens to a furrow, from the bottom of which a rigid projection rises (Fig. 10), pointing forwards and consisting of a fibrous central pillar clothed with a simple layer of small ectoderm cells. The male orifice in *Diaphana* is situated near to the mouth on the right side. From it leads a ciliated seminal groove backwards under the cephalic lobe and over the neck to the female orifice. This is simple with a tendency to fall into two pores, of which one leads into a canal combined with a glandular dilatation along its outer side (Fig. 11), the other belongs to a narrower, complexly winding duct, lined with a folded ciliated epithelium and communicating at many points with the canal just named; in its upper part the last duct exhibits a sac-formed dilatation. This last-named canal is probably a rudimentary male outlet of the hermaphrodite duct. The second canal is the oviduct with its albumen gland. The connections between them reminds one of the conditions found in the Nudibranchia. At their upper ends the female and the male ducts join and pass into a glandular hermaphrodite canal, which issues from the hermaphrodite gland.

As regards *Ptisanula*, an outer seminal groove is likewise present at the right side of the body, but the other parts of the genital apparatus seem to be simpler than in *Diaphana*. One duct only, as far as can be stated, leads from the female

aperture; it is furnished with glandular walls in its distal part and with thin walls in its proximal end where it issues from the hermaphrodite gland. In the centre of this the spermatozoids are produced and so are the ova in its peripheral layer; both of the genital products are comparatively large, the spermatozoids measuring about 210 μ in length and the ova 110 μ in diameter. The sperma was mature and lay stored up in the upper part of the spermoviduct.

The Nervous System. By means of reconstruction of sections the following organization has been found for *Ptisanula* (Fig. 18). The nervous ring is situated in front of the pharyngeal bulbus. The cerebral ganglia are placed above and at the sides of the pharyngeal cavity and connected together by a commissure on the upper side of it. They send nerves forwards to the mouth, the sides of the head and the cephalic disc. Alongside them there is a special ganglion from which the optic nerve emerges. From the same ganglion is also innervated the epithelium situated on the under-side of the cephalic lobe. Among the connective tissue below this epithelium there is a layer of diffuse gangliar cells; these indicate, together with the fact that the epithelium itself is somewhat folded, the presence of an olfactory sense-organ.

On the under-side of the cerebral ganglia connectives emerge to the pedal ganglia; these are joined together by a double commissure below the pharynx. At their outer and posterior sides the statocysts are situated. Details of their constructions were not to be observed in *Ptisanula*, but in *Diaphana* they contain a great number of ovate statoliths.

From the hind side of the cerebral ganglia there issue short connectives running back to the pleural ganglia, which are also joined on to the pedal ones. A pair of long commissures also start from the hind side of the cerebral centra and run to the buccal ganglia, which are situated behind the pharyngeal bulbus and under the oesophagus.

From the pleural ganglia the pleurovisceral connectives continue in the backward direction. In them the parietal ganglia are differentiated. The right one is the largest and is found at the side of the pharynx somewhat higher than the left one, that being smaller and lying beneath the oesophageal coil. Both ganglia are situated at the sides of the buccal centra. We recognize in them the supraintestinal and

the subintestinal ganglia. The visceral ganglion is somewhat removed from those two, being situated under the intestine. Only a trace of the prosobranchiate crossing of the connectives remains in the visceral loop; the nervous system of *Ptisanula* thus exhibits the characteristics of the opisthobranchiate type and resembles that of *Scaphander* (cfr PELSENEER 1894).

A comparison of the organization just described with that of *Diaphana* (Fig. 19) gives the following results: In the last-named form the nervous system is more concentrated. Thus, we find that the right pleural ganglion is closely joined to the cerebral as well as to the pedal one through the fusion of their respective connectives; the visceral loop further is constricted to a mere ring around the pharynx, and the visceral ganglion lies close to the parietal ganglia. It represents therefore a higher stage of concentration than that of *Ptisanula*, which on the other hand is somewhat more contracted than that of *Scaphander*, owing to its shorter cerebroparietal connectives.

