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AQUATIC OLIGOCHAETA
(SYSTEMATICS, ECOLOGY AND STUDIES OF THE SOVIET FAUNA)

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EDITORIAL NOTE

The volume is a collection of articles dealing with various aspects of the study of aquatic Oligochaeta in the USSR.

Several articles contain new information on the role of oligochaetes as items in the diet of fishes.

Part of the volume is devoted to current problems concerned with the formation of an oligochaete fauna in reservoirs and with the abundance and biomass dynamics of oligochaetes.

New information is given on various aspects of the biology and ecology of aquatic oligochaetes, including methods of rearing and the role of aquatic oligochaetes as intermediate hosts for fish helminths.

Consideration is given to the role of aquatic oligochaetes in the oxygen balance of bodies of water.

The book is intended for hydrobiologists, ichthyologists, specialists in zoology, undergraduate and postgraduate students and teachers in higher educational institutions.

I. SYSTEMATICS.

THE PRESENT POSITION AS REGARDS THE SYSTEMATICS OF AQUATIC OLIGOCHAETA (FAM.TUBIFICIDAE)

By O.V.Chekanovskaya, Institute of Zoology,
USSR Academy of Sciences

Aquatic Oligochaeta do not form a systematic grouping, but are united only by the ecological attribute. They include all families in the order Naidomorpha: Aeolosomatidae, Potamodrilidae, Naididae, Tubificidae, Phreodrilidae and Enchytraeidae, plus the families Haplotaxidae, Lumbriculidae, Branchiobdellidae, Alluroididae and Lycodrilidae from the order Lumbricomorpha. Many species from the remaining families of the Lumbricomorpha can also be facultative inhabitants of fresh water.

More than 70 years have passed since the publication of Michaelsen's last reference work (Michaelsen, 1900) on the systematics and fauna of the Oligochaeta in all parts of the world. During that period there have been many publications devoted to the Oligochaeta, mostly faunistic articles listing species requiring critical examination with a view to the updating of systematic data and species nomenclature. The larger works which have appeared on the aquatic Oligochaeta either make very little mention of systematics (Stephenson, 1930; Stolte, 1933-1962), or investigate the systematics of individual families (Sperber, 1948; Černosvitov, 1937), or are zonal or regional descriptions (Michaelsen, 1909, 1927; Piguet and Bretscher, 1913; Ude, 1929; Hrabě, 1954; Chekanovskaya, 1962; Izosimov, 1962). All these works have shown that the greater part of this family is in need of thorough revision of its component taxa, for only a few of which the position is relatively satisfactory. The fact that until recently the systematics of the Oligochaeta was based mainly on the structural characters of the reproductive system is a measure of its inadequacy, since accurate species identification of sexually immature specimens is, as a rule, completely impossible other than for the families Naididae and Aeolosomatidae and this renders valueless most of the material collected on aquatic Oligochaeta. It is obvious that insufficient importance is attached to other characters, although further study of the characters of the nervous (cerebral), vascular and excretory systems for this purpose should be very promising.

Aquatic Oligochaeta are one of the leading groups of 4
freshwater benthic invertebrates and their role in the littoral zone of seas and brackish bodies of water is also considerable. Proper attention to material on aquatic Oligochaeta is therefore becoming an essential element of all kinds of hydrobiological investigations. The identification of oligochaetes, a group whose systematics is based on the microscopic study of the details of internal organisation, has never been easy, but it has been made particularly difficult in recent years for the reasons stated above. The identification of species of the family Tubificidae (which, in fact, is of the greatest importance to hydrobiology since populations of its species are most abundant and have the highest biomass in the benthos) has become particularly difficult. In recent years the systematics of this family has been intensively investigated abroad, with the result that the identification key for aquatic Oligochaeta (Chekanovskaya, 1962) has become seriously out-of-date as regards the Tubificidae. An independent assessment of the

conflicting data in contemporary foreign publications concerning synonymy, the generic position of species and a number of other systematic problems is necessary when identifying species of the family and this naturally makes our work considerably more difficult. The revision of material on the Tubificidae is quite impossible where no publications exist. The aim of the present article is a critical review of new published data on a preliminary revision of tubificid genera which would aid taxonomic work on the Oligochaeta. Brief information on new work on the systematics of some other families of aquatic Oligochaeta has been added to the survey of the family Tubificidae.

Family Tubificidae.

In spite of the large number of works the systematics of this family remains full of obscurities and contradictions and its revision is therefore an urgent necessity.

The diagnostic criteria for tubificid species and genera have still not been adequately worked out. The characters of many species under consideration have been inadequately investigated and require description and supplementation. Suffice it to say that some 67 species described between the years 1776 and 1909 have not as yet been revised. As at present constituted the family Tubificidae consists of 22 genera and approximately 150 species.

The greatest recent advances in study of the systematics of this family have been made by Hrabě (1958, 1960, 1962a, 1962b, 1963, 1964, 1965) but far from all the species have been reduced to order and there is still much work to be done. The systematics of this family is also being investigated by Brinkhurst (1960, 1962a, 1962b, 1963, 1965a, 1966a, 1966b), but so far there have been few positive and incontestable advances in his work on the revision of the Tubificidae.

Brinkhurst's conclusions require careful critical examination. Frequently the solutions which he adopts are then completely rejected in later works, which makes the existing confusion even greater.

Our review of the genera and certain ideas and propositions expressed here should be regarded mainly as a summary of information (mostly new) on the systematics of this family. We attempt in passing to direct attention to the major difficulties and weaknesses in tubificid systematics.

1. Genus <u>Aulodrilus</u> Bretsch., 1899.

One of the most primitive genera. Differentiated from other tubificids by a number of characters: gonads located in practically the same segments as in the Naididae, respiratory organ formed by structural modification of posterior extremity of body, small size and transparency of body, asexual reproduction by architomy (though sexual reproduction is sometimes encountered), only posterior seminal vesicle present, periintestinal sinus of vascular system continuous. Otherwise these are typical tubificids.

<u>Diagnosis of genus</u>. Setae of different types, in bifid setae distal crotchet shorter than proximal one. Hair-setae short. Apart from bifid setae the bundles of some species contain oar-shaped setae. No large coelomocytes. 1 - 3 pairs of testes in segments IV - VI.[1] Vasa deferentia short. Atria tubular to round in shape, prostate differentiated and fairly large (Fig.1a). Male sexual pore on VII or IX. Beyond the zone in which new segments form at the posterior end of the body there is a non-segmented, richly vascularized area functioning as a respiratory apparatus.

[1] The word "segment" is subsequently omitted.

The genus is at present constituted by 17 species: Aulodrilus limnobius Bretsch., 1899; A.pluriseta (Piguet, 1906); A.pigueti Kow., 1914 (= A.remex Steph.); A.stephensoni Mehra, 1922; A.kashi Mehra, 1922; A.trivandranum Aiyer, 1925; A.pectinatus Aiyer, 1928; A.tenuis (Čern., 1937); A.prothecatus Chen, 1940; A.cernosvitovi Marcus, 1947; A.japonicus Yamag., 1953; A.americanus Brinkh. and Cook, 1966.

There are, unfortunately, no data on the reproductive organs in the descriptions of a number of Aulodrilus species since sexually mature individuals are quite rare occurrences. This gives grounds for doubt that the species really exist.

The description of a new species A.americanus Brinkhurst and Cook, 1966 was published recently. Though the author had sexually mature individuals at his disposal the description of this species is very short and illustrated by only one drawing of the setae. Such important systematic characters as the location of the male gonoduct, testis and clitellum remain unknown. The unusual shape of the setae, not found in any other Aulodrilus species, and the absence of a spermatheca compel us to treat A.americanus with some caution.

Brinkhurst (1963) considers that A.prothecatus, 8
A.černosvitovi and A.stephensoni are species identical to A.pigueti, and that A.trivandranum is a synonym of A.pluriseta. These combinations have not been adequately substantiated.

2. Genus Epirodrilus Hrabe, 1930

The organisation of the male gonoducts is the most primitive among the Tubificidae in species of this genus. The type species of this genus E.pygmaeus was discovered in Czechoslovakia. Hrabě (1935) isolated this species into the separate genus Moraviodrilus, having

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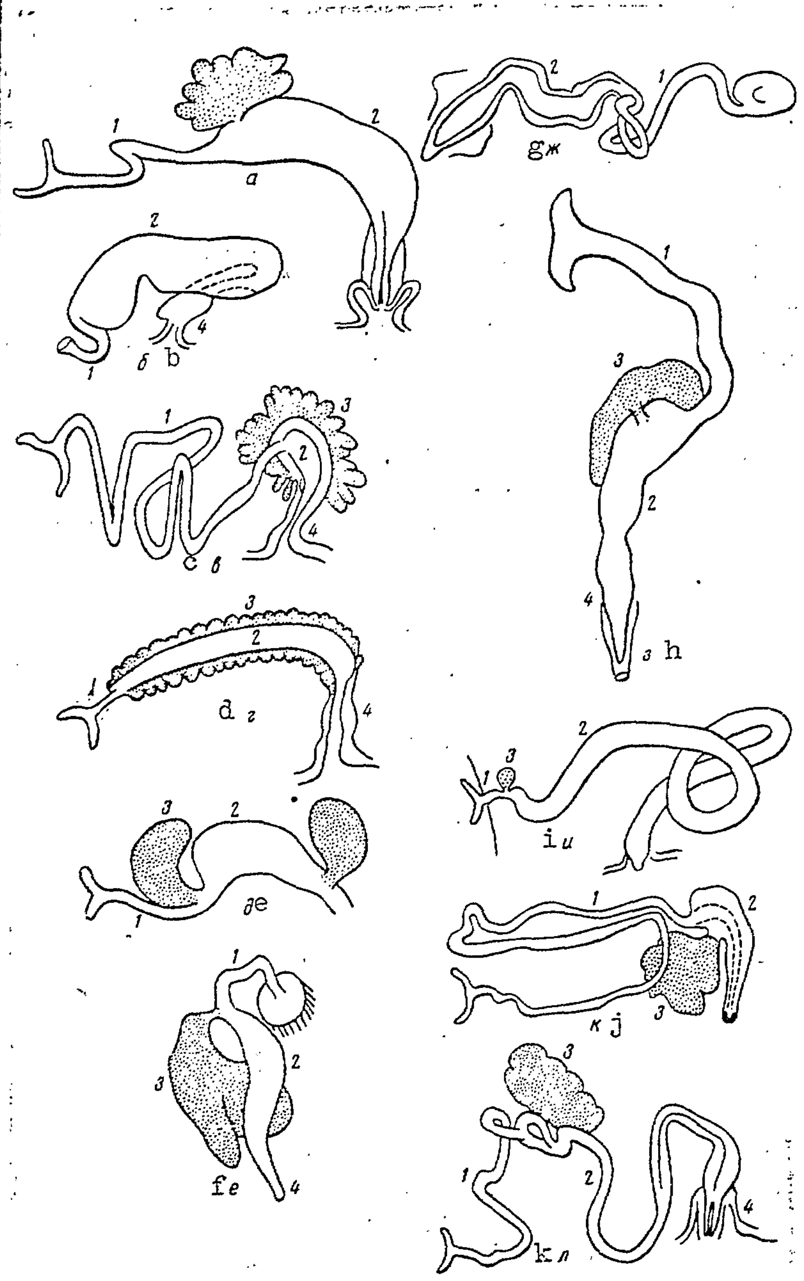

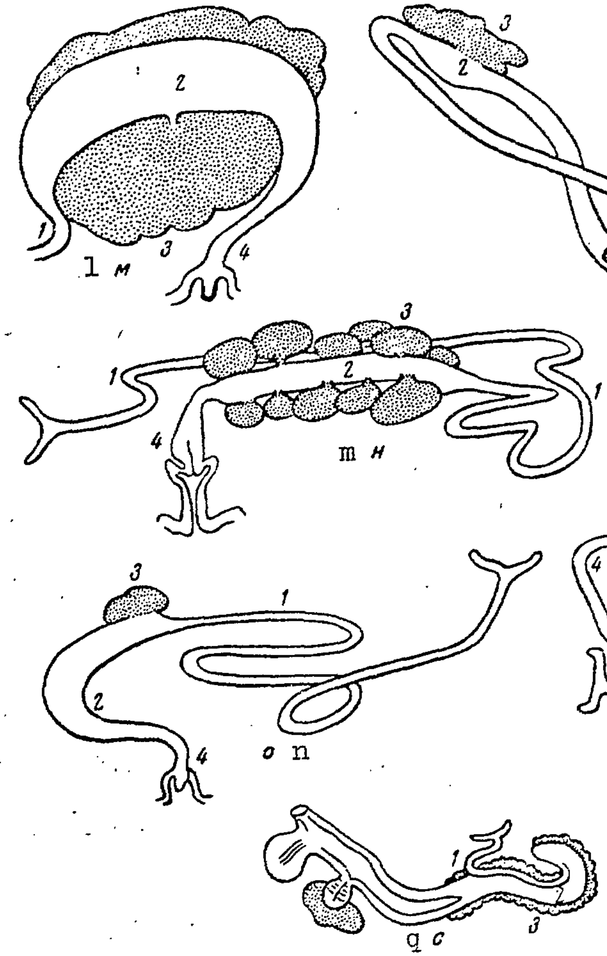

Caption to Fig.1 on typescript P.10....

Рис.1. Схемы строения мужских гонодуктов в разных родах сем. Tubificidae

Проксимальный конец гонодукта обращен влево или кверху; за ним следуют: семепровод (1), атрий (2), выводная часть гонодукта (4). Простатические железы (3) обозначены точками, как и пениальная трубка у Limnodrilus.

а – Aulodrilus (ориг.); б – Epirodrilus (по Hrabě, 1935); в – Rhyacodrilus (ориг.); г – Monopylephorus (по Brinkhurst, 1963); д – Phallodrilus (по Hrabě, 1960); е – Limnodriloides (по Pierantoni, 1904); ж – Clitellio (по Brinkhurst, 1966); з – Ilyodrilus (по Eisen, 1879); и – Euilyodrilus (по Hrabě, 1954); к – Tubifex (по Stolte, 1940); л – Psammoryctides (по Hrabě, 1934); м – Peloscolex (по Brinkhurst, 1965); н – Alexandrovia (по Hrabě, 1962); о – Isochaetides (ориг.); п – Limnodrilus (по Černosvitov, 1939); р – Branchiura (по Chen, 1940); с – Bothrioneurum (по Brinkhurst, 1963)

Fig.1. Organisation of male gonoducts in different genera of the family Tubificidae. Proximal end of gonoduct directed leftward or upward; it is followed by: vas deferens (1), atrium (2), discharge portion of the gonoduct (4). Prostate glands (3) and penial bulb of Limnodrilus shaded.

a - Aulodrilus (orig.); b - Epirodrilus (after Hrabe, 1935); c - Rhyacodrilus (orig.); d - Monopylephorus (after Brinkhurst,1963); e - Phalodrilus (after Hrabě, 1960); f - Limnodriloides (after Pierantoni, 1904); g - Clitellio (after Brinkhurst, 1966); h - Ilyodrilus (after Eisen, 1879); i - Euilyodrilus (after Hrabé, 1954); j - Tubifex (after Stolte, 1940); k - Psammoryctides (after Hrabě, 1934); l - Peloscolex (after Brinkhurst, 1965); m - Alexandrovia (after Hrabě, 1962); n - Isochaetides (orig.); o - Limnodrilus (after Černosvitov, 1939); p - Branchiura (after Chen, 1940); q - Bothrioereum (after Brinkhurst, 1963)

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noted its affinity to Epirodrilus. Černosvitov (1939), who described E.antipodum from South American mountain lake material, slightly changed the diagnosis of the genus,since the characters of this species finally bridge the differences between Epirodrilus and Moraviodrilus. Nonetheless, Hrabě (1954), kept the name Moraviodrilus for the Czech genus, which seems insufficiently substantiated. It can evidently be considered as a synonym of Epirodrilus. This problem may possibly have to be reexamined in the future.

