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The tertiary gastropod *Orygoceras* found living.*)

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The strange uncoiled fossil shells named *Orygoceras* by BRUSINA (1882) have been a systematic puzzle ever since. Heretofore they have been known from late Tertiary deposits in southeastern Europe and in southern Idaho (northwestern U. S. A.). This is to record the astonishing discovery that *Orygoceras* still lives in subterranean waters of Texas, and to urge my colleagues to search for living *Orygoceras* also in the Balkan region.

Previous classification. BRUSINA separated his genus in a monotypic family Orygoceratidae, that he thought was probably one of the Pulmonata. Subsequently there have been two principal views. *Orygoceras* has been interpreted in effect as either an uncoiled prosobranch of the Valvatidae (see WENZ, 1938-44), or an uncoiled pulmonate related to *Gyraulus* of the Planorbidae (PAPP, 1962). There can be few other genera subject to such divergent classification: Pulmonata vs. Prosobranchia.

Discovery in Texas. I detected a single empty but fresh specimen of *Orygoceras* in fine screenings from Roaring Springs, Real County, Texas, in June 1973 and returned for intensive collection July 10, 1973. On both occasions my visit was shortly after a period of heavy rains and local flooding. Hence it seems possible that all specimens had been recently flushed from below ground. At the edge of the spring outflow the white shells were visible not uncommonly against dark mud when I searched for them in July. I should have seen them if they were so numerous on my first visit, but as the shells are only ca. 2 mm long and pass easily through a fine screen when turned lengthwise, I could certainly have missed many. Intensive search at various places yielded several hundred fresh, adult shells of *Orygoceras* but only one living specimen.

Habitat. Roaring Springs is one of numerous springs found along the Balcones Escarpment of central and western Texas. This escarpment marks the southern edge of the Edwards Plateau, a great mass of mainly Cretaceous limestone that is broken by faults so that it ends abruptly against the nearly flat sedimentary terrain of the coastal plain. Locally artesian waters form large limnocrene springs, but wherever a stream cuts deeply enough to intersect the water table there will be perennial flow. Roaring Springs is a rheocrene of unremarkable size in the region, but the outflow from the limestone is about 15 m above the floor of the immediate stream bed. Thus there is a springbrook about 75 m long, up to 4 m wide, and in pools to 30 cm deep, that is largely protected from

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the effects of flooding. I searched intensively in many places, but found only empty shells, except in the coarse gravel accumulation nearest to the source. Here in the gravel were 1 living *Orygoceras* and 3 living „*Horatia.*“

The discovery of the snails only close to the source, their occurence in the interstices of gravel, their total lack of eyes, and the time of collecting after a period of exceptional rain, all lead me to think that the snails are hypogean and phreatic, not crenobiontic. Hence I believe that search in the larger, more readily accessible cave streams may not yield living *Orygoceras.* Numerous small prosobranch snails have been described from the Karst regions of the Balkans in recent years, but perhaps *Orygoceras* might have survived undetected in such a special habitat.

M o r p h o l o g y As I found only one living specimen of *Orygoceras* a description in detail, naming, and illustration will be postponed in the hope of obtaining a living series. In summary, the remarkable shell does not enclose a body that is equally remarkable. *Orygoceras* is one of the Hydrobiidae (s. l.) much like *Horatia,* and I expect it will turn out to be one of the Orientaliidae of RADOMAN (1973).

The body of the specimen studied had practically no color in life, and some structural details could not be observed on account of the lack of color contrast. Through the shell could be seen (1) food in the stomach, being rotated by (2)