Organs of Sense. Another remarkable difference between *Ptisanula* and *Diaphana* exists in the reciprocal relation of the optic and olfactory regions. While in *Ptisanula* the optic nerve issues from a ganglion and a nerve-trunk, which is common to it and the tentacular nerve passing to the olfactory epithelium, *Diaphana* exhibits another arrangement: the optic nerves emerge direct from the cerebral centra and are separated from the tentacular nerves and their ganglia (cfr. Figs. 16, 17). In connection with the conditions named there is a remarkable difference in the position and the construction of the eyes. In *Ptisanula* they are situated immediately beneath the ectoderm, from which they are not separated by a stratum of connective tissue. The eye has the shape of a ball (Fig. 14), consisting of a peripheral layer of retinal cells, pigmented in their inner ends, and a central vitreous corpuscle of a grainy consistency. The external side of this lens, where no pigment covers it, is flattened or is only slightly convex. The optic nerve enters in the hind wall of the eye. The eyes are surrounded, except on their front side, by connective fibres and blood lagoons. Beneath them some cells are observable containing a secretion (*a* in Fig. 14); these cells are probably chromatophores.

In *Diaphana* the eye has sunk deeper in the cephalic lobe and has become embedded in the connective tissue (Fig. 13). It appears to be somewhat reduced in size if compared with that of *Ptisanula*, the specimen of *D. glacialis* being twice as large as the *Ptisanula* one; the eye, however, is of the same size as in the latter. The structure is chiefly uniform but here a homogeneous sphæroid lens of a solid consistency replaces the vitreous corpuscule. The hind half of the lens is covered by pigment, the front half of it projects semisphæroidally with a strongly convex surface.

If the tentacular nerve is followed up in its distal ramifications, a stratum of diffuse nervous cells will be found, as already mentioned, located just in the angle between the under-side of the cephalic disc and the sides of the head. Here, the olfactory or rhinophorial organ is to be found, as stated above. The ectoderm is folded irregularly and consists of cylindrical ciliated cells with a large basal nucleus; they are in contact with the ganglious cells. The composition displays the same scheme as the rhinophorial lamellæ of *Haminea hydatis*, as described by PELSENEER 1894. Consequently the epithelium mentioned is to be considered as representing a rudiment of rhinophores, not yet differentiated to the same degree as in *Bulla*. In *Ptisanula* and *Diaphana* we meet with the first stage of development of the rhinophores, which are so characteristic for the Opistobranchia. They assume the olfactory function by the gradual reduction of the osphradium. Starting on the assumption that the forms described here represent this first stage, I have made an attempt at analysing the further development of the rhinophores. Though it lies, strictly speaking, outside my present subject, this survey may be given here, as nothing of the kind has hitherto been published, the origin of the rhinophores having been very uncertain. Further, this process, on the assumption here given, seems to throw a new light upon the mutual relationship existing among the Opisthobranchia.

Phylogeny of the Rhinophores of Opistobranchia.

In *Actæon* I found, on examining sections, that the optic and the tentacular nerves start from a common, though short,

root. The optic nerve is long and ascends to the superficial eye, the tentacular nerve descends and becomes almost immediately bifurcated into one fore and one hind branch, which innervate the cephalic lobe and the sides of the head. No diffuse ganglious layer and no expansion of the nerval root to a tentacular ganglion are noticeable (Fig. 15).

In *Doridium*, *Philine* and *Scaphander* the optic and tentacular nerves start separate from one another, though they are together. *Doridium* alone has long eye nerves, the others have very short ones. The tentacular nerve has no proximal ganglion and its distal ends lead to an olfactory organ, that is distinct only in *Doridium*. In *Scaphander* it is very rudimentary (VAYSSIÈRE 1879).

