Notes on the Anatomy and Biology of Subulina kassaiana Rochebrune et Germain

by
L. A. W. C. VENMANS and E. FRÖMMING

In November 1954 the Rev. Father CHR. VAN DEN HOF collected a number of about 300 living specimens of a *Subulina*-species in the environments of Yanonge in the Belgian Congo, and kindly presented the first named author with them. The shells are now in the collection VENMANS and registered under No. 6793.

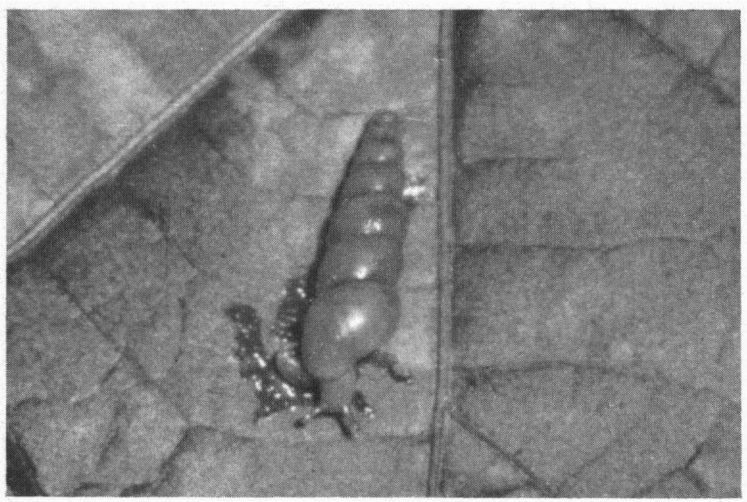

Fig. 1. *Subulina kassaiana* Rochebr. & Germ., specimen feeding on the epidermis of a leaf.

Mr. G. RANSON, curator of the malacological department of the Natural History Museum at Paris, kindly compared them with the *Subulina*-material in his Museum, and came to the conclusion, that they belonged to the species *Subulina kassaiana* Rochebrune & Germain.

The species was hitherto only known from the type locality at the confluence of the Kasai and Congo rivers, in the western part of the Belgian Congo, where it was found by Mr. DU BOURG DE BOZAS at an altitude of 300 meters. It has been described and figured by

the authors in 1904, and afterwards by PILSBRY in 1906. It is also mentioned by PILSBRY in his Land Mollusks of the Belgian Congo in 1919.

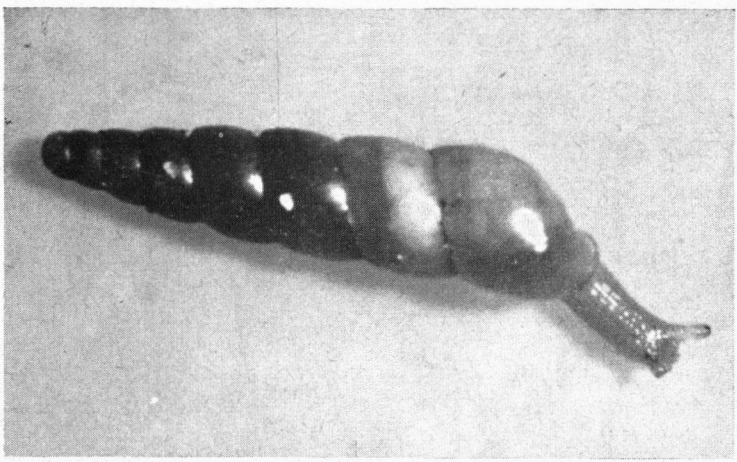

Fig. 2. *Subulina kassaiana* Rochebr. & Germ., almost full-grown specimen.

At their arrival in the Netherlands most of the specimens from Yanonge were still living (figs. 1, 2), so that one of us (FRÖMMING) could study the biology of the species, whereas the study of the shells and the anatomy of the animals was undertaken by the other author (VENMANS), who is indebted to Dr. H. E. QUICK for his kind and indispensable assistance.

THE SHELL

The translation by PILSBRY (1906, p. 83) of the original latin description of ROCHEBRUNE and GERMAIN (1904, p. 142) runs as follows:

„Shell imperforate, very slender, long-cylindric, rather solid, translucent, a little shining, corneous greenish, moderately and regularly striatulate. Spire very long, cylindric, obtuse at the summit; apex obtuse, the embryonic whorl very minute. Whorls 8, convex, slowly increasing, separated by a deep suture, the last whorl convex. Aperture oblique, ovate, buff within; peristome unexpanded, acute; columella short, rather stout, abruptly truncate below".