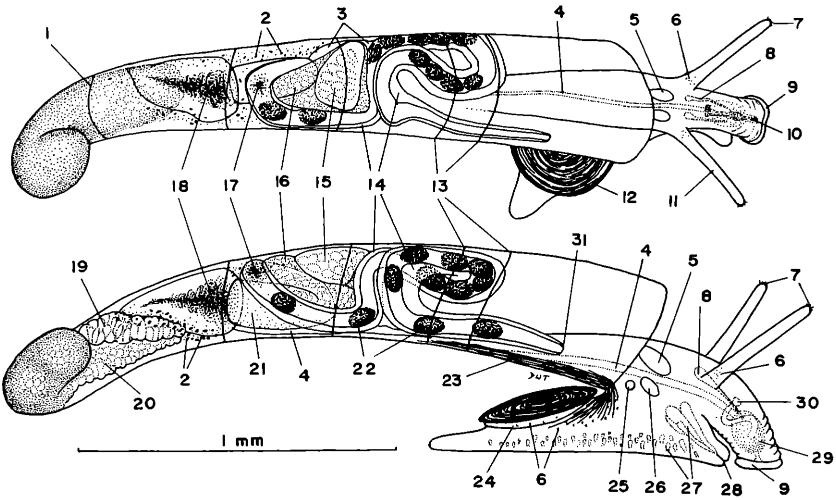

Fig. 1. *Orygoceras* sp. — 1) limit of protoconch; 2) granules in connective tissue; 3) pericardium; 4) esophagus; 5) cerebral ganglion; 6) hyaline granules; 7) setae; 8) salivary gland; 9) lip pad; 10) mouth; 11) tentacle; 12) operculum; 13) growth lines on shell; 14) subintestinal sinus; 15) bursa ?; 16) kidney; 17) locus of fecal pellet compaction; 18) food rotating in stomach; 19) ovary; 20) digestive gland; 21) style sac; 22) fecal pellets; 23) columellar muscle; 24) operculigerous lobe; 25) statocyst; 26) pedal ganglion; 27) mucus glands; 28) anterior transverse slit, receiving secretions of anterior pedal mucous gland; 29) buccal mass; 30) radular sac; 31) anus.

the style, (3) fecal pellets in the intestine, (4) much of the esophagus, (5) the pale yellow-brown digestive gland filling the coiled apex, (6) the pale yellow-brown ovary lying dorsally and on the right side of the digestive gland, (7) the pulsating heart, on the lower left side; (8) kidney, not readily separable from what I interpret as (9) bursa, (10) anus, (11) the enourmously developed subintestinal sinus enclosing the intestine like a sleeve, and (12) proximal body stalk and columellar muscle. In the head-foot visible features were slender, rod-like tentacles that entirely lacked eyes, but had a few setae on the tips; paired salivary glands; a mobile rostrum containing a faintly pink buccal mass; and a narrow foot with an anterior transverse slit into which emptied the principal mucus glands. Larger ganglia and the statocysts were visible, but details of connectives were not. Neither by transmitted light, nor by direct viewing of the mantle cavity from the front, could any trace of ctenidium or osphradium be seen. The operculum is round, with central nucleus, paucispiral.

S h e l l (described from numerous fresh empty specimens). The protoconch in defined by an abrupt change in sculpture after a coil of about 225° The later, relatively straight part of the shell (teleoconch) has a sculpture of axial growth lines only. Protoconch sculpture is at first irregular, with neither spiral nor axial elements on the apical bulb. It consists of irregular oval, elongate or worm-like raised elements that are seldom branched but complexly interlocked, do not overlap or cross, and are separated by intervals narrower than the raised elements. On the later half of the protoconch these raised elements may become transverse wrinkles near the sutures. On the peripheral surface they become generally aligned spirally, are unbranched but not straight, and are more widely spaced. These raised elements thus appear as spiral sculpture, but they do not form spiral threads as they are not all parallel and are short, discontinuous, and may be waved. The interaction of spiral and axial sculpture on the later part of the protoconch is an alignment of ends of the raised sculpture. None of the sinuous or linear elements overlap or cross.

At 50x the sculpture of the protoconch can be seen (though without detail) provided the shell is clean both inside and out, without bubbles to distort viewing, and light is transmitted. But with merely a change to direct illumination the protoconch sculpture will practically vanish.

Brief comparison with suitably fresh, cleaned shells of American species previously referred to *Horatia* or *Hauffenia* shows that they too have a distinctive protoconch sculpture. Evidently there is a whole set of characters, previously unknown, that can be investigated in at least some of the Hydrobiidae (s. l.). I hope that some of my European colleagues with access to a scanning electron microscope (SEM) can begin such a study. In retrospect now one can see that the protoconch sculpture of *Orygoceras* is so different from that of Valvatidae (Binder, 1967) that the better-preserved fossil *Orygoceras* should be recognizably different also.

F o r m a n d f u n c t i o n . The asymmetrical, coiled shell is such a hallmark of gastropods that one immediately seeks to explain any exception. In the case of this living *Orygoceras* an adaptive explanation seems simple. The uncoiled, tubular shell enables an animal of given size to pass through smaller spaces in gravel or coarse sand than it could otherwise. What a clear example of adaptation to an interstitial existence!

In southern Idaho I have had extensive experience in collecting *Orygoceras* from the Pliocene sediments where the shells are locally common. The deposits are those of a large lake and partly of a river; the texture of the sediments is sand; all localities of *Orygoceras* are far from any possible caves; and these Pliocene *Orygoceras* (up to 10-12 mm long) are all larger than the modern form of Texas. There is no chance that they were phreatic or hypogean snails, nor interstitial. From limited reading the Balkan fossils seem also to occur in large lake basins. Future speculations on the origin and relative age of uncoiled shell, blindness, and phreatic, fossorial, or interstitial habitat should take these data into account. Regardless of what interpretations may eventually find favor, the discovery of this living fossil in Texas should stimulate the study of *Orygoceras* and its relatives, living and fossil, elsewhere.

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