In *Gastropteron* the optic nerve emerges from a ganglion common to it and the tentacular nerve, as in *Ptisanula;* it is of considerable length; the tentacular nerve ramifies in the cephalic disc; olfactory organs are absent (VAYSSIÈRE 1879).

Thus, among the Tectibranchia the variation is considerable as regards the nerves and the exterior equipment of the olfactory organs. Where these begin to appear, as in *Diaphana* and *Ptisanula*, the sensory epithelium is uniformly and simultaneously distributed to the under-side of the cephalic disc and to the sides of the head. In this arrangement we may find the origin of the various kinds of olfactory lamellæ in the Bullidæ, they being in some forms placed laterally on the head, in others on the under-side of the cephalic lobe. In the first case they are usually bipectinate and resemble the rhinophores of the Nudibranchia. They have been described in *Haminea* (VAYSSIÈRE 1879, PELSENEER 1894) and *Atys* (VAYSSIÈRE 1906). In the second case they are present, either as transversal simple lamellæ in *Bulla* (VAYSSIÈRE 1885, 1906), or as a pectinate projection like a paucifoliate gill in *Aplustrum* (VAYSSIÈRE 1906 and my own observations). Both in *Bulla* and in *Aplustrum* the folds are placed between the fore and the hind lobes of the cephalic disc. In *Aplustrum* these lobes are produced in tentacles and infolded like channels.

The nervous system in all Bullidæ shows a long optic nerve leading to a superficial eye and a tentacular nerve separated from it, but placed quite close, without any prox-

imal ganglion but with diffuse gangliar cells beneath the olfactory lamellæ (VAYSSIÈRE 1870, 1906, PELSENEER 1894).

Thus, within the Bullids, several types are represented, and among them may be traced the origin of the higher forms of the olfactory organs or rhinophores of the Opisthobranchia. This later development will probably have taken place in the following way:

The lamellæ of the *Bulla* type extend to the hind lobe of the cephalic disc, which becomes enrolled just as in *Aplustrum*, and more or less produced; the anterior lobe is subject to a similar infoldation. The whole inner surface of the lobe (= hind tentacle or rhinophore) is thus either strongly laminated (*Umbrella*, *Tylodina*, *Pleurobranchæa*), or has at least traces of lamination. In *Hermæa dendritica*, *Oxynoë olivacea* and *Pleurobranchus stellatus* I have seen them on sections within the rhinophores; by macroscopical examination they are not observable. The rhinophores of all these forms are consequently homologous to the hind cephalic lobe of the Bullidæ.

The lamellæ on the inner surface of the rhinophores may become specialized in several directions, *e. g.* combined to a bipectinate projecting column which is enclosed within the rest of the rhinophore surrounding the named lamelliferous club or column like a sheath (*Tethys*, *Tritonia*, *Doridídæ phanerobranchiatæ*, *Dendronotus*, *Doto*).

From the stages of development just described processes of secondary reduction or simplification may arise. Thus, in a more primitive stage, the channel-shaped rhinophores may grow together to conical features (*Ercolania funera;* in *E. Panceri* they are still open; VAYSSIÈRE 1889) or may wholly disappear (*Limapontia*).

In the higher forms of rhinophores the sheath may disappear (as in all the *Aeolididæ*, all the *Doridídæ cryptobranchiatæ*, and many *D. phanerobranchiate*) or the lamellæ of the rhinophorial club may do so (as in many *Aeolididæ* and many *D. phanerobranchiatæ*).[1] The crista interrhinophorialis in *Janidæ* is perhaps to be interpreted as a remnant of the sheath. The rhinophores thus represent the remaining central pillar

[1] In *Corambe* only two of the lamellæ are present; they are much expanded and therefore cause some resemblance to an infolded rhinophore (cfr FISCHER 1891).