The measurements given by the authors in their first publication (1904, p. 142) are: Height 12.5—14.5, Diameter 3—3.5, Height of aperture 3, Breadth of aperture 2—2.5 mm. In their second publication (1904, p. 16) they give, in contravention of their former

statement, the measurements of the aperture: height 3—3.5, breadth 2—2.25 mm.

The shells from Yanonge agree completely with the description of ROCHEBRUNE and GERMAIN.

The embryonic shell consists of one and a half to two whorls, and is up to 1.7 mm in diameter. Under a strong magnification the first embryonic whorl appears to have a microscopically fine spiral and transverse striation, which, however, only very seldom is retained in adult specimens. On the following half whorl only a faint irregular transverse striation can be seen, which is somewhat stronger towards the suture.

From the measurements following below it appears, that *Subulina kassaiana* can become much larger and can have more whorls than is mentioned by ROCHEBRUNE and GERMAIN. One specimen of the Yanonge population even attained a height of shell of 17.4 mm and has 10 whorls. 8% have a height of shell of more than 14.5 mm (maximum 17.4 mm); 38.4% have more than 8 whorls (maximum 10 whorls); 35.6% have a major diameter of more than 3.5 mm (maximum 4.3 mm); 16.4% have a height of aperture of more than 3 mm (maximum 3.7 mm); 2% have a breadth of aperture of more than 2 mm (maximum 2.2 mm).

It is almost never possible to make out with complete certainty, whether a *Subulina kassaiana* shell is fully adult, the outer lip of the aperture remaining thin and sharp even in adult shells. Nor is the

Table. 1. Ratio number of whorls: height of shell

Height of shell	Number of whorls													Total number
in mm × 10	10	9¾	9½	9¼	9	8¾	8½	8¼	8	7¾	7½	7¼	7	of specimens
92—95	—	—	—	—	—	—	—	—	—	—	—	—	1	1
95—100	—	—	—	—	—	—	—	—	—	—	2	5	3	10
100—105	—	—	—	—	—	—	—	—	—	2	10	5	1	18
105—110	—	—	—	—	—	—	—	—	—	9	15	4	—	28
110—115	—	—	—	—	—	—	—	1	4	8	6	1	—	20
115—120	—	—	—	—	—	—	—	1	6	8	1	—	—	16
120—125	—	—	—	—	—	—	6	8	9	2	—	—	—	25
125—130	—	—	—	—	1	—	5	4	6	1	—	—	—	17
130—135	—	—	—	—	1	1	6	2	2	—	—	—	—	12
135—140	—	—	—	2	3	8	5	3	—	—	—	—	—	21
140—145	—	—	—	1	4	4	1	1	—	—	—	—	—	11
145—150	—	1	1	1	2	1	—	—	—	—	—	—	—	6
150—155	—	1	1	—	1	1	—	—	—	—	—	—	—	4
155—160	—	1	1	1	—	1	—	—	—	—	—	—	—	4
160—165	—	—	—	—	1	—	—	—	—	—	—	—	—	1
165—170	—	1	1	—	1	—	—	—	—	—	—	—	—	3
170—174	1	1	1	—	—	—	—	—	—	—	—	—	—	3
Total number of specimens	1	5	5	5	14	16	23	20	27	30	34	15	5	200

presence of eggs in the uterus a conclusive proof that we have to do with a full-grown specimen. Just as in *Subulina octona* (Brug.) (PILSBRY, 1946, p. 173) and other Subulininae, also in decidedly young animals of *Subulina kassaiana* with scarcely developed male organs