Diagnosis of the genus. All setae in abdominal bundles bifid; hair-setae may also be found in dorsal bundles. Vasa deferentia short, atria tubular, several times longer than vasa deferentia (Fig.1b). Prostate glands wanting. Penes wanting. Nephridia situated in postseptum, nodules in body-cavity large. Sperm not aggregated into spermozeugmas.

The genus has only 3 species: E.michaelseni Hr., 1930; E.antipodum Čern, 1939; E.pygmaeus (Hr., 1935).

3. Genus Rhyacodrilus Bretsch., 1901.

This genus is close to the lower tubificids (Aulodrilus and Epirodrilus) insofar as it preserves a number of primitive characters such as the variable location of the genitalia, the absence of a differentiated prostate gland, short atria and non-aggregated sperm.

In some species the spermathecae communicate with the intestine. This character is typical of the family Enchytraeidae and is not found in any other tubificid genus. Thus, the genus Rhyacodrilus is the connecting link between the families Tubificidae and Enchytraeidae.

Diagnosis of the genus. Setae bifid in abdominal bundles, bifid or pectinate in dorsal bundles, hair-setae also found in most species. Penial setae distinguished from abdominal by shape and size.

Large granular nodules present in body cavity. Testes in VIII or X, vasa deferentia never very long. Atria in IX or XI, spherical to tubular in shape. Differentiated prostate gland usually absent; wall of atrium externally sheathed by monocellular prostate glands (Fig.1, c). Male sexual pores in IX or XI. Spermathecae in VIII or X. In some species they communicate with intestinal cavity. Sperm not aggregated into spermatozeugmas.

Seventeen species of this genus are known at present: Rhyacodrilus coccineus (Vejd., 1875); Rh.falciformis Bretsch., 1901; Rh.simplex (Benh., 1903); Rh.Palustris (Ditl., 1904); Rh.sinicus (Chen, 1940); Rh.lepnevae Malev., 1949; Rh.Pleurotheca (Benh.,1907); Rh.ekmani Piguet, 1928; Rh.subterraneus Hrabě,1963; Rh.punctatus Hrabě, 1931; Rh.altaianus Mich.,1935; Rh.stephensoni Čern.,1942; Rh.lindbergi Hrabě, 1963; Rh.balmensis Juget, 1959; Rh.montana (Brink., 1965); Rh.korotneffi (Mich., 1905); Rh.multispinus (Mich., 1905).

Certain changes in the composition of this genus have resulted from the review of a number of species.

1. Brinkhurst (1963) transferred Rh.prostatus Knoll to the genus Thalassodrilus, since he considered it impossible to unite species with and without a differentiated prostate gland in a single genus. He also included Tubifex minor Sok.in this genus because of the presence of coelomocytes in the body cavity. We, however, agree with Hrabě (1967); following a reexamination of Rh.prostatus Hrabě placed it in Limnodriloides, but left T.minor Sok. in the genus Tubifex.

2. Brinkhurst (1965) described the new genus and species Edmonsonia montana on the basis of external characters only (shape and number of setae, body size). In 1966, after additional investigation, Brinkhurst transferred this species to Rhyacodrilus with complete justification in my opnion.

3. Rh.brevidentatus Brinkhurst, 1965 was very briefly described and provisionally placed in the genus Rhyacodrilus. In fact, the absence of a principal character of the genus, namely large nodules in the body cavity, taken in conjunction with the absence of copulatory setae and the shape of the locomotory setae does indeed make it doubtful whether this species belongs to the genus Rhyacodrilus.

This view is strengthened by the male sexual pores, which are converged about the median line and set in depressions, and by the elongated shape of the atrium. For the time being this species should be qualified as a species incertae sedis.

4. Brinkhurst (1963) considers the species Rh.altaianus and Rh.multispinus as doubtful, without sufficient justification.

5. Rh.simplex (Benh.) is, according to Brinkhurst (1963), a doubtful species. This we cannot accept since the species was

described from 12 specimens re-investigated by Hrabě (1963) including some which were fully mature sexually and not, as Brinkhurst (1963) states, from 3 slightly immature specimens.

6. *Rh.sinicus* (Chen, 1940) was described under the name *Tubifex sinicus*. The correct genus was established by Sokol'skaya (1958) and accepted by Brinkhurst (1965a).

7. Sokol'skaya (1968) identified *Rh.riabuschinskii* (Mich., 1929) with *Rh.coccineus* (Vejd.).

4. Genus *Monopylephorus* Levinsen, 1883. 10

Levinsen, 1883; Goodrich, 1892: 474 (*Vermiculus*); Hatai, 1899 (*Vermiculus*); Michaelsen, 1903: 169 (*Rhizodrilus*); Benham, 1903: 268 (*Rhizodrilus*); Boldt, 1926: 175 (*Postiodrilus*); Chen, 1940: 96 (*Littodrilus*); Hrabě, 1962: 338 (*Rhizodrilus*); Brinkhurst, 1963: 59 (*Monopylephorus*); Marcus, 1965: 75 (*Monopylephorus*).

The synonymy of the genus is presented here as an exception. The author has explained the complexity of the genus and argued the case for the initial generic name *Monopylephorus* in a previous publication (Chekanovskaya, 1962, p.287). Sixteen *Monopylephorus* species have so far been described from all over the world; a considerable number of them are found in seas and brackish bodies of water. This genus includes species which have, undoubtedly, much in common, but yet are so varied that current diagnoses of *Monopylephorus* do not, strictly speaking, contain any characters which apply to all species of this genus and which are not shared by other genera in the family Tubificidae. Neither are combinations of the characters of this genus unique to it. The diagnosis presented below, based on diagnoses formulated by Hrabě (1962a) and Brinkhurst (1963) is an attempt to reflect the prototype of a genus in which species have been incorporated that have partly lost the primitive characters of the genus or have not embodied its characteristic morphogenetic tendencies. Although plasticity of characters is invariably associated with the primitiveness of taxa, the diagnosis of this genus is of such a nature that it primarily indicates the inadequate level of investigation of its constituent species. On this understanding the genus Monopylephorus is most probably a combination of allied genera; one possible way in which it might be divided up is indicated below.

Provisional diagnosis of the genus. Setae mainly bifid but some species have both simply pointed and pectinate hair-setae. Male gonoducts represented by short vasa deferentia (except that M.limosus and M.africanus have well expressed vasa deferentia) and tubular atria (except that M.limosus has round atria) invariably lacking a compact differentiated prostate but with entire surface of atria covered in prostate cells; distally the atria may bear unusual dilations; penes sometimes present (Fig.1, d). Convergence of the distal ends of the male gonoducts on the median line of the ventral surface of the body (ventral male sexual pore) is the most characteristic feature of the genus. Male sexual pores unpaired in only half the species, but in species with paired male sexual apertures all remaining characters are so close to those of the other species that it is possible to class the ventral unpaired male sexual pore either as a typical evolutionary acquisition which did not extend to all species of this genus, or as a character lost in some species. Vasa deferentia present in all species except M.jaulus Marcus; their surface pores also sometimes merge medially on the ventral line. Spermathecal setae sometimes present.

Spermatozeugmas wanting, sperm not aggregated. Postseptal portion 11
of nephridia of the enchytraeid type, but for many species no description of the nephridia exists. The body cavity of all species contains coelomocytes.

In accordance with views expressed by Hrabě (1962a, 1967), we consider that, after inclusion of the species described by Marcus (1965) under the name Jolydrilus jaulus, the genus consists of the following 16 species: Monopylephorus rubroniveus Levins, 1884; M.limosus (Hatai, 1899); M.fluviatilis (Ferronière, 1899); M.lactaeus (Smith, 1900); M.parvus Ditlev, 1904; M.trichochaetus Ditl., 1904; M.glaber Moore, 1905; M.irroratus (Moore, 1905); M.auklandicus (Benh., 1909); M.africanus (Mich., 1912); M.kermadecensis (Benh., 1915); M.sonderi (Boldt, 1926); M.montanus (Hrabě, 1962); M.jaulus (Marcus, 1965); M.ponticus (Hrabě, 1968).

This list was considerably shortened by Brinkhurst (1965a), who accepted M.fluviatilis, M.glaber and M.kermadecensis as synonyms of M.rubioniveus and recognised M.trichochaetus, M.sonderi and M.glotini as synonyms of M.irroratus, while doubting the reality of the differences between M.africanus and M.lactaeus. He thus denies the reality of 7 species from the above list. The paucity of information about the species reduced to synonyms by Brinkhurst must be admitted. But some other species of this genus requires additional investigation. At the same time, since it has proved possible to compile a synoptic key from the available information (Hrabě, 1962a), we therefore consider that there are insufficient grounds for the omission of the species indicated. It is noteworthy that seven of the first eight species listed above combine the presence of unpaired male and spermathecal pores with the absence of hair-setae and pectinate setae (in M.irroratus, M.auklandia, M.africanus, M.kermadecensis, M.sonderi, M.montanus and M.ponticus). M.jaulus differs sharply from the rest of these species by the absence of spermathecae and it was therefore isolated by Marcus as a special genus Jolydrilus g.n. Might not this prompt future investigators to divide Monopylephorus into three genera - Monopylephorus, Rhizodrilus and Jolydrilus?

5. Genus Spiridion Knöll., 1935.

Diagnosis of genus. Ventral and dorsal bundles contain bifid setae only. Penial setae present in XI. Length of vasa deferentia and atria identical Atria tubular, with narrow proximal and dilated distal portion. Prostate large. Pseudopenes. Sperm not aggregated into spermatozeugmas.

The genus is at present known to contain two species: Spiridion insigne Knöll., 1935 and Sp.scrobiculare Last., 1937.

Certain primitive characters typical of this species (absence of penes and spermatozeugmas) are combined with the existence of a differentiated prostate gland, which is characteristic of the higher tubificid genera.

Both Spiridion species inhabit the Baltic. Hrabě (1967) 12
considers S.scrobiculare a doubtful species, while Brinkhurst (1963) suggests that S.scrobiculare is a synonym of S.insigne. However, the medially situated depression on the ventral side of the body, into which the converged male sexual pores open, is a character which cannot be ignored.

6. Genus Aktedrilus Knöll, 1935.

Diagnosis of genus. Only bifid setae. Vas deferens short, same length as atrium. Atrium cylindrical with two prostate glands; one discharges into the proximal and the other into the distal portion, which terminated in an oval penis without cuticular sheath. Single spermatheca with medially situated aperture on dorsal surface in intersegmental groove IX - X. Genital setae wanting. Sperm not aggregated into spermatozeugmas. No large nodules in body cavity.

One species only: Aktedrilus monospermathecus Knöll, 1935.

A brackish-water species similar to Phallodrilus but clearly differentiated by the unpaired spermatheca with dorsal pore.

7. Genus Phallodrilus Pierant., 1902.

Very small genus.

Diagnosis of genus. All setae bifid. Vas deferens short, almost same length as atrium, which is cylindrical, dilating somewhat at distal end. Two prostate glands; one discharges into the proximal, the other into the distal portion of the atrium (Fig.1, e). A number of modified genital setae (2 - 7). Penis wanting.

Only two species known: Phallodrilus parthenopaeus Pier., 1902 and Ph.aquaedulcis Hrabě, 1960.

This genus is well differentiated from other tubificids by the presence of two prostate glands on each atrium. The discovery of the freshwater species Ph.aquaedulcis is of great interest.

8. Genus Limnodriloides Pierant., 1904.

This marine and brackish water genus was combined by Brinkhurst (1963) with the genus Clitellio. He considered that differences in the organisation of the male gonoducts and the presence of a large differentiated prostate gland in Limnodriloides could not stand in the way of the unification of these genera. Hrabě (1967) rightly disagrees with this and retains the genus *Limnodriloides*.

Diagnosis of genus. Setae in dorsal and ventral bundles 13
bifid only. Spermathecal setae possibly present, though not of the type found in *Euilyodrilus hammoniensis*. Vas deferens shorter than the tubular atrium. Large prostate gland present. Distal portion of atrium terminating in pseudopenis. Male sexual pores paired (Fig.1, f). Spermathecae with long cylindrical ampulla not clearly differentiated from the external duct and on same segment as testes, i.e., on the Xth or rarely VIIIth segment, spermathecal pores paired.

Oesophageal diverticula sometimes found in VIII. Spermatozeugmas present.

The genus contains six species: *Limnodriloides roseus* Pier., 1903; *L.pectinatus* Pier.,1903; *L.appendiculatus* Pier., 1904; *L.winckelmanni* Michaels., 1914; *L.prostatus* (Knöll., 1935 (*Rhyacodrilus*); *L.agnes* Hrabě, 1968.

Limnodriloides dnieprobugensis Jar. is a synonym of *Euilyodrilus caspicus* (Last.).

9. Genus *Heterodrilus* Pierant., 1902.

Until very recently this genus contained only one species; in 1967 two marine species were added to the genus by Hrabě (Hrabě, 1967), who transferred them from the genus *Clitellio*.

Diagnosis of genus. Neither hair-setae nor pectinate setae found in dorsal bundles. The anterior preclitellar bundles contain two tridendate setae each. Vas deferens short, giving way to short atrium. Prostate gland wanting. Penis present. Spermathecae may be absent. Penial setae present.

Three species in all: Heterodrilus arenicolus Pier., 1902; H.abjörnseni Mich., 1907; H.subtilis Pier., 1916.

10. Genus Clitellio Sav., 1820.

The genus, which is very small, contains only one marine species. Two other species, Clitellio abjörnseni and C.subtilis, were recently transferred by Hrabě (1967) to the genus Heterodrilus.

In 1966 Brinkhurst suggested that the genera Clitellio and Heterodrilus were very close and in his next work, published the same year, he was already quite definite that the two genera be united and proposed to deal with this in his next work (Brinkhurst,1966a, p.734).

Diagnosis of genus. Setae bifid or simply pointed. Large nodules in body cavity wanting. Vas deferens well developed, long, convoluted. Atria tubular, long, but shorter than vasa deferentia and terminating in large penis without cuticular sheath, spermathecae extending into XV. Prostate gland wanting (Fig.1, g). Sperm aggregated into spermatozeugmas.

There is only one species: Clitellio arenarius (Muller, 1776).

11. Genus Ilyodrilus Eisen, 1879. 14

A group of species was isolated from this composite genus into the special genus Euilyodrilus by Brinkhurst (1963) on the grounds that the length of the atrium and penis exceeds that of the vas deferens in American species belonging to the type species of the genus Ilyodrilus Eisen. Prostate gland differentiated. Penis present. Vas deferens of Euilyodrilus rudimentary, prostate gland small, sometimes absent.

Diagnosis of genus. Hair-setae and pectinate setae in dorsal bundles, bifid setae in ventral bundles. Atrium more or less tubular. Vas deferens of almost same length as atrium and penis, or slightly longer or shorter than them. Large differentiated prostate gland present (Fig.1, h). Penis possessing thin cuticular sheath. No coelomocytes in body cavity. Spermatozeugmas wanting. Altogether the genus contains five species, of which one (I.sodalis Eisen) is provisional: Ilyodrilus perieri Eisen, 1879; I.fragilis Eisen, 1879; I.sodalis Eisen, 1879; I.templetoni (South., 1909); I.orientalis Sokol., 1969.

