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TARMO TIMM

ON THE REPRODUCTION OF *EUILYODRILUS BEDOTI* (PIGUET, 1913) (*OLIGOCHAETA, TUBIFICIDAE*)

Euilyodrilus bedoti occurs in fresh waters in the western part of the Palaearctic and has obviously been introduced to North America as well. So far, rather few habitats are known (Fig. 1). It is a characteristic feature that in samples *E. bedoti* is found in small numbers; on the second

Fig. 1. Habitats of *Euilyodrilus bedoti* mentioned in the literature.

1 — Switzerland: Lake Bret and River Seyon (Piguet, 1913; Piguet, Bretscher, 1913); *2* — France: Lake Saint-Point (Piguet, 1928); *3* — Czechoslovakia: River Ohre (Hrabě, 1938); *4* — Czechoslovakia: River Danube (Hrabě, 1941); *5* — Ukrainian SSR: Estuary of Dniepr and Bug (Ярошенко, 1948; Финогенова, 1969); *6* — Moldavian SSR: River Dniestr (Ярошенко, 1970); *7* — Moldavian SSR: River Prut (Чокырлан, 1970); *8* — Uzbek SSR: Spring Aidin-Bulak near Kokand (Чекановская, 1959); *9* — Uzbek SSR: Spring Buta-Kara near Andizhan (Чекановская, 1959); *10* — Estonian SSR: springs and upper courses of rivers in Pandivere Uplands (Тимм, 1964; Timm, 1970; see also Fig. 2); *11* — Karelian ASSR: several smaller lakes (Попченко, 1968); *12* — Sweden: Lake Mälaren (Milbrink, 1970); *13* — USA: Lake Cayuga in State New York (Brinkhurst, 1965); *14* — USA: Lake Michigan (Hiltunen, 1967); *15* — USA: Lake Ontario (Hiltunen, 1969),

In the three last-mentioned cases (13—15) the authors call it *Euilyodrilus bavaricus,* considering *E. bedoti* be a synonym. The form of genital setae and the exceptionally small size of the worms (Hiltunen, 1967), also the fact that genital setae are placed on segments VII—IX (written information by J. K. Hiltunen) or on segment VII, only (Brinkhurst, 1965), are a clear proof of its being *E. bedoti.* Unspecified data by Lastochkin (Ласточкин, 1949) on the occurrence of *E. bedoti* in storage reservoirs are not drawn on the map.

catch it is not found in the same place (Piguet, 1928). But we should bear in mind that the species can firmly be identified only when sexually mature: in juvenile state it is practically indistinguishable from the

E. hammoniensis and some other more common species. *E. bedoti* has repeatedly been found in some North-Estonian springs (Roosna-Alliku and Mõdriku; see Fig. 2).

Among the tubificid species *E. bedoti* is one of the smallest: according to the original description (Piguet, 1913) its length is 10—18 mm, while the number of segments is rather great — 70—90. The sexually mature individuals found in the bottom samples in Estonia have mostly been damaged, without the caudal part. One undamaged specimen from the spring Saduküla Suur Allikas (Sep. 5, 1968) was 10 mm long when preserved in alcohol and consisted of 80 segments (without the non-segmented tail). A sexually mature worm found in an aquarium in July 3, 1969, was also 10 mm long and consisted of 90 segments.

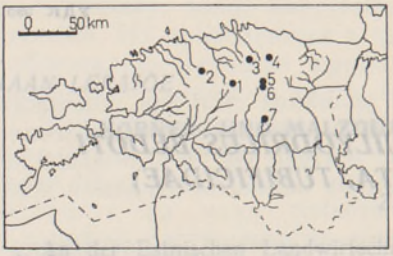

Fig. 2. Habitats of *Euilyodrilus bedoti* in Estonia.

1 — Spring Roosna-Alliku; *2* — River Pirita, Paunküla; *3* — Spring Imastu; *4* — Spring Mõdriku; *5* — River Vao, Kiltsi; *6* — The alkalitrophic Lake Äntu Sinijärv; *7* — Spring Saduküla Suur Allikas.
Habitat *3*, *6* and *7* are new.

Unlike in all other tubificids, the genital setae of *E. bedoti* have a beak-like form and the whole reproductive system is situated as much as two segments forward. So the male pores and penial setae are not to be found on the 11th, but on the 9th segment. There may be one or two pairs of spermathecae and, accordingly, also spermathecal setae, either on the 7th and 8th, or only on the 8th segment. Piguet (1928) asserts that the spermathecae of the 7th segment develop somewhat later and are missing in the individuals with the developing genital system. The same is proved by the author's observations in the aquarium. In nature the author has found individuals both with one and two pairs of spermathecae, in Karelia and Estonia, respectively. All genital setae, spermathecal and penial, are of similar form. There occur sexually mature individuals which have only crotchets, or transition forms between crotchets and genital setae, or no ventral setae on the 7th—9th segments at all.