Table 2. Ratio height of shell: major diameter of shell

Height of shell in mm × 10	Major diameter of shell in mm × 10														Total number of specimens
	30	31	32	33	34	35	36	37	38	39	40	41	42	43	
170—174	—	—	—	—	—	—	—	—	—	—	1	—	1	1	3
165—170	—	—	—	—	—	—	—	—	—	—	3	—	—	—	3
160—165	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
155—160	—	—	—	—	—	—	—	—	1	2	—	1	—	—	4
150—155	—	—	—	—	—	—	—	1	1	—	2	—	—	—	4
145—150	—	—	—	—	—	—	1	3	2	—	—	—	—	—	6
140—145	—	—	—	—	—	1	2	3	3	2	—	—	—	—	11
135—140	—	—	—	—	2	3	5	5	2	2	2	—	—	—	21
130—135	—	—	—	—	1	1	2	5	1	2	—	—	—	—	12
125—130	—	—	—	—	1	5	6	2	2	—	1	—	—	—	17
120—125	—	—	1	2	6	8	5	1	2	—	—	—	—	—	25
115—120	—	—	1	2	4	3	2	3	—	1	—	—	—	—	16
110—115	1	—	2	4	5	4	3	1	—	—	—	—	—	—	20
105—110	1	2	6	6	9	2	—	1	1	—	—	—	—	—	28
100—105	2	2	4	4	3	3	—	—	—	—	—	—	—	—	18
95—100	4	2	1	1	1	1	—	—	—	—	—	—	—	—	10
92—95	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Total number of specimens	8	7	15	19	32	31	26	25	15	9	9	2	1	1	200

Table 3. Ratio height of shell: height of aperture

Height of shell in mm × 10	Height of aperture in mm × 10																	Total number specimens
	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37		
170—174	—	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—		3
165—170	—	—	—	—	—	—	—	—	—	—	—	2	—	—	1	—		3
160—165	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1		1
155—160	—	—	—	—	—	—	1	—	1	—	1	—	1	—	—	—		4
150—155	—	—	—	—	—	—	—	—	—	1	1	—	1	1	—	—		4
145—150	—	—	—	—	—	—	—	—	3	1	1	1	—	—	—	—		6
140—145	—	—	—	—	—	—	—	2	4	1	3	—	1	—	—	—		11
135—140	—	—	—	1	—	3	—	4	5	4	2	—	2	—	—	—		21
130—135	—	—	—	—	—	1	1	2	4	1	1	1	1	—	—	—		12
125—130	—	—	—	1	1	1	4	2	5	2	—	1	—	—	—	—		17
120—125	—	—	—	—	1	5	8	3	5	3	—	—	—	—	—	—		25
115—120	—	—	—	—	2	1	5	4	3	—	1	—	—	—	—	—		16
110—115	—	—	—	1	1	5	7	3	3	—	—	—	—	—	—	—		20
105—110	—	—	1	2	8	7	3	4	2	—	1	—	—	—	—	—		28
100—105	1	2	2	3	2	3	4	—	1	—	—	—	—	—	—	—		18
95—100	—	—	2	2	4	—	1	1	—	—	—	—	—	—	—	—		10
92—95	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—		1
Total number of specimens	1	2	5	10	20	26	34	25	36	14	11	5	6	1	3	1		200

and with shells of only 6 whorls and a height of 8.5 mm, eggs may be present.

In consequence of the uncertainty as to whether a shell is full-grown, it is impossible to calculate the exact averages of measurements nor their standard deviations. In order to get a notion of the taxonomic unities and to show the variability of the species, which is quite great, the tables 1-3 are composed.

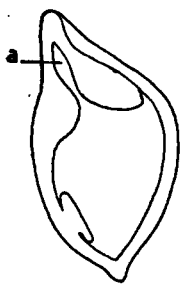

Fig. 3. *Subulina kassaiana* Rochebr. & Germ., mantle edge; a. respiratory orifice.

THE ANIMAL

Through want of time the animals had to be preserved during one year before examination was possible. The liquid in which they were preserved consisted of 17 parts of alcohol 96%, 20 parts of distilled water, 2 parts of formalin, and 1 part of glycerin, which liquid as a rule has proved to preserve the colours of molluscs quite well. In examining the animals preserved in that liquid the skin of the foot, head and mantle appeared to be completely unpigmented. Only the dark pigmentation of the eyes is perceptible, as is usually also the case in other molluscs. The first 3 or 4 whorls appear light brownish according to the colour of the underlying organs.

The foot is pointed posteriorly; in front it is evenly rounded; a conspicuous irregularly wrinkled peripodial groove and a small, vertically grooved foot-fringe are present. The footsole is narrow and undivided longitudinally. A caudal mucus pore has not been found.

The shell-lobes of the mantle-edge (Fig. 3) are absent, but the neck-lobes are well developed, the lower left neck-lobe being rather widely separated from the upper one.

The animal is ovoviviparous like many of the Subulinidae.

PALLIAL ORGANS (Fig. 4)

The mantle-cavity is narrow and very long, about eight times as long as the pericardium, occupying the last two whorls of the shell. The roof is very thin; the main pulmonary vein, which runs back throughout the length of the roof into the auricle of the heart, is faintly visible; of a secondary venation scarcely any trace is perceptible.