1. Brinkhurst (1965a) first considered the American species I.sodalis Eis. doubtful, but a little later he transferred this species without hesitation to Rhyacodrilus. A careful study of the drawing of this species from Eisen's work clearly shows that its characters do not correspond to the generic diagnosis of Rhyacodrilus and for the time being it should be left provisionally in the genus Ilyodrilus, taking into account the length of the vas deferens, the presence of a differentiated prostatic gland and of a penis. Hrabě (1965), however, is inclined to assign this species to Rhyacodrilus because of the presence of nodules in the body-cavity, the allegedly diffuse (?) prostate gland and the existence of penial setae, which are not found in other Ilyodrilus species.

2. Ilyodrilus asiaticus Chen has been described so inadequately that for the time being it should be considered a doubtful species. Hrabě (1967) suggested that most probably it belongs to the genus Rhizodrilus. Brinkhurst (1966a) assigns it to the genus Isochaetides.

3. Ilyodrilus frantzi Brinkh. requires additional

investigation. If we rely on the description and drawing in Fig.7 (Brinkhurst, 1965) it cannot be assigned to the genus Ilyodrilus: it has a very narrow vas deferens which is considerably shorter than the joint length of the atrium and penis; the depiction of the distal portion of the gonoduct is totally incomprehensible. The sacciform (rather than tubular) atrium gives way to a narrow duct which ends in an improbably thick and long penis. There are unusual spermatozeugmas (Sp. incertae sedis).

4. Tubifex templetoni South. was justifiedly assigned by Hrabě (1965) to Ilyodrilus, but Brinkhurst (1865a) disagrees and leaves it in the genus Tubifex.

12. Genus Euilyodrilus Brinkhurst, 1963

As proposed by Brinkhurst (1963), the species described as
Ilyodrilus Hammoniensis (Michaelsen, 1901) has now become the type 15
species of his genus Euilyodrilus. Fourteen other species previously belonging to the genus Ilyodrilus have now been annexed to this genus. This new genus deserves general acceptance.

Diagnosis of genus. Vas deferens very short. Atrium long and tubular. Prostate gland vestigial or completely absent, its duct opens the atrium where it joins the vas deferens. Ductus deferens absent. Atria giving way to true penis without cuticular sheath. Sperm aggregated into spermatozeugmas. No coelomocytes in body cavity.

The genus contains 15 species at present: Euilyodrilus hammoniensis (Mich., 1901); E.heuscheri (Bretsch., 1900); E.moldaviensis (Vejd. et Mraz., 1902) with the subspecies E.m.moldaviensis and E.m.mitropolskiji; E.bavaricus (Oeschm,1913);

E.bedoti (Pig., 1913); E.prespaensis (Hrabě, 1931); E.isochaetus (Hrabě, 1931); E.ochridanus (Hrabě, 1931); E.caspicus (Last, 1937); E.svirenkoi (Last., 1937); E.orientalis (Čern., 1938); E.vejdovskyi (Hrabě, 1941); E.danubialis (Hrabě, 1941); E.mrazeki (Hrabě, 1941); E.grimmi (Hrabě, 1950).

Brinkhurst (1963) regards Euilyodrilus bedoti (Pig.) as a pathological anomaly of the species Euilyodrilus bavaricus. This is unacceptable, since E.bedoti is a "good" species with typical characters and it has been found repeatedly in different geographical locations.

13. Genus Tubifex Lamark, 1816

This genus now contains far less species than a few years ago. The new generic diagnosis compiled by Brinkhurst (1963) was criticized by Hrabe (1965) since it failed to account for the characters of all Tubifex species. After the revision carried out by Hrabě in 1965 some of the species were transferred to Isochaetides, some to Ilyodrilus, and five independent species were reduced to subspecies.

Diagnosis of genus. Dorsal bundles in the preclitellar portion contain hair-setae, pectinate and bifid setae which form different combinations in the bundles. The vas deferens is long and opens into the proximal end of the atrium (Fig.1, j). Ampulla of atrium pyriform, with large prostate gland entering its proximal portion; distal end of male gonoduct not divided into two portions, as in Psammoryctides, but ending in a true penis. Some species have copulatory setae. Spermatozeugmas present.

The genus now comprises 12 species: Tubifex tubifex Müll., 1774 with five subspecies: T.t.blanchardi Vejd., 1891; T.t.bergi

Hrabě, 1935; T.t.kleerekoperi Marcus, 1944; T.t.siolii Marcus 1947; T.t.chocoensis (Steph.,1931); T.costatus Clap., 1863; T.ignotus (Štolc, 1886); T.davidis Benh., 1907; T.nerthus Mich., 1907; T.montanus Kowal., 1919; T.smirnovi Last., 1927; T.speciosus Hrabě, 1931 with two 16
subspecies: T.s.speciosus Hrabě and T.s.monfalconensis Hrabě; T.dojranensis Hrabě, 1958; T.minor Sok., 1961; T.kessleri Hrabě, 1962; T.flabellisetosus Hrabě, 1965.

The following species have been transferred to the genus Isochaetides: Tubifex hamatus Moore and T.lacustris Černosv. The species Tubifex templetoni South. has been transferred to the genus Ilyodrilus.

14. Genus Psammoryctides Vejdovskyi, 1875

This old genus was not accepted by Michaelsen (1900) who merged it in the genus Tubifex. Hrabě (1931) drew attention to the special features in the organisation of the male gonoducts (the presence of a rounded ampulla and a glandular and efferent portion in the atrium) and made Psammoryctes a subgenus of the genus Tubifex, though in 1950 he restored it to the rank of an independent genus. In 1964 Hrabě corrected the old generic name Psammoryctes when it became apparent that it was preoccupied in mammalogy (as a generic name in the Rodentia). Michaelsen had been aware of this (Michaelsen, 1900) but made no correction to the nomenclature since he did not accept the existence of this genus and he gives its name in synonyms only.

Diagnosis of genus. Hair-setae, pectinate and bifid setae. Characteristic spermathecal setae present. Vasa deferentia well developed, shorter than atria or no more than twice their length.

The atria consist of a small rounded or pyriform ampulla and a long tubular portion which divides into a proximal glandular and a distal efferent part. Prostate gland well developed, its duct enters the proximal part of the atrium (Fig.1, k). Cuticular sheath investing penes. Spermathecae present. Sperm aggregated into spermatozeugmas. No large coelomocytes.

Six species are known: Psammoryctides barbatus (Grube, 1861; P.deserticola (Grimm, 1876) (= Ilyodrilus raduli Jar.) with the subspecies P.d.lastočkini Brink. (= Limnodrilus lastočkini Jar.); P.albicola (Mich., 1901); P.moravicus (Hrabě, 1929) with the subspecies P.m.moravicus Hrabě and P.m.fontinalis Hrabě; P.oligosetosus (Hrabě, 1931); P.ochridanus (Hrabě, 1931).

1. Psammoryctes? minutus Brinkh., 1965 - no description of reproductive organs in diagnosis (Sp.dubia).

2. Ps.californianus Brinkh., 1965 - very sketchily illustrated brief description. The male gonoduct has no features in common with Psammoryctides. Atrium tubular, fairly large, no drawing of distal part (Sp.incertae sedis).

3. Psammoryctides heterochaetus (Last.) - synonym of Peloscolex svirenkoi Hrabě (see Peloscolex).

15. Genus Peloscolex Leidy, 1852 17

By the end of the last century the diagnosis of this genus had become so inconsistent that in 1900 Michaelsen refused to recognize it at all in his extensive monograph (Michaelsen, 1900), though he later restored it as a subgenus of Tubifex. It was not until the publication of monographs by Ude (1929) and Stephenson (1930) that the genus Peloscolex received universal recognition and the number of its species began to increase rapidly.

(It should be noted that this increase was due mainly to the description of new species; practically no species were transferred from other genera). Today the genus has clearly delineated limits and is the most extensive tubificid genus. (Its complex synonymy will be omitted as it is only of a historical interest and was thoroughly dealt with by Brinkhurst in 1963).

The description of this species is based on features of the organisation and secretory activity of the external epithelium. The surface of the body usually bears scattered papillae (with embedded particles of detritus), the organisation and nature of which have been variously interpreted. Hrabě (1964) gives the correct explanation.

The particles of detritus glued together by glandular secretions from the external epithelium do not, as in other tubificids, form a loose tube, within which the worm can move about freely, but remain firmly attached to the epidermis. The glands, which produce a sticky congealing secretion, are usually arranged in many rows of transverse rings on the segment and when a worm is removed from the bottom it appears to be covered in dark round or foliate papillae which may cover its entire surface or only a certain portion. Sensory tubercles with percipient hairs lie between these papillae. The composition of this unusual integument formed by the congealed secretion and the particles adhering to it is not in any way constant, but changes all the time. This can be seen when the worms are placed in clean water. Gradually they "free" themselves from their covering of dark papillae as new secretion arrives at the surface of the body and as peripheral areas are evidently liquified and washed off. Some species have a continuous layer of congealed secretion over the surface of the body instead of secretory papillae (P.werestschagini, P.zavreli, P.tenuis, P.apapillatus, P.euxinicus). Integuments of this nature represent a sort of intermediate stage between a tube abandoned during movement and an external skeleton. Some Peloscolex species are considered to have no glandular secretions on the surface of the body. In view of what has been said above, such information should be treated with caution; an existing glandular integument has often remained undiscovered until reinvestigation has revealed its presence in one form or another.

This character should therefore still be considered as basic to the genus. Papillae formed by thick secretion on the body surface have now admittedly been found outside the genus Peloscolex (see the genus Alexandrovia Hrabě, 1962) and even outside the family
Tubificidae (in Slavina evelinae Marcus, 1942), but this does not 18
detract from the diagnostic value of the character since other features of organisation, especially the nature of the male gonoducts, must, of course, always be taken into account. The species Peloscolex ringulatus Sok. was therefore transferred to the genus Alexandrovia on the basis of a careful investigation of the reproductive organs (Hrabě, 1964).

Diagnosis of genus. The congealed secretion of the epidermal glands containing particles of bottom material forms tubercles or a continuous layer on the body surface (in whole or in part), which also bears sensory papillae (these may be absent and the secretion may be difficult to distinguish). Ventral bundles may contain double-pointed and single-pointed setae; bifid, hair-setae (usually relatively short and thick) and pectinate setae may all be found in the dorsal bundles. Spermathecal setae fairly common. No large nodules in body cavity. The ends of the well expressed vasa deferentia enter the atria, which are elongate-pyriform, cylindrical or medially dilated, usually curved and of moderate length. Large differentiated prostate gland with duct entering the middle of the atrium (Fig.1, 1). Spermatozeugmas present.

The following 27 species can now be said to belong to this genus: Peloscolex variegatus Leidy, 1852; P.benedeni Udekem, 1855; P.ferox (Grube, 1879); P.velutinus (Grube, 1879); P.multisetosus (Smith, 1900); P.inflatus (Mich., 1901); P.insularis (Steph.,1922); P.heterochaetus (Mich., 1926); P.pigueti Mich., 1928; P.stankovići Hrabě, 1931; P.tenuis Hrabě, 1931; P.werestschagini Mich., 1933; P.nomurai amamoto Okada, 1940; P.zavreli Hrabě, 1942; P.svirenkoi (Jar., 1948); P.gabriellae Marcus, 1950; P.nikolskyi Last-Sok., 1954; P.apapillatus Last-Sok., 1954; P.scodraensis Hrabě, 1958; P.černosvitovi Hrabě., 1958; P.kamtschaticus Sok., 1961; P.kurenkovi Sok., 1961; P.fontinalis Hrabě, 1964; P.euxinicus Hrabě, 1965; P.beetoni Brinkh., 1965; P.carolinensis Brinkh., 1965; P.freji Brinkh., 1965.

Because the reproductive organs of the species P.insularis, P.pigueti, P.scodraensis, P.černosvitovi and P.fontinalis have not yet been described, the inclusion of these species in the genus Peloscolex must be considered provisional. In addition, P.fontinalis Hrabě cannot, strictly speaking, be considered a species since no diagnosis or description of it has yet been published. Our knowledge of this species is confined to drawings of ventral setae and to the few characters included in a key for the identification of Peloscolex species (Hrabě, 1964), although these admittedly distinguish P. fontinalis very clearly from other species of this genus.

Doubtful species: 1) Peloscolex canadensis Brinkh., 1965 - very brief, sketchily illustrated description. No characters proving

that this species belongs to the genus *Peloscolex* or features sufficient for the characterisation of the species are given; 2) *P.oregonensis* Brinkh., 1965 - the brief description of one sexually immature specimen does not make it possible to distinguish between this form and *P.carolinensis* Brinkh., 1965;3) *P.simsi*
Brink., 1966 - description as brief as in the preceding species. 19
The integuments and male gonoducts have remained unknown.

Sp. incertae sedis: *Peloscolex superiorensis* Brink., 1966. The tubular atrium, long cylindrical (chitinoid?) penial tube and absence of papillae on integument are a combination of characters which do not correspond to the diagnosis of the genus.

16. *Alexandrovia* Hrabě, 1962

Very similar to *Peloscolex* in external appearance. The main distinguishing feature is the diffuse prostate gland with differentiated ducts. Brinkhurst (1965a) uses this character to support his proposal for the merging of *Alexandrovia* in the American genus *Telmatodrilus*, which has a similar prostate gland. Hrabě (1967) objects to this on the basis that other characters of these genera do not coincide: *Telmatodrilus* has only non-pronged or very weakly pronged setae in the dorsal bundles and possesses lateral vessels with blind branches and a lobe on the posterior face of the cerebral gangliori (on the median line). The systematic position of *Alexandrovia* is a question which cannot be resolved finally until there has been additional study of *Telmatodrilus*, which was inadequately described by Eisen (1885).

Diagnosis of genus. Cerebral lobe rounded, usually retracted into the segment II. The body wall contains a mass of glandular cells. Surface of the body covered by a thick layer of secretion mixed with mineral particles. The secretion does not form heaps as in *Peloscolex*, but produces "armour" instead; the epithelium contains both glandular cells and sensory papillae.

The dorsal bundles consist solely of hair-setae. Setae in ventral bundles bifid, with distal denticle longer than proximal one. Spermathecal setae present, thin, long, with slightly curved end. Vas deferens very long, atrium tubular, entered by 10 to 17 (and maybe more) prostate glands with separate ducts (Fig.1, m). Pseudopenis. Spermatozeugmas present in spermathecae.

The genus contains two species: *Alexandrovia onegensis* Hrabě, 1962; *A.ringulata* (Sok.), 1961.

Peloscolex ringulatus, assigned by Hrabě (1964) to the genus *Alexandrovia*, was described by Sokol'skaya (1961).

17. Genus *Telmatodrilus* Eisen, 1879.

Monomorphic genus, suggested by Brinkhurst (1965a) to be synonym of *Alexandrovia* (Hrabě, 1962b).

Diagnosis of genus. All setae singly-pointed, sometimes indistinctly pronged. Surface of body not covered in secretion. Atrium tubular, entered throughout its length by the separate ducts of numerous small, independent prostate glands. These genera do not coincide: *Telmatodrilus* has only non-pronged or very weakly pronged setae in the dorsal bundles and possesses lateral vessels with blind branches and a lobe on the posterior face of the cerebral gangliori
(on the median line). Distal portion of male gonoduct ends in 20
pseudopenis. Spermathecae present, sperm not aggregated into spermatozeugmas. No coelomocytes in body-cavity.

Only two species, described from California and not found anywhere else, are known: *Telmatodrilus vejdovskyi* Eis., 1879;

T.macgregori Eis., 1900.