is perhaps *Diaphana*. Neither *Newnesia* nor *Diaphana* have parapodia, jaws or stomach plates, and the radula is very narrow, being triseriate in *Diaphana*, uniseriate in *Newnesia*». Further, there are rudimentary tentacles in the anterior corners of the cephalic disc and an external seminal groove. In many of its characters *Newnesia* approaches *Ptisanula* too, and the radula of this form seems to be intermediate between *Diaphana* and *Newnesia*, owing to its rudimentary or reduced lateral laminæ. On the other hand, however, *Newnesia* has its head-shield prolonged behind into two well-developed, grooved processes, and has a shell resembling that of *Aplustrum*. ELIOT assumes that it might perhaps constitute a form connecting the *Bullacea* and the *Lophocercidæ* together.

The difference in characters between *Diaphana* and *Ptisanula* on the one hand and the other *Scaphandridæ* on the other justifies keeping them apart and placing the former in a distinct family, *Diaphanidæ*, to embrace probably *Newnesia* also. Our present knowledge, however, of the affinities among Tectibranchia is still very superficial, and further investigations must be carried out before their delimitation into natural groups can be undertaken with any pretence to scientific accuracy.

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Explanation of the Plate.

Fig. 1. *Ptisanula limnæoides*, fossil shell from Kapellbacken, at 22 m above the sea; spire somewhat broken. × 10 and nat. size.

Fig. 2. The same, a recent shell from Bel Sound, 5—12 fms, seen from aperture and from back; cuticula removed. × 10 and nat. size.

Fig. 3. The same from Horn Sound, with cuticula and withdrawn animal. × 10 and nat. size.

Fig. 4. The same, fossil, from Kapellbacken at 26 m above the sea. × 10 and nat. size.

Fig. 5. Scheme of the organisation of *Ptisanula*. *f* median furrow in which the foot gland opens, behind the pharynx, *int* intestine, *m* mouth, *oc* eye, *p* penis, *ph* pharynx, ♂, ♀ male and female genitale pore. Nervous system black.

Fig. 6. Radula of *Ptisanula limnæoides;* some teeth from the side; the lam. laterales cover the median teeth. × 325.

Fig. 7. Transversal section of the radular sheath; *lat* lam. laterales.

Fig. 8. Radula, seen somewhat from below; under the median teeth the lam. laterales of the left side are seen from outside. × 325.

Fig. 9. Genital apparatus of *Ptisanula limnæoides*. *p* penis.

Fig. 10. Penis of *Diaphana glacialis* in its sheath.

Fig. 11. Genital apparatus of *Diaphana glacialis*. *gl* albumen gland, *p* penis, *sp* spermatocyst, ♂ hermaphrodite gland with its ductus deferens *(duct)*, ♀ orifice of the vagina, ♂ orifice of the penis sheath.

Fig. 12. Transversal section of the stomach of *Ptisanula*. *cut* cuticula, *m* muscular layer.

Fig. 13. Horizontal section through the eye of *Diaphana glacialis*. *c* cerebral ganglion, *gangl* diffuse olfactory ganglious layer, *n* nerve, *oc* eye, *ol* proximal or tentacular ganglion. × 185.

Fig. 14. Frontal section through the eye of *Ptisanula*. *a* chromatophores, *oc* eye. × 185.

Figs. 15—17. Scheme of the combination of optic and tentacular nerves in *Actæon* (Fig. 15), *Ptisanula* (Fig. 16), and *Diaphana* (Fig. 17). *c* cerebral ganglion, *ect* ectoderm, *gangl* diffuse olfactory ganglious layer, *oc* eye, *tent* tentacular nerve.

Figs. 18—19. Scheme of the nervous systems of *Ptisanula* (Fig. 18) and *Diaphana* (Fig. 19). *bucc* buccal ganglia, *c* cerebral ganglia, *gl* salivary glands, *int* intestine, *m* mouth, *oc* eyes, *ol* tentacular ganglia and the diffuse olfactory layer, *ped* pedal ganglia, *ph* pharynx, *pl* pleural ganglia, *sub* subintestinal ganglion, *sup* supraintestinal ganglion, *visc* visceral ganglion.