The pericardium has a length of about 1 mm, and a major diameter of about 0.4 mm.

The kidney, which is situated at the hinder end of the mantle-cavity, is roughly triangular, and surpasses the pericardium anteriorly as well as posteriorly, as is usual in most Subulininae. The cardiac border is concave in accordance with the convexity of the pericardium. Near the top the kidney gives rise to the primary ureter, which runs backwards to near its base, and then bends quite abruptly forwards as the secondary ureter, close to the rectum, until it reaches the mantle-edge.

DIGESTIVE SYSTEM

The aulacognath jaw is slightly arcuate, thin, yellowish brown. From tip to tip the flattened jaw (Fig. 5a) measures about 0.8 mm, whereas the mean breadth is about 0.2 mm. Posteriorly it shows a weak projection in the middle. The surface is densely and irregularly wrinkled.

The radula (Fig. 5b) has a length of about 1.7, and a breadth of about 0.7 mm. The number of transverse rows, which have a course as is shown in fig. 6c, goes in the specimens examined to the limit of 86. Apart from the rhachidian tooth each row consists of 52 tricuspid teeth. The rhachidian tooth is well developed, its basal plate is narrow, the sides slightly diverging in the middle. It has a length of about 0.022 and a mean breadth of 0.009 mm. The small tooth itself consists of a relatively large mesocone and an indication of a minute cusp on either side. The first ten or eleven teeth on each side of the rhachidian tooth are about two or three times as broad; they are tricuspid having a large, rather broad mesocone, whose pointed end considerably surpasses the posterior edge of the basal plate, and on each side of it a small pointed cusp. In the marginal teeth, which are also tricuspid, the basal plate diminishes in size towards the edges, and becomes squarer, whereas the mesocone becomes gradually smaller and the entocone proportionally lengthens. From about the seventeenth marginal tooth towards the outer edges of the radula

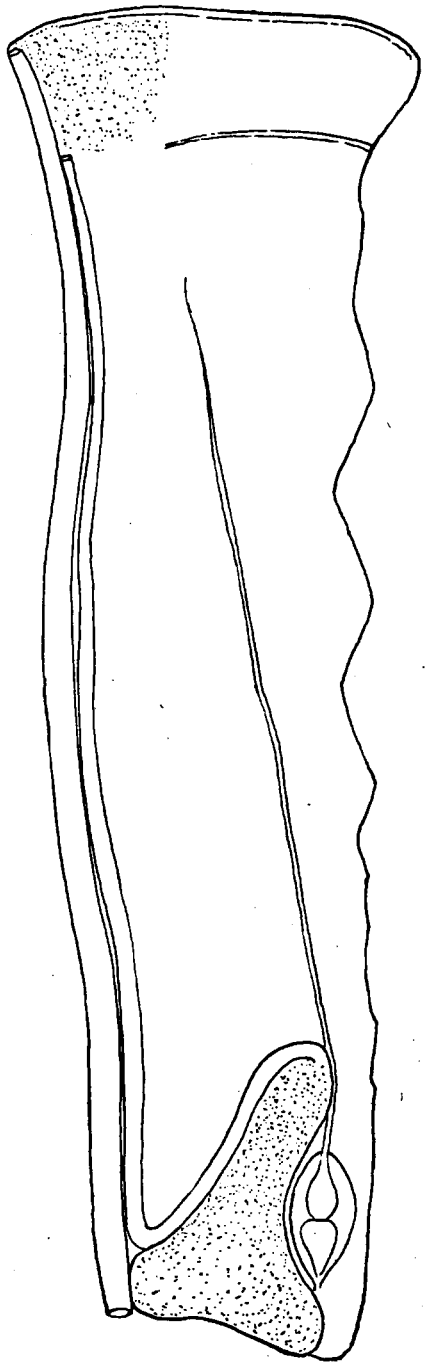

Fig. 4. *Subulina kassaiana* Rochebr. & Germ., pallial organs.

the mesocone and the ectocone are very small and of about the same length, whereas the entocone excels them considerably in length.