18. Isochaetides Hrabě, 1965.

The old genus Isochaeta was restored by Brinkhurst (1965), who isolated it from the genus Limnodrilus on the basis that the organisation of the male gonoduct was not the same in all species of the old genus Limnodrilus. The penis of some of these is bare and lacks a chitinous penial investment, while in other species this is present and has expanded distal margins. Brinkhurst accorded the first group of species to the genus Isochaeta. Hrabě (1965) showed that the form described by Pointner (1911) under the name Isochaeta virulenta (generic type) was in fact a sexually immature specimen of Limnodrilus udekemianus. This view had been previously expressed by Michaelsen (1926). As a result Hrabě proposed in 1965 that the genus should be renamed Isochaetides, with I.Baicalensis Mich. as the generic type. Hrabě should be considered the author of the genus, since he gave a different formulation of its diagnosis on the basis of a different generic type as well as correcting its name.

Diagnosis of genus. Ventral and dorsal setae identical, bifid only, with no intermediate denticles. Vas deferens much longer than tubular atrium plus penis. Atrium not divided into narrow ciliated portion and dilated non-ciliated portion (Fig.1, n). Penis bare or covered by thin cuticular sheath, but without a penial investment of the type of Limnodrilus. Large prostate gland. Penial and spermathecal setae may be present. Spermatozeugmas present, large coelomocytes absent.

The following 11 species, previously included in the genera Limnodrilus and Tubifex, belong to this genus:

Isochaetides baicalensis (Mich., 1902); I.newaensis (Mich., 1903); I.hamatus (Moore, 1905); I.arenarius (Mich., 1926); I.michaelseni Last, 1937); I.lacustris (Černosv., 1937); I.neotropicus (Černosv., 1939); I.adetus (Ev.Marcus, 1947); I.lastočkini (Jar., 1948); I.pseudogaster (Dahl., 1960); I.suspectus (Sok., 1964).

Isochaeta nevadana Brinkhurst, 1965 cannot be included in the genus Isochaetides since its main characters do not correspond to the generic diagnosis. The rudimentary vas deferens, the long tubular atrium with small prostate gland at its proximal end and the presence of hair-setae and pectinate setae are all characters of Euilyodrilus rather than Isochaetides. The drawing of the male gonoduct is very sketchy. There is doubt concerning its proximal portion (funnel?). This species must be classified as incertae sedis.

19. Genus Limnodrilus Clap., 1862. 21

This genus used to contain a great number of species, but after the removal of Isochaetides and the revision of the diagnosis only five species were left.

Diagnosis of genus. Dorsal and ventral bundles contain identically shaped bifid setae only. Vas deferens long and narrow. The cylindrical chitinoid penial investment has a developed outer margin (Fig.1, o). Prostate gland large and compact. Spermatozeugmas present. No large nodules in body-cavity.

The following five species belong to the genus Limnodrilus: Limnodrilus hoffmeisteri Clap., 1862; L.silvani Eis., 1879 (= L.grandisetosus Nomura); L.claparedeanus Ratz., 1968; L.udekemianus Clap., 1862; L.helveticus Piguet, 1913.

Other species of the old genus Limnodrilus have been merged in the genus Isochaetides (p.30), among them L.newaensis.

Brinkhurst (1963, 1966b) based his description of new species (L.maumeensis, L.angustipenis and L.cervix)on the shape of the distal end of the penial investment and its thickness. These characters are known to be highly variable; they were used by Southern (1909) in his attempt at describing new species which were later found to be synonyms of earlier known species. Because of the organisation of the male gonoduct, Brinkhurst (1962b) assigned L.newaensis to the genus Tubifex.

20. Genus Branchiura Bedd., 1892.

Monomorphic genus differentiated from other genera by the possession of a number of characters unique to it. Each segment on the posterior part of the body carries a pair of gill filaments along the mid-dorsal and mid-ventral lines.

Diagnosis of genus. Hair-setae and bifid setae in dorsal bundles, bifid setae in ventral bundles. Vasa deferentia short, leading into tubular atria, consisting of a proximal dilated portion with a diffuse gland and of a narrow distal portion without glands, entered by an unusual tubular gland - the paratrium (this, evidently, has nothing in common with the gland of the same name in Bothrioneurum (Fig.1, p). The left and right atria open into a common unpaired copulatory sac. Male penial pore unpaired. Pseudopenis present. Pair spermathecae in X, sperm not aggregated into spermatozeugmas. The only species of this genus at present is Branchiurus sowerbyi Beddard, 1892.

21. Genus Bothrioneurum Štolc, 1888. 22

Very unusual genus substantially differentiated from others by characters not found in any other tubificid genera. These include, inter alia, ventral pores connecting the coelom with the external environment, an unusual paratrium and spermatophores affixed to the body surface because of the absence of vasa deferentia.

Diagnosis of genus. Sensory pit on cerebral lobe, dorsal pores connecting the coelom to external environment present. Setae in ventral and dorsal bundles identical, bifid only. Unusual penial setae present. Vasa deferentia shorter than tubular atria. Distal portion of atrium possibly dilated. Prostate gland diffuse. Right and left atria enter a common copulatory chamber which terminates at the surface in an unpaired penial pore (Fig.1, r). Paired penial pores occasionally encountered. A blind-ended tubular gland - the paratrium - whose secretion aggregates the spermatozoa into spermatophores enters the copulatory chamber. Spermathecae absent. Spermatophores affixed to body surface. Large coelomocytes present in body cavity. Asexual reproduction by architomy.

This genus contains five species: Bothrioneurum vejdovskyanum Štolc, 1888; B.americanum Beddard, 1894; B.iris Beddard, 1901; B.pyrrhum Marcus, 1942; B.brauni Marcus, 1949.

22. Genus Smithsonidrilus Brinkh., 1966.

This genus was created by Brinkhurst for the species Smithsonidrilus marinus Brinkh. newly described by him. This description is so brief and the illustrations are so sketchy that our knowledge of the organisation of the male gonoduct must be considered inadequate. Length of vas deferens and atrium unknown; atrium lacking prostate glands. Both male ducts enter a common copulatory sac, antered also by two paratria with prostate glands.

Male penial pore unpaired, situated ventrally. Three to four spermathecal setae around each spermatheca. Sperm aggregated into spermatozeugmas. The combination of characters described by Brinkhurst (1966b) is extremely unusual. The 3 - 4 setae around each spermathecal pore and shaped like penial setae (!) are unique. The combination of paratria similar to those of Bothrioneurum with spermatozeugmas in the spermathecae is also very curious. Further study of this interesting form is highly desirable.

THE GROUPING AND INTERRELATIONSHIP OF GENERA IN THE TUBIFICIDAE

As far back as 1885 Eisen separated the genus Telmatodrilus, established by him, into the subfamily Telmatodrilinae, which he contrasted to all other tubificid genera in the subfamily Tubificinae. He based this on the presence of a number of differentiated prostate glands on the atrium of Telmatodrilus instead of the single prostate or absence of a prostate in other genera of the family. A third subfamily - Ilyodrilinae Štolc, 1885 - the type species for which was Ilyodrilus coccineus (Vejd., 1875), a synonym of Rhyacodrilus coccineus (Vejd., 1875), was isolated at the same time. For this For this reason the family has now been renamed Rhyacodrilinae (Hrabě, 1954).

These subdivisions of the Tubificidae were not recognised in any of Michaelsen's works. But subsequently Hrabě (1954, 1963, 1964, 1965, 1967) not only re-established the three tubificid subfamilies, but added another two - Branchiurinae and Aulodrilinae.

According to Hrabě, the family Tubificidae thus consists of the following five subfamilies:

I. Rhyacodrilinae, characterised by: 1) diffuse prostate gland, 2) absence of spermatozeugmas, 3) spermathecae opening near anterior intersegmental septum, 4) ova maturing in partitional ovaries ("Teilovarien"), 5) postseptal nephridia of the enchytraeid type, 6) large coelomocytes present in body-cavity.

Characters 1, 2, 4, 6 converge this subfamily with the family Naididae, while characters 4 and 5 also can converge it with the Enchytraeidae.

The Rhyacodrilinae comprise the following genera: Rhyacodrilus, Monopylephorus, Epirodrilus, Moraviodrilus and Bothrioneurum.

II. Tubificinae, characterised by: 1) differentiated prostate gland; two on each atrium or none may sometimes be found, 2) sperm aggregated into spermatozeugmas, 3) no large coelomocytes in body cavity, 4) true penis, usually present, 5) loops of nephridial tubes not fused in postseptum, 6) maturing ovocytes rupturing singly from the ovary. This subfamily includes most of the tubificid genera.

Hrabě (1965) divided this subfamily into three groups on the basis of the relative length of the vas deferens: A) with rudimentary vasa deferentia (Euilyodrilus); B) with vasa deferentia shorter than remaining portion of male gonoducts (Ilyodrilus, Clitellio, Heterodrilus, Limnodriloides, Aktedrilus, Phallodrilus, Spiridion); C) with vasa deferentia longer than remaining portion of male gonoduct (Tubifex, Peloscolex, Psammoryctides, Limnodrilus, Isochaetides).

III. Telmatodrilinae with the subfamilial diagnosis compiled by Eisen (see above). This includes the genera Telmatodrilus and Alexandrovia.

IV. Branchiurinae with the characters of the genus _Branchiura_ (see p. 32).

V. Aulodrilinae with the characters of the genus _Aulodrilus_ (see p. 7).

Hrabě's grouping of the tubificid genera merits attention as the first serious attempt to reduce to some sort of surveyable order the whole diversity of varied and freely combining characters and trends of specialisation to be seen in tubificids. It is interesting to note that Hrabě's series of studies on the systematics of the Tubificidae gradually increased the number of subfamilies, which has reached five in his latest work (Hrabě, 1967). In this case the formation of new subfamilies is merely an indication of the impossibility of deriving the characters of a given genus (or group of genera) from the group of characters of other existing genera of this family. The subfamilies undoubtedly become more homogeneous and natural as their number increases.

It seems to us, however, that the isolation of independent specialisation trends in the family Tubificidae is a process that should be continued. The subfamily Rhyacodrilinae, for example, can scarcely be considered a natural grouping while it includes the genera _Bothrioneurum_ and _Monopylephorus_. It is clearly impossible to derive the characters of the genus _Bothrioneurum_ from the characters of other genera in this subfamily; this genus demonstrates the exceptional realisation of potentialities (such as dorsal pores) completely unknown not only in the family Tubificidae, but in the entire order Naidomorpha. They are, however, very common in a number of families of the order Lumbricomorpha. The sharp differentiation of the genus _Bothrioneurum_ from other tubificid genera is obscured by its inclusion in the subfamily Rhyacodrilinae. Though the genus

Monopylephorus is most probably collective and demonstrates tendencies alien to *Rhyacodrilus* and *Epirodrilus* (unpaired copulatory pores, tubular atria) we consider that it can remain in the subfamily Rhyacodrilinae. The subfamily Tubificinae has without doubt gained from the exclusion of the genus *Aulodrilus*, to form a separate subfamily Aulodrilinae (Hrabě, 1967). A number of characters relate *Aulodrilus* to the family Naididae and it is quite correct to differentiate this genus from other tubificid genera. It seems very likely that the subdivision of the other genera in this subfamily into three groups as proposed by Hrabě will be confirmed by further investigation and will provide the basis for natural groupings within this subfamily.

The isolation of the genus *Branchiura* into an independent line of development seems to us fully substantiated. It is, however, difficult to agree with the isolation of the genus *Telmatodrilus* into a separate subfamily. It must be admitted that the establishment of a new taxon of subfamilial rank on the basis of a single character (in this case the plurality of prostate glands on the atrium) is very risky, given the weakness of the correlations between organisational features (which is highly typical for tubificids) The inclusion by Hrabě of the genus *Alexandrovia*, whose affinity to *Peloscolex* cannot be doubted, further undermines the case for the subfamily Telmatodrilinae.

The diagram in Fig.2 represents our view of the generic 25
interrelationships in the family Tubificidae. Vertical lines represent various mutually irreducible trends of specialisation. We consider that five independent lines may be distinguished in the family Tubificidae and that they may be given the provisional rank of subfamilies. These are: Aulodrilinae, Rhyacodrilinae, Tubificinae,

Branchiurinae and Bothrioneurinae. It is possible that the one heavily branched line on the diagram, which has 15 genera, may later be subdivided into groups (as has been mentioned above this work has already been commenced by Hrabě), but it is unlikely to be broken up into independent lines. The height of the lines and entries is also intended to be significant. Different levels of structural organisation can be discerned in the Tubificidae. We wish, in particular, to treat genera possessing a differentiated prostate gland, spermatozeugmas and true penes (those forming the rosette of 15 genera on the diagram) as "higher" tubificids by comparison with the majority of other genera.

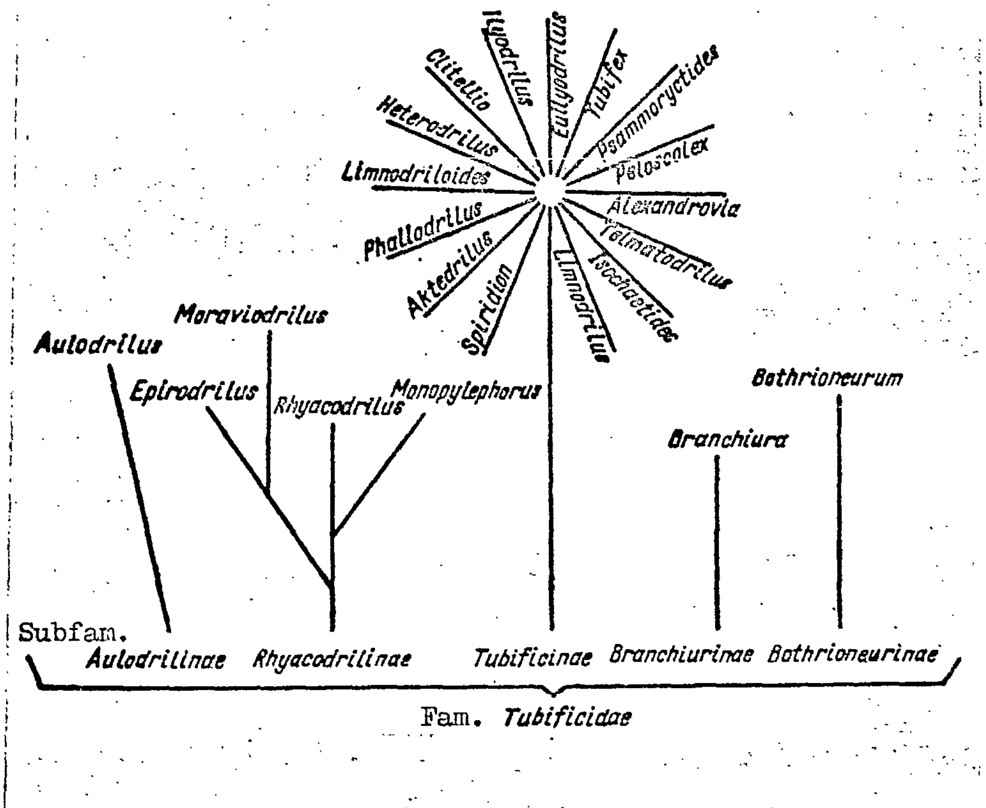

Рис.2. Схема соотношения родов в сем. Tubificidae (Объяснение в тексте)

Fig.2. Diagram of generic interrelationships in the family Tubificidae. (Explained in text).