The genital system shifted somewhat forward is characteristic of several oligochaetes which, besides sexual reproduction, have also the asexual kind — paratomy or architomy (the whole family of *Naididae*; *Aulodrilus* of the family of *Tubificidae*; *Cognettia* of *Enchytraeidae*; *Lumbriculus* among *Lumbriculidae*). Besides the forward position of the genital system, a rather considerable number of individuals with the regenerating anterior or posterior end in the material from the Estonian springs are another proof of the possible asexual kind of reproduction of *E. bedoti*. Michaelsen (1926) even supposed that *E. bedoti* may have developed from *E. bavaricus* as a result of the shifting of the reproductive system during regeneration, and Brinkhurst (1963) declared *E. bedoti* be the synonym of *E. bavaricus*. According to Hrabě (1967), both species are still independent and easily distinguishable (see also Timm, 1970).

A well developed reproductive system of *E. bedoti* points to its sexual kind of reproduction: already Piguet (1913) found spermatozeugmata in spermathecae, i. e. copulation had taken place. In the samples taken from the Spring Roosna-Alliku in 1959 (the whole year round) the species was found in the sexually mature form mainly in the second half of the year,

from July to November, and in one case in March. In other springs there have been finds from June to September. Cocoons, even when they occurred in the material from springs, could not be distinguished by the author from those of other species. Thus direct proofs of both sexual and asexual reproduction in *E. bedoti* were absent so far.

Studying the life cycles of *Tubifex tubifex, Euilyodrilus hammoniensis* and other tubificids in the aquaria of the Võrtsjärv Limnological Station (on the substrate of sieved mud from Lake Võrtsjärv), I found (on three occasions), early in the spring of 1967 and summer of 1968, minute worms with hair setae, similar to the youth of the above-mentioned species, in some experimental vessels. Surprisingly, these worms did not grow any bigger and did not reach sexual maturity; nevertheless, the number increased. To the 10 individuals left in the aquarium 16—87 new ones were added by the time of the next check-up which followed in 3—7 months. It makes 7—20 new worms per month. In one aquarium from where the increase was not removed, the number of worms in three years increased gradually from 10 to 1,200 and became stable then (the volume of the aquaria allows to keep there about 0.3 l of mud). In the body cavity of some individuals the cestode parasite *Caryophyllaeus* could be seen. Such tubificids did not reproduce until they had got free of the parasite.

In nearly all cases only minute juvenile individuals without any trace of genital organs could be found in this culture kept at the room temperature. Mostly they consisted of 55—60 segments and were 6 mm long when fixed in alcohol; the length of the biggest ones reached 8 mm and the number of segments 80 or 90. As for their form, setae and behaviour they were similar to the juvenile forms of *E. hammoniensis,* but they were obviousiy more mucous and often stuck to the glass when observed. The worms were undoubtedly reproduced by architomy as they easily fell into pieces on manipulation, and the pieces, caudal parts included, regenerated into full individuals under the experiment. Regenerates could be seen abundantly. So on Dec. 10, 1968, among 53 individuals in one aquarium there were 30 intact ones, 9 with regenerating tail, 3 with regenerating head, 3 with regenerating head and tail and 8 with the newly dropped tail — 56, 17, 6, 6 and 15 per cent respectively. On Sep. 8, 1970, I found a two-branched individual, on the right side of the 6th segment of which a mobile extra-head consisting of 3 segments was fixed.

In the autumn of 1968 I took one aquarium with 10 worms of this culture to a cellar where the temperature in winter remained between 2 and 4 °C for some months and was lower than in the laboratory in summer, too. At low temperature the architomy ceased, but by summer genital organs were developing with three individuals, the clitellum included. The same happened in 1969/70 when in the cellar or tub, cooled by running water (12°), 3 aquaria were kept in winter: when the water became warm again, some sexually mature individuals appeared. There were no difficulties in identifying them as *E. bedoti.*