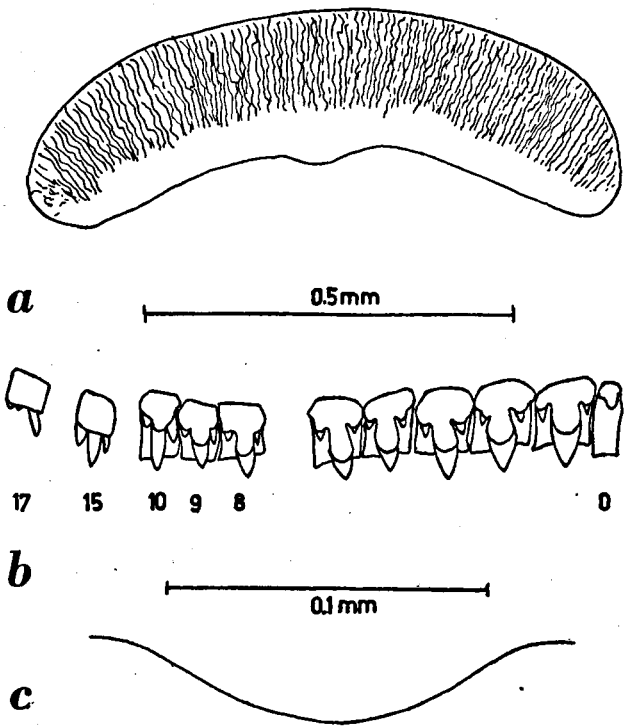

Fig. 5. *Subulina kassaiana* Rochebr. & Germ., a jaw; b. teeth of the radula; c. course of transverse rows of the radula.

GENITALIA (Fig. 6)

The ovotestis is composed of three fan-shaped tubules. The hermaphroditic duct is long and rather wide; it consists at first of a very short, straight tube, and then distally proceeds by four or five wide convolutions towards the albumen gland, which is comparatively large, elongated and somewhat narrowing apically. At the end of the hermaphroditic duct is a claviform talon.

The spermoviduct is small, but in pregnant animals it is enormously swollen to accomodate the large eggs, of which up to five

have been counted. In accordance the transparent walls consisting of interlacing fibers are very thin and delicate.

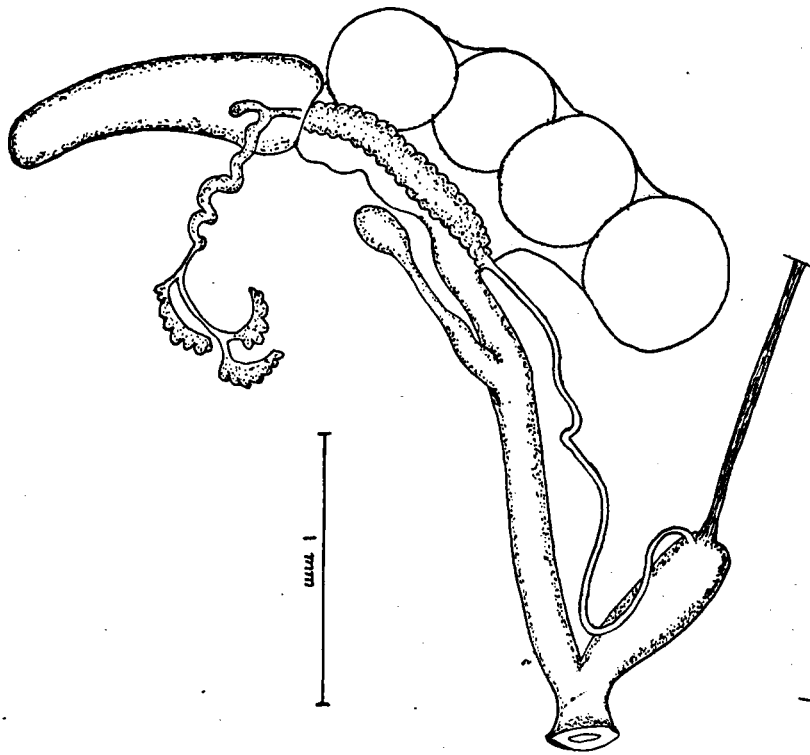

Fig. 6. *Subulina kassaiana* Rochebr. & Germ., genital organs.

The white egg-capsules are calcareous and of an oblately spheroidal form. Each of them contains a very pale yellow, subglobular, apically depressed embryonic shell. The embryos still show the caudal vesicle or podocyst (Fig. 7, c), which is observed in the embryos of most Stylommatophora. When alive this little organ, which degenerates completely in a later state of growth, rhythmically pulsates in order to ensure the circulation of the nutritive fluid in the elementary circulatory system.

The male side of the spermoviduct shows a well developed prostate gland.

The free oviduct is rather wide, but not very long, having a length of about 0.4 mm. The short receptaculum-duct is narrow apically, but slightly swollen towards the base; it has a length of about 0.3 mm, and bears a club-shaped spermatheca, which is situated close to the anterior end of the basal uterus.