It can thus be seen that we fully support Hrabě's separation of mutually irreducible generic groups in the family Tubificidae and are trying to continue it. It must, however, be admitted that it may be slightly premature to classify these groups of genera as subfamilies, since it is not yet possible to fulfill the requirement necessary for the erection of a new taxon, namely that its diagnosis should be based on a set of mutually correlated characters. Further profound investigation of the morphology of the family Tubificidae, which is distinguished by the great plasticity of its organisation, is therefore essential. 26

SOME INFORMATION CONCERNING WORKS ON THE SYSTEMATICS OF AQUATIC OLIGOCHAETA BELONGING TO OTHER FAMILIES

This article is not intended to provide a review of the data on the systematics of other families of aquatic Oligochaeta similar to that provided above for the family Tubificidae, we nonetheless consider it relevant to mention new research on these families and to assess the level of development of their systematics.

Fam. Potamodrilidae Bunke, 1967. This new family of the order Naidomorpha arose from the erection of the genus Potamodrilus Lastočkin into a separate family. Bunke, who found this worm in the psammon of the river Weser near Bremen, has made a thorough study of its anatomy both in vivo and in serial sections. The organisational features he found were so unusual that the isolation of this form from the family Aeolosomatidae is undoubtedly correct. Bunke even considers it possible that the characters converging Potamodrilus with the Aeolosomatidae (ciliated cerebral lobe and nervous system within the external epithelium) may have arisen independently since other organisational. features, especially the organisation of the reproductive organs, are so divergent.

Fam. Aeolosomatidae. A number of investigators have worked on this family in India (Naidu, 1961), France (Juget, 1959) and Yugoslavia (Georgevitch, 1957b). But the work by Bunke (1967), to which reference has been made above and which contains many new observations and descriptions of new species, was the main event in the study of the Aeolosomatidae during this period. It is an excellent monograph on this family, embodying a critical evaluation and a thorough revision of all the available information on a world-wide scale.

Fam. Naididae. The systematics of this family are also in very good order thanks to Sperber's excellent monograph (Sperber, 1948) though it is already becoming necessary to review some of its tenets. A fifth subfamily, Stephensoninae V. Naidu, 1961, has been
added to the four previously existing ones (Chekanovskaya, 1962). 27
A new genus and species Waspa evelinae Marcus, 1965, belonging to the subfamily Paranaidinae, has been described from South America. Sokol'skaya (1962) has described a new genus and species Neonais elegans and the new species Nais koshovi, Nais baicalensis, Nais beckmani, Uncinais minor and Amphichaeta magna from Baikal, as well as the species Nais borutzkii from brackish waters on Sakhalin (Sokol'skaya, 1964). The new species Prestina longidentata Harman, 1965 has also been described.

Fam. Enchytraeidae. This extensive family contains relatively few specifically aquatic species, but a systematic study of it must naturally include all its component forms. The systematics of the Enchytraediae were, until recently, extremely neglected and no one was studying the subject. However, interest in the systematics of this family was sharply increased after the work of Nielsen and Christensen (1959) who used in vivo observation methods for the identification of these worms. It is now being thoroughly investigated by the following: Nurminen (1961, 1962, 1964, 1965a, 1965b, 1965c) in Finland, Lassere (1964, 1966) in France and Tynen (1966) and Kennedy (1966) in Ireland.

The family Haplotaxidae has been revised recently by Brinkhurst (1966a, 1966b); he also referred to the small fam. Alluroididae in these works.

Fam. Branchiobdellidae. The systematics of this small parasitic family is in fairly good order. Important new works have been published by Hoffman (1963), Pop (1965), Georgevitch (1955, 1957a) and Holt (1960, 1963, 1964, 1968).

Fam. Lumbriculidae. The position as regards this extensive and difficult to identify family is much less satisfactory. The description of new species is being continued (Hrabě, 1960 and other works by this author and Sokol'skaya, 1967). A monograph on the lumbriculids of Lake Baikal has been published by V.V.Izosimov (1962). Brinkhurst and Cook have begun work on a survey of species in the fauna of North America (Brinkhurst, 1965b; Brinkhurst and Cook, 1966). A revision of all known species of this family and an investigation of generic interrelationships within it are, however, urgent but so far almost untouched tasks.

In conclusion, it may be said that (disregarding small and less important families) the Aeolosomatidae and the Naididae are the only families of aquatic Oligochaeta whose systematics is in a satisfactory state. These are the families which have recently been the subject of sizable monographs with world-wide coverage.

It is of course only by the creation of such monographs that order can be brought into systematics and accurate and unambiguous identification of species can thus be ensured.

It is thus essential to encourage the publication of major 28
monographs on the systematics of a number of families for a proper understanding of the composition of the Oligochaeta, which is so necessary in present hydrobiological work.

This applies primarily to the families Tubificidae, Enchytraeidae and Lumbriculidae. Although all three include forms of considerable importance in the life of bodies of water, pride of place should be given to the Tubificidae as the family of the greatest importance to the study of the benthos. The confused state of its systematics creates great difficulties in the identification of species and adversely affects the accuracy of information on the composition of the aquatic fauna. The aim of our review of the genera in the family Tubificidae has been to draw attention to this problem.

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THE PRESENT POSITION AS REGARDS THE SYSTEMATICS OF AQUATIC OLIGOCHAETA (FAMILY TUBIFICIDAE) 32

By O.V.Chekanovskaya

Summary

Many new species of the family Tubificidae have been described during the last decade, many new genera have been established and some old ones reinstated. Many species have been transferred from one genus to another.

Further revision of all genera in the family Tubificidae is necessary to put its systematics in order. The generic groupings in this family are another question in need of further investigation. We consider that it is too early to solve the problem of the erection of subfamilies, but an outline of a possible grouping of genera is provided. The families Aeolosomatidae and Naididae, which have had excellent monographs devoted to them, are in the best systematic order. The systematics of the families Tubificidae, Enchytraeidae and Lumbriculidae is unsatisfactory. Bibliography: 75 titles.

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II. FAUNAL STUDIES

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NEW INFORMATION ON THE DEEPWATER OLIGOCHAETES OF LAKE BAIKAL

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Baikal is the deepest freshwater body of water in the world and possesses a true abyssal zone. According to G.Yu. Vereshchagin (1949) it reaches depths of 1741 m.[1] Kozhov (1962)

[1] Kozhov (1962), in a footnote on p.12, quotes G.I.Galazii to the effect that "the maximum depth in the central part of Lake Baikal is 1620 m".

considers that the abyssal zone extends from the upper subzone (250 - 500 m) to the lower subzone, which includes maximum depths, and he also notes that "the benthos at depths greater than 250 m has been so far very inadequately investigated".

Some new information on the oligochaete fauna of the abyssal zone of Baikal is presented below. The material placed at our disposal by the Institute of Limnology, USSR Academy of Sciences, included a sample from one of the deepest points in Baikal-- it is labelled 1705 m.[2]

[2] This increase on the maximum depth may possibly be explained by the drifting of the ship and the consequent distortion of the cable.

The author's observations, made in 1961, on the body colouring of certain live deepwater oligochaetes are also set out in the article.

Limnodrilus infundibuliferus, Isossimov sp. n.

Location: Lake Baikal. Ukhan-Tonkii section, depth 1705 m, silt; September 1, 1949.

Material. One fragment of anterior end (34 somites) in poor condition.

Membership of the genus Limnodrilus is established solely by the chitinized portions (setae and penial tube). All setae exclusively bicuspid; hairlike or pectinate setae and intermediate denticles absent. Chitinized penial tube present. This species can, therefore, be included in generic group III of the subfamily 34
Tubificinae (Hrabe, 1966, p.71). The possession of a chitinized

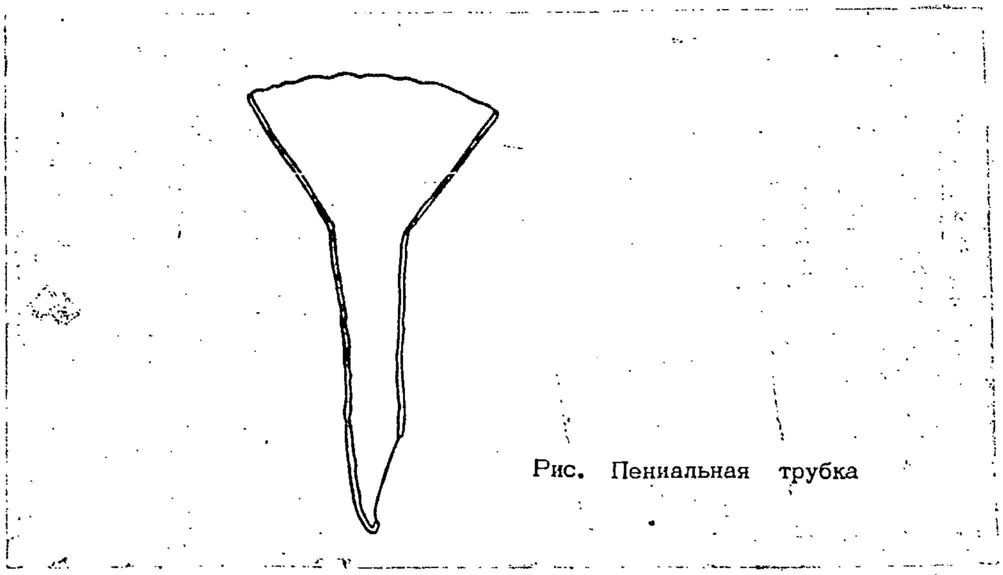

Fig. Penial tube.

penial tube typical of the genus Limnodrilus distinguishes the species from the genus Isochaetides.

Description. Body surface smooth (no papillae). Prostomium shaped like a short rounded mitre. Length : width ratio of prostomium 3 : 5. Its anterior end bears a low conoid process with a thinner epidermis and circular muscles. There is a possibility that this tubercle may be extensible since cross striation, indicative of circular muscles, can be seen clearly beneath the fine epidermis. Intersomitic grooves well expressed but shallow. Somites slightly convex.

Both the dorsal and ventral bundles contain 3 - 4 setae approximately 0.27 mm long (= 3 somites). Setae bifid, lacking intermediate denticles, S-shaped with a well expressed distal nodule (location of nodule expressed by ratio 1 : 2 from distal end of seta). Proximal denticle of setae bent almost at 90% towards distal denticle and slightly thicker. One pair of penial tubes in XIth somite. Chitinized portion of male reproductive organs reminiscent of laboratory funnel with a tubular distal section and a conoid proximal section (see Fig.)

The chitinized portion of the penis is a distinctive feature of this species. Ratio of distal portion to proximal portion approximately 2 : 1 along tube axis. Diameter of tubular portion approximately $\frac{1}{4}$ diameter of funnel (optical section). Distal end of one penial tube oblique and inner (proximal) margin slightly undate. End of other (paired) tube cut straight across, transition from tube to conoid portion smoother. Wall of tubular portion much thicker than wall of conoid portion of penial tube.

<u>Haplotaxis ascaridoides</u> Mich. 35

One fragment of a young, sexually immature specimen of this species was discovered in the same deepwater sample (depth 1705 m).

Ventral setae slightly S-shaped, uncinate at distal end, usually distributed singly, nodule distally located (5 : 8).

Dorsal setae normally paired, very close together in each pair, rod-like, slightly curved, with the nodule a third of the length from the distal end. They are hard to distinguish in a total preparation among the well developed muscles of the musculo-cutaneous sac and are little more than 1/5th the length and 1/4 - 1/5th the thickness of the ventral setae. Michaelsen (1905) notes that the dorsal setae are somewhat more curved than the ventral ones. In our specimen this relationship is somewhat different. The entire prenodular portion is very slightly sickle-shaped, while in the ventral setae the distal end of this portion is backward recurved in a hook. It is impossible to say whether these deviations in the shape of the setae are of any systematic significance. The specimen was found to be sexually immature.

Observations of live H.ascaridoides (1961) showed that their muscular-cutaneous sac was non-pigmented and transparent. The body is dark red (flesh-coloured) because the blood vessels show through.

Although the Lumbricullidae reach great depths, they cannot be considered purely abyssal because they have been found above the upper limit of the upper abyssal subzone.

According to O.V.Chekanovskaya (1962), for example, Teleoscolex baicalensis Mich. was found at depths of 98 to 1197 m, Lamprodrilus pallidus Mich. at 3 to 1073 m, L.inflatus Mich. at 65 to 1073 m and Rhynchelmis brachycephala Mich. f. typica at 83 to 1073 m.

Live specimens of these species have the monotypic colouration characteristic of great depths. They are of various depths of red (flesh coloured).

The present material confirms the author's previously expressed point of view (Izosimov, 1962) that "Baikal is not a palaeontological museum, but one of the major foci of speciation in which the Tertiary fauna gave rise to a number of endemic forms." Limnodrilus infundibuliferus is just such a form which penetrated to the maximum depths without acquiring the expressed features of deepwater Oligochaeta.

A slightly expressed tendency towards an increase in the 36
transparency of the body can be observed in eurybathic forms, which include most abyssal oligochaetes, with the result that the blood vessels show through and the body becomes a shade of red of some intensity (flesh coloured).

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NEW INFORMATION ON THE DEEPWATER OLIGOCHAETES OF LAKE BAIKAL

By V.V. Izosimov

Summary

Limnodrilus infundibuliferus, a species new to science, is described from a depth of 1705 m in Lake Baikal. *Haplotaxis ascaridoides* was found at the same station.

Bibliography: 6 titles.

OLIGOCHAETA IN THE SOUTH OF LAKE PSKOV

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The south of Lake Pskov, north of the Talabskiye Islands, was investigated in August of 1965 and 1966. Forty-two stations were occupied at right angles to the long axis of the lake. Benthos was collected with a Petersen grab (1/40 m^2), three to four samples per station. Standard procedures were used in the preservation and examination of specimens. Twenty-five oligochaete species were found in the benthos.

The Naididae found were: *Stylaria lacustris* (L.), *Arcteonais lomondi* (Martin), *Nais pseudobtusa* Piguet, *N. barbata* Müller, *N. communis* Piguet, *N. elinguis* Müller, *N. bretscheri* Michaelsen, *Specaria josinae* (Vejdovsky), *Piguetiella blanci* (Piguet), *Uncinais uncinata* (Oersted), *Homochaeta naidina* Bretscher, *Chaetogaster diaphanus* (Gruithuisen), *Pristina foreli* (Piguet).

Tubificidae were represented by the following species: *Aulodrilus limnobius* Bretscher, *A. pluriseta* (Piguet), *A. pigueti* Kowalevsky, *Limnodrilus udekemianus* Claparède, *L. hoffmeisteri* Claparède, *L. claparedeanus* Ratzel, *Euilyodrilus hammoniensis* (Michaelsen), *Psammoryctides barbatus* (Grube), *Ps. albicola* (Michaelsen), *Peloscolex ferox* (Eisen).

Propappus volki Michaelsen was recorded from the Enchytraeidae, but most members of the family were not identified to species level; Lumbricullidae were represented by the discovery of *Lamprodrilus isoporus* Michaelsen. *Arcteonais lomondi*, *Nais* *bretscheri*, *N.elinguis*, *Piguetiella blanci*, *Specaria josinae*, *Homochaeta naidina* and all three *Aulodrilus* species are recorded in Lake Pskov for the first time to judge by previous check-lists (Ioffe, 1948; Timm, 1962; Tyl'p, 1966).

The abundance of Oligochaeta ranged during the collections between 600 and 9940 specimens/m^2 and the biomass between 1 and 20 g/m^2. At 26 of the 42 stations the biomass of Oligochaeta exceeded 50% of the total benthic biomass.

Analysis of the distribution of the Oligochaeta by bottom materials and depths and calculation of the index of similarity between the stations by Mountford's method (Mountford, 1962) enabled us to distinguish a number of oligochaete associations. The association in which *Euilyodrilus hammoniensis* predominates, characteristic of depths between 3 and 5 m (greater depths are rare in this part of the lake) and of a silty bottom is the most prevalent in the lake.