The dependence of the ways of reproduction of *E. bedoti* on temperature was studied by an experiment which lasted about a year. The beginning of the experiment was on Feb. 10, 1970, and the end (in different variants) on Feb. 22 or 23, 1971. At the beginning of the experiment there were 10 small juvenile forms of *E. bedoti* in each of the 13 aquaria (crystallizers with a diameter 10 cm and volume 0.3 l) of 8 variants. The aquaria were checked up six times: in April, June, August, October, December, and at the end of the experiment. Each time new mud was substituted for the old one, the young worms were removed, while 10 biggest and darkest —

presumably the oldest ones — were left in the aquarium. The variant I was kept in a cellar where the seasonal changes of temperature were more or less similar to those in the water of our lakes and rivers. In the aquaria of the variants II and III an attempt was made to keep the temperature steadily at a low level like that in springs (although the temperature in the Estonian springs is mostly lower, 5—7°), cooling them by running water from taps. Variant IV was kept at room temperature in the aquarium pavilion. Variants V and VI were warmed by electrical heating bodies (since May an automatic thermoregulation by a contact thermometer). Variants VII and VIII were kept alternately at higher and lower temperature (together with variants II or IV and V or VI), while the conditions were changed in every 2 months in variant VII and in every month in variant VIII (as an exception, the period from June till August lasted two months in both cases). The temperature was measured either every day or every two-three days, 332 times in all. The results of the experiment can be seen from the following table.

The experiment revealed that *E. bedoti* can survive, at least for a short period, at temperatures from 0 to 34° as a minimum; the average temperatures during two months in different variants during different periods were from 3.7 — 26.2°. Reproduction by architomy took place at an average temperature of 11.4 — 26.2°. In a somewhat colder water (on the average 3.7 — 10.4° in variants I and II) new individuals were not added although this does not fully exclude the possibility of reproduction at that temperature during a longer period. The optimum seems to be about 20°. At higher temperatures, asexual reproduction is slower, but does not cease. Frequent changes in temperature conditions, as in variants VII and VIII, often restrain reproduction.

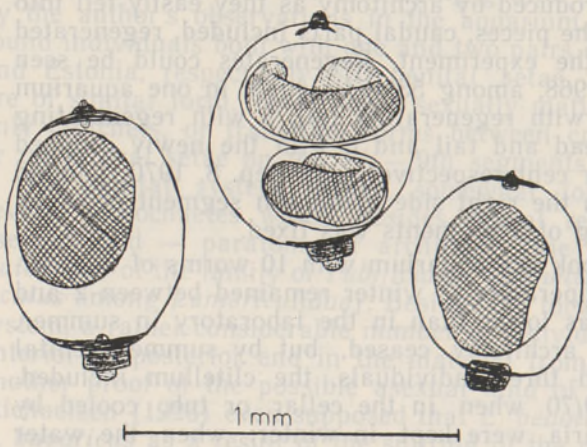

Fig. 3. Cocoons of *Euilyodrilus bedoti* formed in aquaria.

Sexually mature individuals appeared in permanently cool water, seldom at room temperature (the average temperature 10.5—18.5°), but not in all aquaria, and they were always in the minority. The maximum was 7 mature worms out of 13. One worm with genital organs appeared at the alternating temperature, in variant VII, too. Sexually mature worms are bigger than the majority of the juvenile forms of the species and have the maximum number of segments. Obviously, architomy ceases with the arrival of sexual maturity.

Cocoons were found in four aquaria, in various seasons, at the average temperature of 14.2 — 18.5°. The cocoons are small, their sizes being 0.79—1.26×0.54—0.69 mm. Their shell is thin, colourless and transparent, similar to that of the cocoons of *Tubifex tubifex*. Very often, particles of mud have stuck to the shell, and sometimes they form a continuous thin layer. The form of cocoons is irregular and changeable (it may be a result of living in aquaria; an analogical phenomenon can