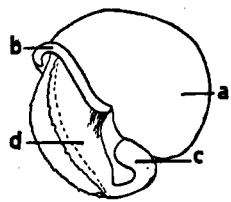

Fig. 7. *Subulina kassaiana* Rochebr. & Germ., left side view of embryo; a. shell; b. mantle; c. podocyst; d. foot.

The vagina is rather long, having a length of about one millimeter. Throughout its length it is of the same breadth, which is only a little narrower than the penis.

The short genital atrium opens into the genital orifice, which is situated at a little distance below and behind the right lower tentacle.

The vas deferens is long and narrow throughout its length; it is completely free and does not wind around the vagina; it extends anteriorly to about the angle between the vagina and the penis, and then passes back to enter the posterior end of the penis near the insertion of the very long penial retractor muscle.

The subcylindrical penis is simple and rather short, having a length of about 0.6 mm and a diameter of about 0.2 mm. There is no penial papilla nor is the penis surrounded by any sheath-like cover. A flagellum is not present.

CENTRAL NERVOUS SYSTEM (Fig. 8)

The buccal ganglia (m), which are situated on the bulb and under the oesophagus, are small and have a globular form. They are united to each other by a rather long and relatively wide commissure (n) and to the cerebral ganglia by shorter cerebro-buccal connectives (q).

The cerebral ganglia (a) are large and have a transversally oval form, the breadth being somewhat greater than the height; anteriorly they are united by a thick cerebral commissure (b). Laterally each is connected with the corresponding eye-tentacle (o) by a rather short optic nerve (p).

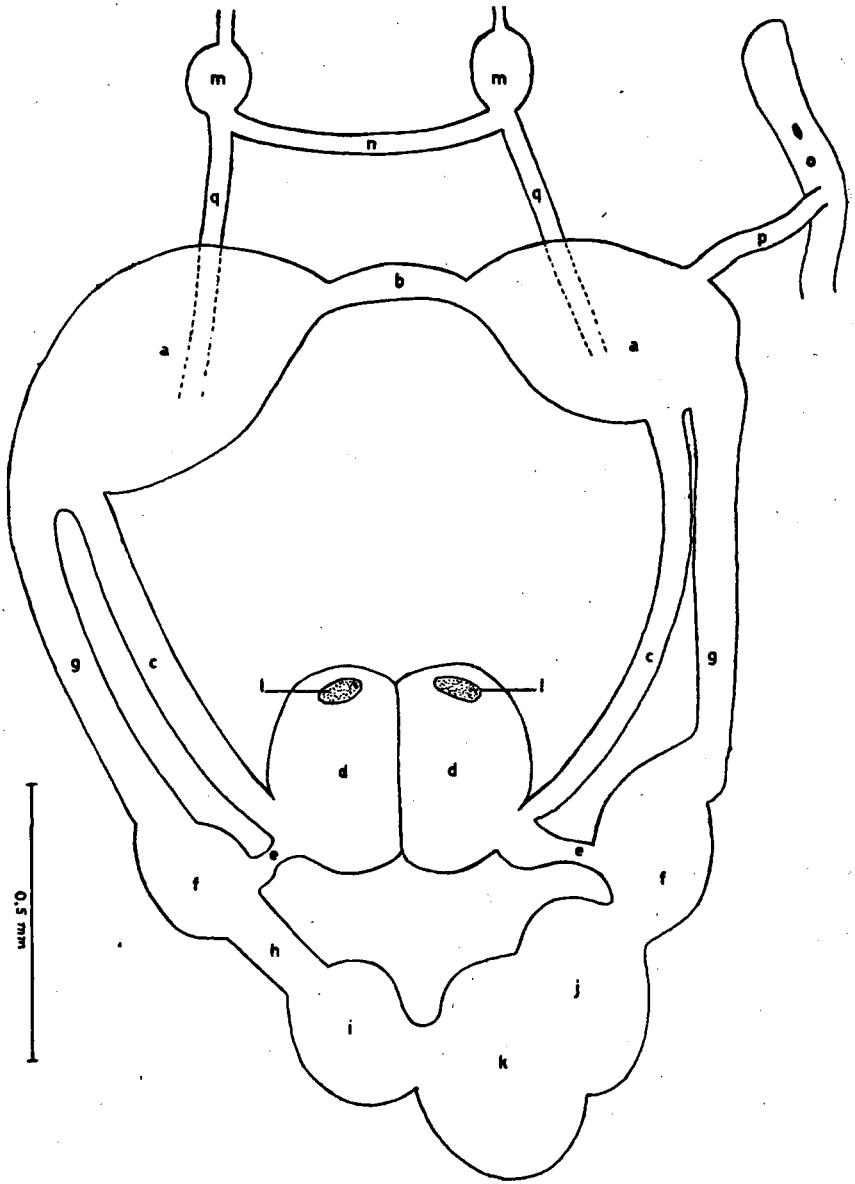

Fig. 8. *Subulina kassaiana* Rochebr. & Germ., central nervous system.