The characteristics of this association are:

1. Clear predominance of the dominant species, *E.hammoniensis*. It was found at all 27 stations in the stated depth range (540 - 3400 specimens/m^2, biomass 2 - 19 g/m^2). At some stations it was the only oligochaete encountered and on average it accounts for 75% of the Oligochaeta in terms of abundance and 81% in terms of biomass.

2. *Limnodrilus hoffmeisteri*, found at more than half 38
the stations, is the subdominant species. Its abundance ranges from 20 to 420 specimens/m^2 and its biomass from 0.1 to 3.1 g/m^2. The average contribution of *L.hoffmeisteri* to the Oligochaeta of the association is 8% in abundance and 9% in biomass.

3. The small tubificids *Aulodrilus* (all three species)

and Arcteonais lomondi are common. Each of these species was encountered at at least a third of the stations. These oligochaetes were discovered in the lake for the first time; in other bodies of water, in Karelia for example (Chekanovskaya, 1965), they are considered rare. It is quite possible that because of their small size they are lost when bottom material is washed through coarse-mesh gauze (we used No.20 mesh gauze instead of the more usual No.10). The abundance of Aulodrilus is 20 - 240 specimens/m^2 and that of A.lomondi 20 - 140 specimens/m^2; the biomass of each species does not exceed 0.1 g/m^2.

4. Small numbers of Naididae of the inshore-weed bed association (20 -140 specimens/m^2) are found: Stylaria lacustris, Uncinais uncinata, Chaetogaster diaphanus. At some stations their biomass reaches 0.3 g/m^2. This is probably explained by the seasonal migration of Naididae from the shores into the open lake which takes place at the time of their mass proliferation in the middle of the summer (Timm, 1964).

In addition to the above-mentioned species, Peloscolex ferox is found sporadically in quantities of 40-80 specimens/m^2. The average abundance of Oligochaeta in this pelophilous association is 2377 specimens/m^2 and the biomass 10.8 g/m^2.

The association in which the relict lumbriculid Lamprodrilus isoporus predominates is also prevalent (10 stations) and well expressed. It occupies depths of 1.5 to 3 m where the bottom is sandy and slightly silty.

Characteristic features of the association:

1. L.isoporus is the dominant species. At the time of the investigation its abundance was 260 - 440 specimens/m^2 and its

biomass 1.0 - 1.3 g/m^2. It accounts for only 23% of the worms in terms of abundance, but for 55% in terms of biomass because of its comparatively large size.

2. The subdominant Uncinais uncinata is found at all stations in quantities of 340 - 540 specimens/m^2 with a biomass of 0.4 - 1.1 g/m^2 (26% of the abundance and 32% of the biomass of Oligochaeta respectively).

3. Propappus volki (180 - 400 specimens/m^2, biomass not exceeding 0.1 g/m^2) is also found at all stations.

It has been noted that P.volki becomes the subdominant form at the beginning of May, when the abundance of Naididae is low. The association includes many other Enchytraeidae (up to 440 specimens/m^2) which we were unable to identify to the species level.

4. The zoocoenosis under investigation always contains a few pelophilous species whose abundance increases as the sand becomes more silted-up but does reach the indices characteristic of the silty bottom in the open part of the lake. Thus, maximum abundance of Euilyodrilus hammoniensis under these conditions is 160 specimens/m^2, that of Limnodrilus hoffmeisteri and Peloscolex ferox is up to 20 specimens/m^2 and that of Aulodrilus up to 40 specimens/m^2. There is no clear boundary between the two associations described: at some stations where the sandy-silty bottom lies at depths exceeding 3 m, which is not very usual in
Lake Pskov but typical of Lake Chudskoe, Lamprodrilus isoporus 39
is found with Euilyodrilus hammoniensis. It should be noted that the pelophilous E.hammoniensis also inhabits slightly silted-up sand at a low density, while the psammophilous L.isoporus is absent from pure silt. Piguetiella blanci and Specaria josinae are among

the rare species belonging to the association. The average abundance of Oligochaeta in the association is 1553 specimens/m^2 and the average biomass is 2.2 g/m^2, one-fifth of the abundance in the pelophilous association.

In addition to the oligochaete associations mentioned above, which occupy the greater part of the lake bottom, there are others, less widely distributed. It is impossible to give a clear description of these because of the paucity of material, nor is it clear how stable they remain over a period. Thus the naidids Stylaria lacustris (max,3140 specimens/m^2), Uncinais incinata (max. 1820 specimens/m^2), Chaetogaster diaphanus (max. 900 specimens/m^2), Nais barbata and N.pseudobtusa (up to 3640 specimens/m^2 altogether) predominate in the fauna of the sandy bottom beneath the reed beds. The total number of the Oligochaeta approaches 10,000 specimens/m^2. The biomass of small naidids here reaches 9.3 g/m^2, while that of tubificids is only 0.8 g/m^2 and that of enchytraeids 0.2 g/m^2. In the middle of the summer the weed beds are the setting for the mass breeding of phytophilous naidids which migrate from them to the centre of the lake. There is only a scanty oligochaete fauna in the washed sands in the shallows of the open littoral zone. Only Uncinais uncinata (740 specimens/m^2) and enchytraeids (20 specimens/m^2, max.), with a biomass of 1 g/m^2, were found under these conditions at a depth of 0.5 m. A practically pelophilous association, but one in which Limnodrilus hoffmeisteri, L.claparedeanus and L.udekemianus predominate and E.hammoniensis receded into the background forms in the mouths of the rivers discharging into the lake (Velikaya, Tolba, Pimzha) where the bottom is impregnated with detritus. According to our data tubificids of the genus Limnodrilus also predominate in the River Velikaya delta. Our outline of oligochaete associations is only approximate, since their seasonal dynamics has yet to be investigated before the problem of their stability, boundaries and interpenetration can be solved.

All Tubificidae are detritus-eaters. The contents of their intestines usually reflect the natural composition of the bottom. For example, in the food of Euilyodrilus hammoniensis, which inhabits the muddy bottom, sand grains are rarely encountered (not more than 5% of the volume of the food bolus). Fairly large sand grains (up to 0.4 mm in diameter), at times amounting to 60% of the volume of the food, are ingested by Lamprodrilus isoporus. The ingestion of ooze together with sand (psammopelophagy) is also characteristic of both Psammoryctides species.

Flexibility in feeding on various bottom materials has been noted in Peloscolex ferox. Only fine silt is found in the intestines of individuals from a muddy bottom, while on a sandy bottom the worm ingests sand grains up to 0.3 mm in diameter (up to 40% of the total food by volume). This feature is also typical of Limnodrilus hoffmeisteri and probably also of many other tubificids.

The feeding of small oligochaetes may be more selective. Propappus volki inhabits a sandy bottom, but because of its size it cannot swallow sand grains but feeds on the finest ooze which accumulates between these grains. Naidids are more inclined to feed
on live organisms. The intestines of Stylaria lacustris contain 40
quantities of the algae Cymatopleura, Synedra and Gloeocapsa and Difflugia. Arcteonais lomondi consumes diatoms, Scenedesmus and Difflugia. Ooze is however always present in the food of these worms.

The mode of feeding of Uncinais uncinata on the sand of the littoral zone is of interest. These worms devour such large sand grains that not only is the intestine deformed, but the very body becomes beaded. U.uncinata measures 0.5 mm in cross section and it devours grains 0.3 mm in diameter. Investigations have shown that these worms consume, in addition to sand grains, the benthic rotifers attached to them (up to 30 of these can be found in the intestine).

Until recently it was considered that the main enemies of Oligochaeta were fishes and that no serious harm could be done to their populations by the attacks of other animals (Chekanovskaya, 1962). Although this question can be solved only by careful investigation, the few observations which have been made show that Oligochaeta have many invertebrate enemies not only in the margins but also in the open areas of bodies of water. Certain predatory chironomid larvae are evidently dangerous enemies. Cryptochironomus gr.nigridens larvae are fairly common in Lake Pskov on the muddy bottom at depths below 3 m (the oligochaete association in which Euilyodrilus hammoniensis predominates). Of 36 such larvae dissected, 22 had empty intestines, but 14 contained E.hammoniensis in a semi-digested state with setal bundles well preserved. The intestines of each larva was found to contain one worm which could be literally squeezed out like paste out of a tube when lightly pressed with the dissecting needle. No other food was found in Cr.nigridens.

Out of 32 intestines of Cryptochironomus gr.defectus larvae, 20 were empty, while 8 contained E.hammoniensis, 2 contained Uncinais uncinata.

Cr.defectus is more widely distributed in the lake than Cr.nigridens. This is explained by the greater variety of food in the latter, consisting of several species of Oligochaeta. Remains of *Stylaria lacustris* were found in 2 intestines of *Diamesa campestris* and setae of *Psammoryctides barabatus* were found in one *Cryptochironomus* gr. *vulneratus* specimen.

In addition *Nais* sp. was found in the gastral cavity of 3 hydras of 20 investigated (crustaceans were the main food of the hydras) and the intestine of one *Planaria* was found to contain *Uncinais uncinata*.

Observations from the delta of the Velikaya River show that Oligochaeta of the genus *Nais* are consumed by the predatory oligochaete *Chaetogaster diaphanus*. Further research will evidently show that Oligochaeta, which form a considerable part of the benthos of a great variety of bodies of water, play an important role in the trophic relationships of invertebrates.

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OLIGOCHAETA IN THE SOUTH OF LAKE PSKOV

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Summary.

Twenty-five oligochaete species, nine of them discovered in the lake for the first time, are recorded. Associations which include _Euilyodrilus hammoniensis_ (Mich.) (on a silt bottom) and _Lamprodrilus isoporus_ Mich. (on a sandy bottom) are widely distributed. The weed bed zone is rich in Naididae which migrate into the open lake in the summer. Information on the feeding of certain species: _Uncinais uncinata_ (Örst) feeds on the benthic rotifers. It was discovered that certain Chironomidae larvae (especially _Cryptochironomus_) are enemies of Oligochaeta.

It appears that the Oligochaeta play a considerable role in the trophic chains of freshwater invertebrates.

Bibliography: 7 titles.

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OLIGOCHAETA IN THE LAKES OF THE SOLOVETSKII ISLANDS

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The earliest information about the Oligochaeta of the 42
Solovetskii Islands is to be found in a well-known work by N.A. Obnorskii (1895), who described five species of the family Enchytraeidae from the littoral zone of the sea and from the soil of the archipelago. However, the freshwater Oligochaeta of the islands have remained uninvestigated down to the present.

The present work is based on material collected by the 1965 - 1966 multi-purpose expedition of the Karelian department of the State Research Institute for Lake and River Fisheries (Gos NIORKh) to 67 lakes on the Great Solovetskii Island. Most of these lakes are glacial, but a few are of marine origin. The Solovetskii lakes demonstrate all stages in the transition from oligotrophic to heavily eutrophic humified and acid bodies of water. Their areas range from 2 to 220 hectares and average depths are between 1.5 and 12 m. The bottom materials are liquid oozes and ore formations, with rock and rock-sand deposits in the inshore area.

Oligochaeta form a considerable part of the invertebrate fauna of the Solovetskii lakes. We have discovered 30 species and forms of aquatic Oligochaeta (see Table). Most of them are widely distributed throughout the USSR and many are cosmopolitan species (Nais communis, N.variabilis, Slavina appendiculata, Limnodrilus hoffmeisteri and others).

As regards species composition, the oligochaete fauna of the Solovetskii lakes is close to the oligochaete fauna of northern Karelian bodies of water. A typical feature of the fauna of these parts is the predominance in the profundal zone of the lakes of species belonging to the northern association: Tubifex tubifex, Peloscolex ferox, Lumbriculus variegatus and Stylodrilus heringianus (Lastochkin, 1947). But while Euilyodrilus hammoniensis is fairly infrequent and found in small quantities in the northern lakes of Karelia, it is widely distributed in the Solovetskii lakes and in some lakes (Goreloe, Zavoznoe) it is the dominant species. When compared with the oligochaete fauna of southern and central Karelia, the species composition of Oligochaeta in the Solovetskii Islands is seen to be much poorer (Gerd, 1950; Chekanovskaya, 1965). The oligochaete fauna of the Solovetskii Islands shows some resemblance to that of the Vashutkiny Lakes (Finogenova, 1966) as well as to the oligochaete fauna of the Pechora Lastochkin, 1953), the Vychegda (Lastochkin, 1955) and the Northern Dvina.

The discovery of the relict lumbriculid Lamprodrilus isoporus on the Solovetskii Islands in Lake Verkhnii Pert is of considerable interest.

The various limnological types of lakes in the Solovetskii 43
Islands are characterised by definite and specific oligochaete associations (see Table).

1. Oligotrophic lakes. Stylodrilus heringianus is especially typical of these lakes, whose oligochaete fauna is poor.

Other species which should be mentioned are Stylaria lacustris, Peloscolex ferox and Limnodrilus udekemianus.

2. Mesotrophic lakes possess a great variety of species among which Limnodrilus hoffmeisteri and Euilyodrilus hammoniensis predominate. Abundant forms (S.lacustris, Nais and Chaetogaster species and others) are common here.

3. In eutrophic lakes Euilyodrilus hammoniensis and Tubifex tubifex are abundant. Such bodies of water are usually distinguished by a reduced number of species of Oligochaeta but high abundance of the species that are present.

4. Dystrophic lakes are characterised by a poor qualitative composition. Lumbriculus variegatus is the dominant species. Their inshore weed-beds are inhabited by Slavina appendiculata and Stylaria lacustris which can withstand waters with a pH reaching 4.8.

5. Brackish bodies of water yielded only one marine species (Clitellic arenarius), the remaining species being freshwater ones. These were representatives of the fam. Naididae (Chaetogaster diaphanus, Ch.langi, Stylaria lacustris, Nais barbata, N.variabalis, N.communis) and of the fam. Tubificidae (Limnodrilus hoffmeisteri and Psammoryctides albicola).

The distribution pattern of Oligochaeta in the Solovetskii lakes is determined primarily by the hydrological and chemical hydrological conditions in them.

The oligochaete fauna is relatively poor in the littoral zone, where the bottom is of rock or of rock and sand. A very unusual microbenthic faunal association inhabits the surfaces of stones covered in a brown diatom film, which usually develops from the month of June. Stylaria lacustris, Nais pseudobtusa, N.communis, Uncinais uncinata and Chaetogaster diaphanus are very common here. The average density of the naidid association ranged between 3 specimens/m^2 (June) and 16 specimens/m^2 (late August). The sand between the stones is inhabited by Stylaria and Nais, and Lumbriculus variegatus is commonly found in areas containing coarse plant detritus.

The oligochaete fauna is particularly rich and varied in the inshore weed-bed zone. The shallowness of these parts of the lakes ensures that the water is well warmed through to the bottom, and the abundant higher and lower aquatic vegetation provides accumulations of detritus and encourages the development of the phytophilous association as well as the appearance of pelophilous species. Stylaria lacustris, Nais barbata, N.simplex, N.pseudobtusa, Chaetogaster diastrophus, Ripistes parasita and others are associated with foulings on macrophyte stems and leaves. Tubificid species (Limnodrilus hoffmeisteri, Tubifex tubifex, Euilyodrilus hammoniensis), Enchytraeidae and Lumbriculus variegatus gather in the muddy bottom between plant roots. Ch.diaphanus, N.communis and N.variabilis are the species most commonly found on the bottom surface.

The lower littoral zone of the Solovetskii Islands is 46
characterised by the considerable variety of the oligochaete fauna. Silting makes this a suitable area for pelophilous species. The naidid composition is less varied here (the most common are Stylaria lacustris, Ripistes parasita and Nais barbata, with Slavina appendiculta in swampy areas), but the number of tubificid species rises appreciably (Limnodrilus hoffmeisteri, L.udekemianus, Peloscolex ferox, Psammoryctides albicola and others).