Reproduction of *Euilyodrilus bedoti* in different temperature conditions

Variant	Conditions	Temperature (average and extreme), °C						Number of aquaria	Number of new individuals	Sexually mature individuals	Cocoons
		February — April	April — June	June — August	August — October	October — December	December — February				
I	In cellar	4.3 (0 — 7)	10.5 (6 — 16)	16.2 (14 — 17)	11.4 (5 — 15)	4.6 (0 — 8)	3.7 (0 — 6)	1	8	1	0[1]
II	Cooling	10.4 (9 — 15)	11.4 (10 — 16)	16.6 (13 — 19)	14.2 (11 — 18)	16.7 (12 — 21)	14.8 (12 — 18)	2	27; 43	7; 0	27; 0
III	Cooling	13.9 (11 — 18)	13.9 (11 — 18)	18.5 (15 — 21)	14.5 (10 — 17)	16.2 (11 — 20)	15.5 (12 — 18)	2	23; 27	2; 4	0; 8
IV	Room temperature	16.7 (13 — 20)	17.0 (14 — 21)	20.6 (18 — 24)	15.5 (10 — 20)	18.2 (13 — 22)	17.9 (13 — 21)	2	60; 45	3; 4	2; 5
V	Warming	20.9 (15 — 26)	21.2 (18 — 27)	21.7 (20 — 24)	20.1 (19 — 22)	20.8 (19 — 23)	21.1 (18 — 23)	1	67	0	0
VI	Warming	26.2 (20 — 32)	25.2 (20 — 34)	25.2 (23 — 28)	24.5 (21 — 26)	25.0 (17 — 28)	25.2 (24 — 28)	1	18[2]	0	0
VII	Alternating in 2 months	17.4 (13 — 32)	25.2 (20 — 34)	16.5 (13 — 19)	20.1 (19 — 22)	16.6 (12 — 21)	23.3 (12 — 28)	2	0[2]; 16	0; 1	0
VIII	Alternating in 1 month	19.4 (10 — 30)	14.0 (9 — 23)	16.0 (13 — 19)	19.5 (11 — 26)	20.7 (12 — 28)	20.2 (12 — 26)	2	52; >9[3]	0	0

[1] Cocoons appeared only in summer 1971, when 5 individuals matured.
[2] The number of worms decreased at the end of the experiment.
[3] The aquarium dried up before the end of the experiment.

also be seen with other tubificids), on fixation in alcohol and preparation in glycerine it deforms even more (Fig. 3). There were 1—2 (seldom 3—5) ova or poorly developed embryos in each cocoon. Mostly they did not reveal any signs of further development. However, some young worms hatched, too.

Conclusion. The main (at the temperature of over +18.5° only) way of reproduction of *E. bedoti* is architomy — a rather rare phenomenon among tubificids. The development of genital organs and sexual reproduction occur at lower temperatures only. That explains the frequent occurrence of the species in springs. Rare and mostly single finds in warmer water bodies — rivers and lakes — in summer do not demonstrate the real frequency of occurrence of the species. Here the whole population may reproduce by an asexual way exclusively and remain undiscovered, since juvenile individuals cannot be identified as a species. The unexpected appearance of *E. bedoti* in the aquaria of the Võrtsjärv Limnological Station points to its probable occurrence in Lake Võrtsjärv.

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TARMO TIMM

EUILYODRILUS BEDOTI (PIGUET, 1913) *(OLIGOCHAETA, TUBIFICIDAE)* SIGIMISEST

Resümee

E. bedoti on liigini määratav ainult suguküpsena. Teda on seni leitud üsna harva, Eestis ainult allikatest ja allikalistest jõgedest. 1967. aastal ilmus Võrtsjärve Limnoloogiajaama akvaariumidesse stiihiliselt mingite väikeste, ainult arhitoomia teel sigivate mudatuplaste kultuur. Katsete abil selgitati, et nad taluvad temperatuuri 0 kuni 34 °C ja et mittesuguliseks sigimiseks on optimaalne temperatuur umbes 20°. Püsivalt jahedas vees (keskmine temperatuur alla 18,5°) arenesid mõnel isendil suguelundid, mille põhjal võis selles ussis ära tunda *E. bedoti*. Esmakordselt saadi ja kirjeldati ka selle liigi kookoneid. Nähtavasti jääb *E. bedoti* soojaveelistes veekogudes sageli leidmata, kuna populatsioonis võivad täiesti puududa suguküpsed isendid.

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ТАРМО ТИММ

О РАЗМНОЖЕНИИ *EUILYODRILUS BEDOTI* (PIGUET, 1913) *(OLIGOCHAETA, TUBIFICIDAE)*

Резюме

E. bedoti определяется до вида только в половозрелом состоянии. Находки его довольно редки. В Эстонии вид был найден в источниках и в родниковых речках. В 1967 г. в аквариумах Выртсъярвской лимнологической станции стихийно появилась культура небольших тубифицид, размножающихся исключительно путем архитомии. В эксперименте установлена толерантность их к температурам от 0 до 34 °C, а также оптимум для бесполого размножения около 20°. В постоянно прохладной воде (средняя температура не выше 18,5°) у некоторых особей развились половые органы, позволяющие определить эту форму как *E. bedoti*. Впервые были получены и описаны коконы этого вида. По-видимому, *E. bedoti* в тепловодных водоемах может часто оставаться незамеченным вследствие отсутствия в популяциях половозрелых особей.

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