A relatively short cerebro-pedal connective (c) connects each cerebral ganglion with the corresponding pedal ganglion (d), which has a vertically ovoid form. The pedal ganglia are closely joined together in the middle without any conspicuous commissure.

Very short pleuro-pedal connectives (e), which are about one and a half times as broad as the cerebro-pedal ones, connect the pedal ganglia with the corresponding pleural ganglia (f).

The pleural ganglia, which have a globular form and are about half as large as the pedal ganglia, are united to the cerebral ganglia by cerebro-pleural connectives (g), which are about one and a half times as wide and somewhat shorter than the cerebro-pedal connectives.

The visceral and abdominal part of the nervous system is asymmetrical and slightly displaced towards the right. The left pleural ganglion is posteriorly connected by a short and wide pleuro-visceral connective (h) with the left visceral ganglion (i), which has a globular form and about the same length as the pleuro-visceral connective. The right pleural ganglion, which has also a globular form, but is slightly larger than the left pleural ganglion, is not connected with the right visceral ganglion (j) by any conspicuous connective, but is only separated from it by a narrowing of the tissue. In the same manner the right visceral ganglion is united posteriorly to the larger abdominal ganglion (k), which is — also without any real connective — at its left side connected with the left visceral ganglion.

In the anterior part of each pedal ganglion there is an elliptical otocyst (l), which is well-marked by its darker pigmentation and contains a great number of very small, roundish crystalline particles.

BIOLOGY

Three living specimens were placed in a container half filled with vegetable mould; in the morning- and evening-twilight the animals were very active; during day-time, however, they were hiding in the crevices of the soil, or burrowed so deep, that only the tops of the shells were visible.

During the winter the animals were provided with carrot, fruit and greens of all sorts, in summer with diverse indigenous higher plants. Many plants were eaten in fresh condition, but equally readily and often apparently with still more appetite the withered and rotten parts were accepted. With this nutriment the animals prospered excellently, so that it is likely that *Subulina kassaiana* also in its natural habitats is chiefly phytophagous.

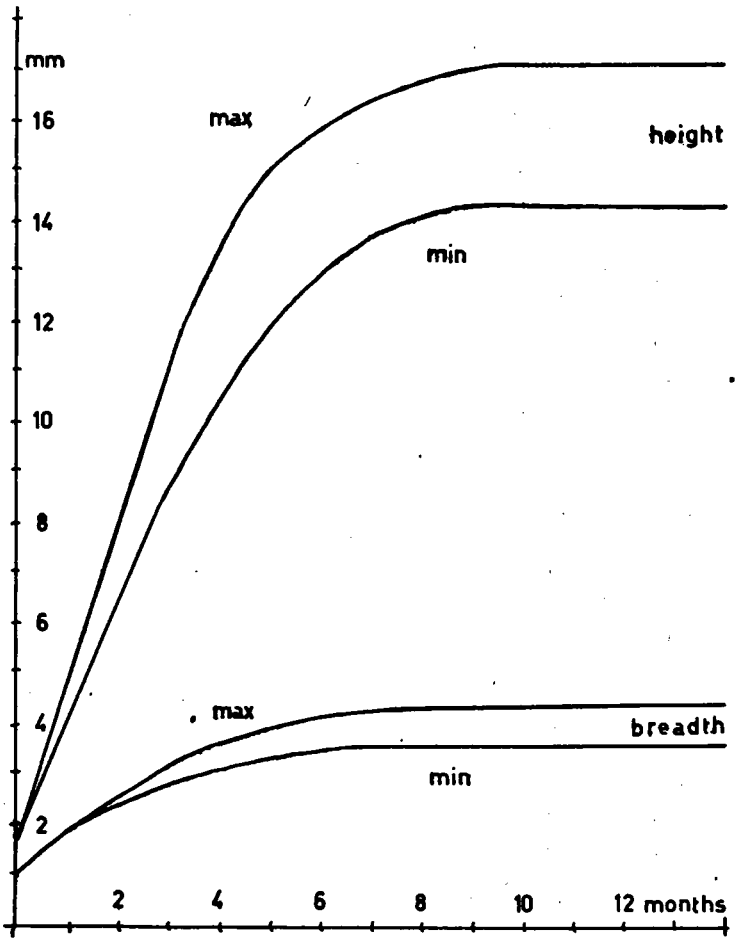

Fig. 9. *Subulina kassaiana* Rochebr. & Germ., graph showing the maximum and minimum monthly increase of the height and breadth of the shell of specimens hatched in captivity.