1 Oligochaeta озер Соловецкого архипелага*

2 Вид	3 Солоноватые водоемы	Пресные водоемы 4						
		Верхняя 5 литораль		Нижняя 8 литораль	Профундаль 9			
		каменисто-песчанистая 6	заросли 7		грубодетритный ил 10	тонкодетритный ил 11	рудоносные участки 12	13 глина
Stylaria lacustris (L.)	X	XX	XX	X	O	–	–	–
Ripistes parasita (Schmidt)	–	–	XX	XX	–	–	–	–
Slavina appendiculata (d'Udekem)	–	–	–	X	O	–	–	–
Nais pseudobtusa Piguet	–	XX	XX	X	–	–	–	–
N. barbata Müller	O	–	XX	XX	–	–	–	–
N. simplex Piguet	–	–	XX	–	–	–	–	–
N. communis Piguet	O	XX	X	–	–	–	–	–
N. variabilis Piguet	O	O	X	–	–	–	–	–
Ophidonais serpentina (Müller)	–	–	0	O	–	–	–	–
Uncinais uncinata (Oersted)	–	X	XX	–	–	–	–	–
Chaetogaster diastrophus (Gruith.)	–	X	XX	–	–	–	–	–
Ch. diaphanus (Gruith.)	O	X	X	–	–	–	–	–
Ch. langi Bretscher	X	O	0	–	–	–	–	–
Pristina foreli Piguet	–	–	0	O	–	–	–	–
P. longiseta Ehrenberg	–	–	0	–	–	–	–	–
Clitellio arenarius (Müller)	XX	–	–	–	–	–	–	–
Limnodrilus udekemianus Claparède	–	–	–	X	O	O	–	–
L. hoffmeisteri Claparède	O	–	X	X	X	X	–	O
Euilyodrilus hammoniensis (Mich.)	O	–	X	XX	XX	XX	O	–
Psammoryctides albicola (Mich.)	O	O	–	O	O	–	–	–
Tubifex tubifex (Müller)	–	–	X	X	XX	X	O	O
Peloscolex ferox (Eisen)	–	–	–	X	O	X	X	–
Tubificidae gen. sp.	–	–	–	O	–	–	–	–
Marionina sp.	X	–	X	–	–	–	–	–
Enchytraeidae gen. sp.	–	–	O	O	O	–	–	–
Lumbriculus variegatus (Müller)	–	X	X	X	X	O	X	–
Lamprodrilus isoporus Mich.	–	–	–	–	–	O	–	–
Stylodrilus heringianus Claperède	–	–	–	–	–	X	X	–
Rhynchelmis sp.	–	–	–	–	–	O	–	–
Lumbriculidae gen. sp.	–	–	–	O	–	–	–	–

14 *XX - часто, X - обычно, O - редко, "–" - отсутствует.

Key to Table on pp.44-45: 1. Oligochaeta in the lakes of the Solovetskii Islands*, 2. Species, 3. Brackish bodies of water, 4. Freshwater bodies, 5. Upper littoral zone, 6. Rock-sand, 7. Weed beds, 8. Lower littoral zone, 9. Profundal zone, 10. silt; 11. ooze; , 12. Ore-bearing areas, 13. Clay, 14.* XX - frequent, X - common, O - rare. "-" - absent.

Pelophilous species predominate in the profundal zone, distinguished by the great uniformity of its environmental conditions. Almost all naidid species are absent with the exception of isolated specimens of S.lacustris, which evidently drifted here from the littoral zone. Tubificidae and Lumbriculidae acquire the greatest significance. The nature of the bottom materials is the main ecological factor influencing the qualitative composition and quantitative development of Oligochaeta in the profundal zone.

The dark-brown ooze typical of the profundal zones of most Solovetskii lakes is predominantly inhabited by the same tubificid species: Tubifex tubifex, Limnodrilus hoffmeisteri and Euilyodrilus hammoniensis, with the latter in the dominant role. The density of Oligochaeta in this biotope ranged between 0.07 and 0.6 g/m^2 for the various lakes. Stylodrilus heringianus flourishes in the ooze of oligotrophic lakes.

The silts typical of the shallow areas adjoining the lower littoral zone and of the shallower lakes of the Solovetskii Archipelago (Goreloe, Karasevo, Dolgoe, Plotich'e and others) are richer oligochaete biotopes of the profundal zone. The density of Oligochaeta is highest in these areas where it reaches 7.5 thousand specimens/m^2 with a maximum biomass of 14.5 g/m^2 of the lake bed. Tubifex tubifex and Euilyodrilus hammoniensis are very abundant here, often in company with less numerous Limnodrilus hoffmeisteri and Lumbriculus variegatus and isolated specimens of of L.udekemianus and Peloscolex ferox. In some, especially eutrophic , lakes (Karasevo, Plotich'e and others) isolated areas of coarse detrital bottom material occupied by vast aggregations of T.tubifex were seen. In places such "live carpets" acquire a density of 12 thousand specimens/m^2 with a biomass of 25.5 g/m^2. Interestingly, areas where there was mass development of chironomid larvae of the genus *Chironomus* were characterised by almost total absence of Oligochaeta, while in areas where Oligochaeta abounded (up to 11,500 spec./m^2) there were very few chironomids (not exceeding 66 specimens/m^2). This has been often noted in the literature (Alm, 1924; Valle, 1927; Gerd, 1950 et al.). Such changes in faunal composition are evidently the result of different interrelationships between these benthic groups: firstly, competition over food (both groups are pelophilous); secondly, many chironomids include Oligochaeta in their diet. We have frequently found oligochaete setae and even isolated segments in the intestines of certain chironomid forms (*Cricotopus*? *versidentatus*, *Cryptochironomus* gr. *defectus*, *Procladius*).

The oligochaete fauna of ore-bearing areas of the profundal
zone, mostly represented by an ore crust of the ferruginous and 47
manganese nodules of varying size and shape, is generally poor but still an appreciable element of the biocenosis. As the extent of mineralization increases chironomids and *Pisidium* are more adversely affected than the oligochaete fauna. *Lumbriculus variegatus* and *Stylodrilus heringianus*, which are found in every sample, predominate here, with the addition of *Tubifex tubifex* and *Peloscolex ferox* in shallower areas. The average abundance of Oligochaeta in ore-bearing areas is low at 66 spec./m^2 with a biomass of 0.132 g/m^2.

Certain bottom areas of some lakes, covered in dense light-grey clayey ooze, are even more impoverished biotopes. Two oligochaete species - *Limnodrilus hoffmeisteri* and *Tubifex tubifex* - have been recorded here.

Oligochaeta form a considerable part of the benthic fauna of the Solovetskii lakes. The highest indices of abundance and biomass were noted in eutrophic bodies of water (Karasevo, Goreloe, Plotich'e), where they amounted to 65% and 92% of total biomass and abundance respectively. In Lake Karasevo, for example, the average biomass of Oligochaeta was 147 kg/ha with an average abundance of 7370 specimens/m^2. In most of the lakes this group accounts at most for 20% of the abundance and 10 - 30% of the benthic biomass. In humus-rich dystrophic lakes (Ostrovnoe gagar'e, Lominoga, Isakovskoe) and in acid lakes (Mokhovoe, Chaika) there are very few oligochaetes (approximately 3% of density and up to 4% of benthic biomass). In such bodies of water tubificids usually occur sporadically or are entirely absent, giving way to Lumbriculus variegatus and Slavina appendiculata. The absence of Oligochaeta from the ooze zone of some bodies of water is evidently caused by a combination of hydrological and chemical hydrological conditions unfavourable to their survival. Such lakes are usually distinguished by a low pH value (between 5.8 and 4.4), high content of organic acids and permanent oxygen deficit (not exceeding 20% of saturation) in the benthic layers. The lake basins are covered by solid "carpets" of green mosses whose decomposition under oxygen deficient conditions is accompanied by the release of a large quantity of hydrogen sulphide.

In order to ascertain summer variations in the biomass and abundance of plentiful tubificid species we carried out observations (2 to 3 times a month) at certain stations in three limnologically different types of lakes (Goreloe, Dolgoe, Karasevo).

The abundance of Limnodrilus hoffmeisteri was minimal(110 spec./m^2, biomass 0.96 g/m^2) in the open part of the lake at the beginning of June. In the majority of individuals encountered at this time the clitellum was already developed but in some specimens

it was still in the development stage. These worms were between 30 and 36 mm. long. At the end of June (June 25) all individuals were sexually mature (Stage IV). From the beginning of July (July 5) the abundance of this species increased to 242 spec./m^2 while the biomass fell to 0.53 g/m^2. Young worms 3 - 5 mm long appeared at this time, while many large individuals lost their clitella. Reproduction 48
therefore commenced at this time although developed clitella persisted in some old worms. No cocoons of these species could be discovered. Maximum abundance (660 spec./m^2) was reached in late July - early September, and maximum biomass (1.3 g/m^2) in September. The majority of specimens in this period were young individuals (5 - 8 mm), only a few of which had developed penial tubes but no clitella. Some decline in abundance (572 spec./m^2 and biomass 1.0 g/m^2) could be observed from mid-September. This can probably be explained by the ending of the reproduction period, by the death of some old individuals and by consumption of some of the worms by benthophage fishes and predatory invertebrates.

Euilyodrilus hammoniensis is the dominant species in the ooze zone of many bodies of water. Maximum abundance was observed from mid-June (594 spec./m^2) until the beginning of September (1254 spec./m^2). Sexually mature individuals are 20 - 32 mm long. Appearance of cocoons was recorded at the end of June. Population density was lowest in June (242 spec./m^2). The fluctuations in the biomass of *E.hammoniensis* practically duplicate its population dynamics. Biomass indices were lowest (0.5 g/m^2) in mid-June and reached maximum values (1.5 g/m^2) in late August and September.

Tubifex tubifex. Sexually mature individuals (22 - 30 mm long, weight 2 - 5 mg) were encountered between June and September inclusive. Isolated cocoons belonging to this species were recorded from the end of June (June 25). The mass appearance of young (3 mm long) typically occurs from early July through August. Maximum population abundance was noted from mid-July through August (from 440 to 1122 spec./m^2 respectively) and the minimum in June (264 spec./m^2). The biomass dynamics of T. tubifex practically duplicate its population dynamics.

Many Peloscolex ferox (19 - 21 mm long) with developed clitella were recorded in the middle of June.

The maximum abundance of tubificids resulting from the appearance of a new generation is thus observed between July and the beginning of September. The temperature of the benthic layers (depth 10 m) fluctuated during this period between 7 and 9.5°C, while in the deeper areas it was constantly below 6°C. The July decline in biomass was evidently the result of the death of many old individuals and the appearance of young small worms. The increase in biomass observed from late August through September was connected with the growth of the new generation of worms.

Comparison of this brief information with data on the population and biomass dynamics of Tubificidae in bodies of water in more southerly latitudes - Estonia (Timm, 1964), Lithuania (Grigyalis, 1961), Rybinsk reservoir (Poddubnaya, 1959) - shows a certain shift in the reproduction periods of the Solovetskii worms towards the warmest period, i.e. the middle and late summer. This phenomenon also characterises the Oligochaeta of Karelian bodies of water, especially in more northerly latitudes. This is most probably explained by the temperature regime of the bodies of water.

The development of an oligochaete fauna in the lakes of the Solovetskii Islands probably began after the ice sheet retreated.

A periglacial freshwater lake evidently existed until the breaking of the ice bridge in the region of the neck of the White Sea, when it began to become salty, with the result that the link between the lakes and the mainland was broken. This later resulted in the separate development of the fauna in the Solovetskii lakes. In the postglacial period the fauna of the Solovetskii lakes developed in a similar manner to the mainland fauna, since both were situated in the same taiga zone. The development of the fauna of the Solovetskii lakes was also strongly influenced by its insular location. The formation of an oligochaete fauna was evidently also greatly aided by waterfowl which migrated to the islands from the mainland in the spring of each year. Some elements of the fauna may have been brought to the islands by boats as well as with fishes introduced for acclimatization.

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OLIGOCHAETA IN THE LAKES OF THE SOLOVETSKII ISLANDS

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Summary.

Information is given on the oligochaete fauna of 67 lakes in the Solovetskii Islands (30 species and forms). The species composition of Oligochaeta in the Solovetskii Islands is similar to that of northern bodies of water in Karelia. In the bodies of water of the Solovetskii Islands, however, Euilyodrilus hammoniensis (Mich.) is widely distributed and is the dominant species in some lakes. The relict species Lamprodrilus isoporus Michaelsen was found in Lake Verkhnii Pert. A description is given of the oligochaete fauna in lakes of different limnological types. The reproduction period of the abundant tubificid species (Limnodrilus hoffmeisteri, E. hammoniensis and Tubifex tubifex) is confined to middle and late summer.

Bibliography: 12 titles.

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AQUATIC OLIGOCHAETA OF THE SOVIET FAR EAST

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As yet the aquatic Oligochaeta of the Soviet Far East have 50
received little attention and only a limited number of publications dealing with this question can be cited. The earliest of these was Michaelsen's work on Kamchatka (Michaelsen, 1929). Investigation of the oligochaete fauna of the Amur River basin was begun by Lastochkin, who included some information about these Oligochaeta in one of his last works (Lastochkin, 1949). Investigation of the freshwater oligochaetes of the Amur basin continued (Lastochkin and Sokol'skaya, 1953; Sokol'skaya, 1957, 1961b). Information was also published on the aquatic oligochaetes of the Iman River basin (Sokol'skaya, 1961a), South Sakhalin (Sokol'skaya, 1964a, 1964b, 1964c, 1967) and Kamchatka (Sokol'skaya, 1961c). Chekanovskaya's monograph (1962) contains the results of the processing of some material from the Maritime Territory (Lake Khanka).

We have processed quite large collections of Far Eastern oligochaetes in recent years. We refer to the collections in the Khabarovsk Department of the Pacific Research Institute for Sea Fisheries and Oceanography (TINRO) made by I.M.Levanidova between 51
1947 and 1961 in the basin of the lower Amur (between the town of Khabarovsk and Amur Bay), in rivers discharging into the Gulf of Tatary and the Okhotsk Sea and in bodies of water in the Ussuri

River basin, as well as collections made by L.O. Nochvina (1963 - 1964) in southern areas of the Maritime Territory (lakes Khasan, Doritsine and others), the new Kamchatkan collections of Kurenkov (1958 - 1965) and Klyuchareva's material from Lake Kunashir (1963). The present article also makes use of data obtained from collections made by I.E.Lokshina in the Maritime Territory (1956) and processed by her in cooperation with the author (unpublished information)[1]. Altogether these collections contain 615 samples (more than 8000 worms).

[1]We wish to take this opportunity to express our deep gratitude to I.M.Levanidova, O.A.Klyuchareva, I.I.Kurenkov, L.O. Nochvina and I.E.Lokshina for the interesting material they have placed at our disposal.

Present knowledge of the aquatic oligochaetes from the Soviet Far East is still totally inadequate for an exhausting analysis of this region, which is of such great zoogeographical interest. We are still in the first stage of such an investigation, i.e. in the process of clarifying the species composition, and further investigation of the oligochaetes will probably yield new information and deepen our present understanding. The information here given should be considered as a preliminary report and the first attempt of this nature as regards the Oligochaeta.