Tryckt den 10 februari 1914.

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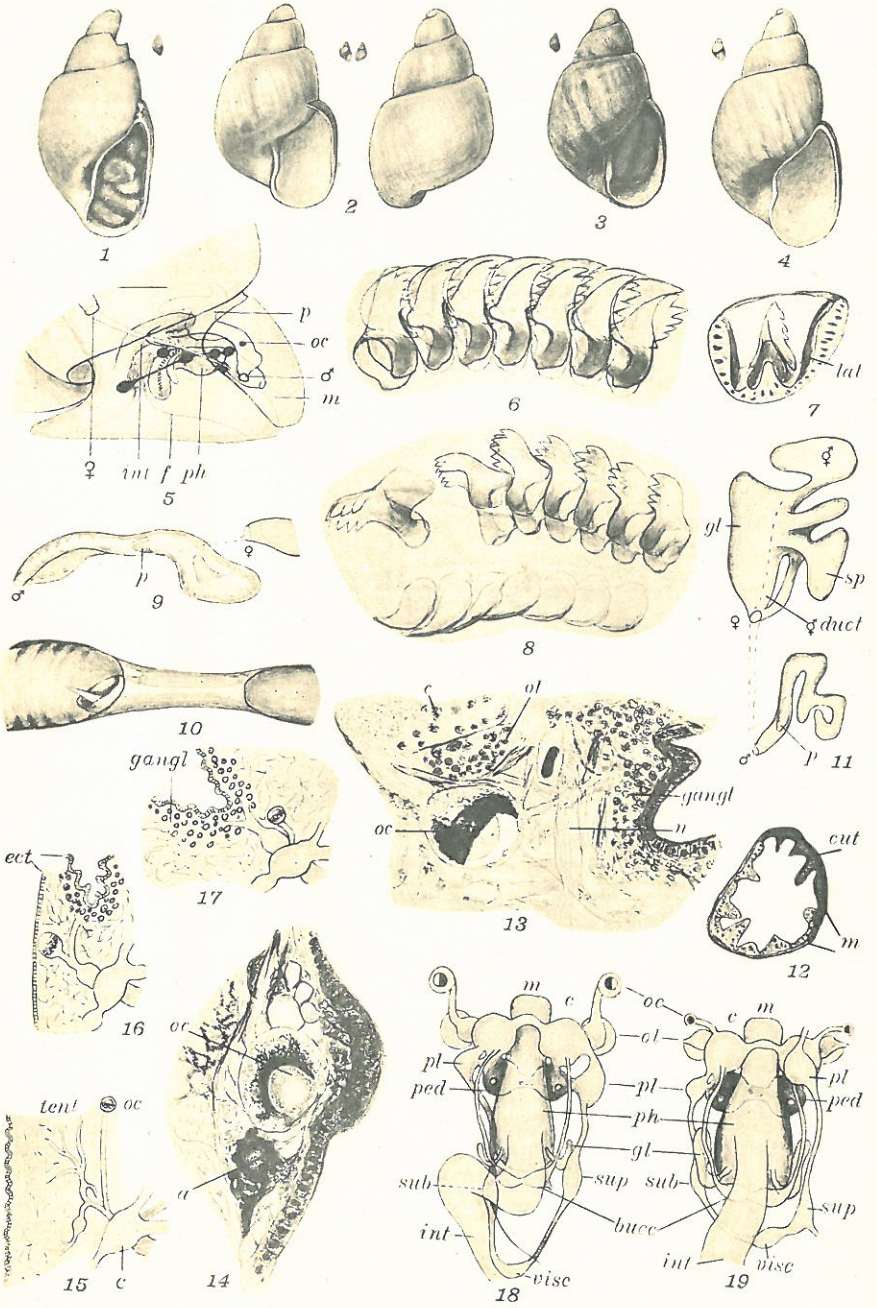
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