An indication of the well-being of the animals was also the ready egg-laying, which already began in the end of December, notwithstanding the fact, that at that time their shells were only 11—12 mm high and not yet fully grown. The production of eggs continued during the whole winter, and at every laying 1—3 eggs were deposited. The eggs were deposited in cavities of the soil, under

stones or plants. They are nearly globular, somewhat flattened at the poles, and lime-white coloured; the major diameter ranges from 1.4 to 1.6 mm. The embryonic development took at indoortemperature 20—25 days.

According to the great number of eggs also the postembryonic development could be studied more thoroughly. When the young animal leaves its egg, it has a uniform whitish colour. The shell contains then 1½—2 whorls, and is almost colourless, transparent and very shining. The young animals remain mostly on the bottom and feed during the first weeks exclusively on withered and rotten plant-like substances. Later on they begin to feed also on higher living plants, such as cut-through turnips, carrots and so on. Especially slices of carrot are eaten eagerly. In consequence of this nutriment the animals grew up rather quickly. A number of them have been measured regularly every four weeks and thus the growth of the shell could be traced.

In Fig. 9 the measurements are plotted as curves; the upper curve shows at every time the height and breadth of the greatest, the lower curve the same measurements of the smallest specimen, so that the natural degree of variation of the growth is defined, because all animals grew up together in the same terrarium.

It is a well-known fact, that in most gastropods such differences of shell-size can be found. Many examples of this phenomenon are quoted by FRÖMMING (1954). These differences appear not only in animals of one and the same population, but also even in animals of the same nidus. Though the fundamental cause of this differentiation is not yet clear, FRÖMMING (1955), in breeding a great number of *Eobania vermiculata* (Müll.), was able to state that the differences are genotypically determined.

For when one observes in a set of eggs the hatching of the animals, one sees, that not all animals come out of their eggs at the same day, though the duration of the development is the same, but that there is a space of several days between the hatching of the first and that of the last animal. The first hatched and usually strongest animals are already eating solid food, whereas their companions are still in their eggs or are still engaged in coming out of them. The last hatched animals tend to be the weakest and generally fail to overtake the others in growth.

This phenomenon appeared also to be present in the life of *Subulina kassaiana*. The animals examined attained a life-time of 14 months, so that one may assume that their natural life-time is about one year.

The adult animals are unicoloured yellow and have a yellow, somewhat lustrous shell.

REFERENCES

ROCHEBRUNE, A. T. DE, et L. GERMAIN, 1904. Diagnoses de Mollusques nouveaux provenant de la Mission du Bourg de Bozas. Bull. Mus. Hist. Nat. Paris, vol. 10, pp. 141—144.

ROCHEBRUNE, A. T. DE, et L. GERMAIN, 1904. Mollusques recueillis par la Mission du Bourg de Bozas. Mém. Soc. Zool. France, vol. 17, p. 16, pl. 1 fig. 9.

PILSBRY, H. A., 1906. Manual of Conchology (2) vol. 18, p. 83, pl. 12 fig. 13.

PILSBRY, H. A., 1919. A Review of the Landmollusks of the Belgian Congo, chiefly based on the collections of the American Museum Congo Expedition, 1909—1915. Bull. Amer. Mus. Nat. Hist., vol. 40, p. 144.

PILSBRY, H. A., 1946. Land Mollusca of North America (North of Mexico). Monograph No. 3 of the Academy of Natural Sciences of Philadelphia, vol. 2, pt. 1.

FRÖMMING, E., 1954. Biologie der mitteleuropäischen Landgastropoden. Berlin.

FRÖMMING, E., 1955. Ökologische Einflüsse auf die postembryonale Entwicklung der gehäusetragenden Landlungenschnecke *Eobania vermiculata* (O. F. Müller). Zool. Jahrb., Abt. Syst., vol. 83, pp. 503—510.