I. Bodies of water in the Amur basin (lower reaches) and the Maritime Territory.

As regards the investigation of aquatic oligochaetes, these are at present the best investigated regions of the Far East. In addition to the large collections of the Amur ichthyological expedition of 1945 - 1949, the results of which have already been published, we have processed 487 qualitative and quantitative samples: 129 from bodies of water in the lower Amur and rivers discharging into the Gulf of Tatary (My River) and Schast'ya Bay (Bol'shaya Iska River), 149 from the Ussuri River basin and 209 from the southern areas of the Maritime Territory.

We are giving joint consideration to the oligochaetes of the Maritime Territory and the basin of the lower Amur (as distinguished from the upper and middle Amur) since both these regions are characterised by the presence of elements typical of a Sino-Indian fauna. Such are Branchiodrilus hortensis (Steph.) and, provisionally, Branchiura sowerbyi Beddard[2]. In connection with B.sowerbyi it must be noted that the geographic range of the species 52
is a disputed question that merits special examination.

[2]One find of B.sowerbyi in a channel in the middle reaches of the Amur has, admittedly, been recorded (Sokol'skaya, 1961b), but the species is very common and has high biomass indicators in bodies of water on the flood plain of the Amur (Sokol'skaya, 1957).

We shall merely note that the range of this species in these regions is a direct continuation of the Sino-Indian section of its range, and the species thus relates the fauna to the Amur fauna. The material at our disposal does not provide sufficient evidence of substantial differences between the oligochaete faunas of the lower Amur and the Maritime Territory, although we do note some differences. (Tables 1 and 2). More Naididae were found in the Maritime Territory (24 species and subspecies); they include the Chinese Pristina biserrata Chen, the Sino-Indian subspecies Chaetogaster limnaei bengalensis (Ann.) and also specimens of Dero sp. and Pristina sp. possessing certain characters of the setal apparatus found in Sino-Indian species groups of these genera. We attribute the variety of naidids in the Maritime Territory primarily to the more careful collections made here by specialists who devoted particular attention to the laborious collection of smaller worms. We therefore do not venture to maintain that the Chinese and Sino-Indian elements of the Naididae found in the Maritime Territory do not penetrate into the bodies of water in the lower Amur system, where one Sino-Indian species (B.hortensis) has already been noted and the total number of known naidid species (15) is much smaller.

Tubificidae are better represented in collections from the lower Amur, which has been well covered by bottom-sampling stations (Table 2). There is, however, no doubt that species as widely distributed in and beyond the Holarctic as Aulodrilus limnobius Bretscher, A.pluriseta (Piguet), Limnodrilus hoffmeisteri Claparède and L.claparedeanus Ratzel are also found in the Maritime Territory. Limnodrilus grandiosetosus Nomura, recently identified by Brinkhurst (Brinkhurst, 1965) with the North American species Limnodrilus silvani Eisen, will probably be found there.

Bothrioneurum vejdovskyanum Štolc has been found in the Maritime Territory and has not been recorded in the basin of the lower Amur. In spite of the better survey of the lower Amur mentioned above we cannot guarantee that this species is really absent there since the differentiation of sexually immature preserved specimens of B.vejdovskyanum is difficult. It is natural to find this species in the Maritime Territory since it is known from Chen's data (Chen, 1940) in China. It has often been noted in Europe (Czechoslovakia) and has recently been listed for North America (Brinkhurst, 1965).

The group of Amur basin endemic species now includes only two tubificid species (Peloscolex nikolskyi Last. and P.apapillatus Last.) and a subspecies of a European species, Piguetilla blanci amurensis Sok. (Naididae). The species L.grandisetosus, which used to be included in this group, has recently been recorded in North America by Brinkhurst (1965) and in Burma by Naidu (1966).

Table 1

1 Таблица 1

2 Распространение видов Naididae в водоемах Приморского края [1]

3 Вид	Бассейн р. Имана 4	Приханкайская низменность 5	Яковлевский р-н 6	Владивостокский р-н 7	Хасанский р-н 8	Встречаемость в водоемах, % 9	Географическое распространение 10
Stylaria lacustris (L.)*	+	+	+	+	+	50,0	Голарктика, Восточная Азия 11
S. fossularis Leidy*	+	+	+	+	+	66,6	Азия, Северо-Восточная, Европа, Америка 12
Arcteonais lomondi (Martin)*	+	–	–	–	–	6,6	Голарктика 13
Ripistes parasita (O.Schmidt)*	+	–	+	+	+	30,0	Палеарктика 14
Vejdovskyella comata (Vejdovsky)	+	–	+	–	–	3,3	Голарктика 13
Slavina appendiculata (d'Udekem)*	+	+	+	+	+	46,6	Космополит 15
Dero (Dero) digitata (Müller)	+	+	+	+	+	33,3	Космополит 15
D.(D.) obtusa d'Udekem	–	+	–	–	–	6,6	Голарктика, Восточная Азия, Южная Америка 16
Dero (Aulophorus) furcatus (Müller)	+	+	+	+	–	10,0	Космополит 15
Branchiodrilus hortensis (Stephenson)*	+	+	+	–	+	20,0	Восточная Азия 17
Nais variabilis Piguet*	+	+	+	+	+	70,0	Космополит 15
N. barbata Müller*	+	+	+	+	+	46,6	Голарктика, Азия 18
N. behningi Michaelsen*	–	–	+	–	–	3,3	Европа, бассейн Амура 19
N. bretscheri Michaelsen*	+	+	–	+	–	10,0	Палеарктика 14
N. pardalis Piguet*	+	+	–	+	+	40,0	Голарктика, Южная Америка 20
N. elinguis Müller	–	+	–	–	–	3,3	Космополит 15
Specaria josinae (Vejdovsky)*	+	–	–	–	–	10,0	Голарктика 13
Piguetiella blanci (Piguet) amurensis Sokolskaja*	+	+	–	–	–	10,0	Бассейн Амура, Приморский край 21
Haemonais waldvogeli Bretscher	–	–	–	–	+	3,3	Голарктика, Сино-Индийская обл. 22
Uncinais uncinata (Orsted)*	+	–	+	–	–	10,0	Голарктика 13
Chaetogaster diaphanus (Gruithuisen)*	+	-	+	+	+	26,6	Голарктика, Сино-Индийская обл. 22
Ch. limnaei (v.Baer) bengalensis (Annandale)	+	·	–	–	+	6,6	Сино-Индийская обл., Приморский край 23
Pristina longiseta longiseta Ehrenberg	–	–	–	–	+	3,3	Европа, Приморский край, Сино-Индийская обл. 24
P. biserrata Chen	+	+	+	–	+	23,3	Приморский край, Китай 25

26 [1] Звездочками отмечены виды, известные в бассейне Амура

Key to Table 1 on typescript page 81........

Key to Table 1. 1. Table 1; 2. The species distribution 53
of Naididae in bodies of water in the Maritime Territory[1]; 3. Species; 4. Iman River basin; 5. Khanka Plain; 6. Yakovlev district; 7. Vladivostok district; 8. Khasan district; 9. Frequency of occurrence in bodies of water, %; 10. Geographic range; 11. Holarctic, East Asia; 12. Asia, Northeast Europe, America; 13. Holarctic; 14. Palearctic; 15. Cosmopolitan; 16. Holarctic, East Asia, South America; 17. East Asia; 18. Holarctic, Asia; 19. Europe, Amur basin; 20. Holarctic, South America; 21. Amur basin, Maritime Territory; 22. Holarctic,
Sino-Indian region; 23. Sino-Indian region, Maritime Territory; 54
24. Europe, Maritime Territory, Sino-Indian region; 25. Maritime Territory, China.

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26. [1] Species known in Amur basin indicated by asterisks.

Table 2

2 Распространение видов Tubificidae в водоемах бассейна нижнего Амура и Приморского края[1] 1 Таблица 2

3 Вид	Бассейн нижнего Амура 4	Приморский край 5	Встречаемость в водоемах,% 6	7 Географическое распространение
Rhyacodrilus coccineus (Vejdovsky)	+	+	–	8 Голарктика, Австралия, о.Ю.Георгия
Rhyacodrilus sp.	+	+	–	9 Бассейн Амура, Приморский край, о.Сахалин
Bothrioneurum vejdovskyanum Štolc	–	+	8,1	10 Европа, Приморский край, Китай, Северная Америка(?)
Branchiura sowerbyi Beddard	+	+	18,9	11 Сино-Индийская и Амурская области. В Европу и Северную Америку, вероятно, завезен.
Aulodrilus limnobius Bretscher	+	–	5,4	12 Голарктика, Южная Америка
A. pluriseta (Piguet)	+	–	2,7	13 Голарктика, Индия, о.Суматра
Aulodrilus sp.	+	–	2,7	14 Нижнее течение Амура
Tubifex tubifex (Müller)	–	+	2,7	15 Голарктика, Сино-Индийская обл., Южная Америка, Новая Зеландия
Peloscolex nikolskyi Last.	+	+	67,5	16 Бассейн Амура, Приморский край, о-ва Сахалин и Кунашир
P. apapillatus Last.	+	+	45,9	17 Бассейны среднего и нижнего Амура, Приморский край, Сахалин
Limnodrilus udekemianus Claparède	+	+	16,2	18 Голарктика, Сино-Индийская обл.
L. grandisetosus Nomura (=L. silvani Eisen)	+	–	8,1	19 Бассейн Амура, Японские острова, С.Америка, Бирма
L. helveticus Piguet [(=L. profundicola (Verrill)?]	+	+	32,4	20 Голарктика (?)
L. hoffmeisteri f.typica Claparède	+	–	8,1	21 Голарктика, Сино-Индийская, Неотропическая и Эфиопская области, о.Ява
L. claparedeanus Ratzel	+	–	2,7	22 Голарктика, Сино-Индийская обл., Южная Америка

23 [1] Мы не приводим встречаемости видов Rhyacodrilus, так как данные о их распространении требуют уточнения.

Key to Table 2 on typescript page 82............

Key to Table 2: 1. Table 2; 2. Distribution of tubificid species in bodies of water in the Amur basin and the Maritime Territory[1]; 3. Species; 4. Lower Amur basin; 5. Maritime Territory; 6. Frequency of accurrence in bodies of water, %; 7. Geographic range; 8. Holarctic, Australia, s.Georgia; 9. Amur basin, Maritime Territory, Sakhalin; 10. Europe, Maritime Territory, China, North America (?); 11. Sino-Indian and Amur regions. Probably imported into Europe and North America; 12. Holarctic, South America; 13. Holarctic, India, Sumatra; 14. Lower reaches of Amur River; 15. Holarctic, Sino-Indian region, South America, New Zealand; 16. Amur basin, Maritime Territory, Sakhalin and Kunasgir Islands; 17. Basins of middle and lower Amur, Maritime Territory, Sakhalin; 18. Holarctic, Sino-Indian region; 19. Amur basin, Japanese Islands, North America, Burma; 20. Holarctic(?); 21. Holarctic, Sino-Indian, Neotropical and Ethiopian regions, Java; 22. Holarctic, Sino-Indian region, South America; 23. [1]No incidence is given for Rhyacodrilus species since data concerning their range are in need of updating. 55

Some other species must also be mentioned. According to data so far available the range of Nais behningi can be considered a relict range formed under the influence of the glacial period (Europe, Amur basin). Similar ranges are known for components of the Amur transitional fauna (Berg, 1949). To judge by information obtained in recent years (Chekanovskaya, 1959, 1962; Sokol'skaya, 1962; Finogenova, 1962), Stylaria fossularis Leidy is not confined to North America and the Sino-Indian region, the Amur basin and the Maritime Territory, but its range also includes the Altai, Central Asia and Lake Baikal and extends into the European part of the Soviet Union in the North. 56

In addition to information about the families Naididae and Tubificidae discussed in detail, the presence of the Palearctic species Propappus volki Mich. (fam. Enchytraeidae) and the Holarctic Lumbriculus variegatus (Müller) (fam. Lumbriculidae) has been noted in the fauna of the regions under consideration.

In concluding this faunistic survey of Oligochaeta from the basin of the lower Amur and the Maritime Territory it should be pointed out that many species from this area have very wide ranges (19 species extending beyond the limits of the Holarctic, 6 Holarctic and 3 Palearctic species).

We have noted the following features in the aquatic oligochaetes of the basin of the lower Amur and the Maritime Territory:

1. A considerable number of widely distributed species.

2. The presence of elements of the Sino-Indian fauna (two species and one subspecies - 7.3%) and of a Chinese species (2.4%).

3. The quantitatively low endemism of the oligochaete fauna (two species and one subspecies - 7.3%).

There can be no doubt today that when attempting a zoogeographical evaluation of the fauna of a region it is not enough merely to record the presence of different faunistic groups of species. It is important to show the significance of different zoogeographical elements in the fauna under investigation and their relative importance expressed in terms of incidence and biomass indices. The information at our disposal enables us to make some progress in this direction. The incidence of tubificid species in the bodies of water of the investigated areas can now be evaluated, although incidence of species within different bodies of water cannot be used for this purpose because they have not all been investigated to the same extent.

In bodies of water in the lower Amur, in rivers discharging into the Tartary and in the Maritime Territory the two Amur endemic species P.nikolskyi and P.apapillatus have the highest incidence (67.5% and 45.9% respectively) (Table 2). They are followed by Limnodrilus helveticus Piguet found in one third (32.4%) of the bodies of water. B.sowerbyi (18.9%), which prefers lakes and placid stretches of rivers, lies in fourth place.

As has already been mentioned, the distribution of Naididae can only be assessed within the Maritime Territory (Table 1). Species with extensive ranges, which are most common here, include

the cosmopolitan species N.variabilis Piguet, S.fossularis Leidy, S.lacustris (L.), N.barbata Müller and Slavina appendiculata (d'Udekem) with an incidence of 50% or even higher (up to 70%). A second group of frequently encountered species (30 to 40% of bodies of water) includes the Palearctic species Ripistes parasita (Schmidt) and the 57
very widely distributed Dero digitata (Müller) (a cosmopolitan species) and Nais pardalis Piguet. The Chinese species Pristina biserrata (23.3%) and the Sino-Indian Branchiodrilus hortensis (20.0%) are encountered far more rarely than the above-mentioned species widely distributed in the Holarctic; Ch.limnaei bengalensis has been recorded even less frequently (6.6% of bodies of water). The Amur endemic species P.blanci amurensis has also seldom been encountered (10% of bodies of water).

It can thus be said that, as regards the rate of incidence, Amur endemic species among Tubificidae and species with very extensive ranges predominate in the Amur basin and in the Maritime Territory. Though Sino-Indian and Chinese species occupy a significant position they are not dominant in this respect. While it is impossible at present to make a detailed analysis of the biocoenoses which incorporate Sino-Indian elements of the oligochaete fauna here, it can be said on the basis of our material that they do not predominate in bodies of water in the areas under consideration.

It can thus be seen that present knowledge of the aquatic Oligochaeta of the Amur region provides information which contradicts the opinion of Starobogatov (1965), who included the Amur region (as a subregion) in the Sino-Indian region on the basis of a study of freshwater molluscs. Data on the Oligochaeta fauna are more in agreement with Berg's concept (1949) of a transitional Amur zoogeographical region. Such a view is supported, for example, by the important role of endemic species of Tubificidae in the benthos which literally cram the investigated bodies of water in all parts of the Amur basin and by the considerably more modest part played by Sino-Indian and Chinese species. In addition the genetic relationships of endemic elements in the Amur region tend more to the Holarctic and Palearctic than to the Sino-Indian fauna. Suffice it to note that the genus Peloscolex to which both the endemic tubificids belong is not encountered within the Sino-Indian region and that P.blanci amurensis is a subspecies of a Palearctic species. The Amur region should thus be included in the Holarctic region on the basis of the data on the oligochaete fauna even if the concept of transitional zoogeographical regions is not recognised and the Amur region is only accorded the rank of a subregion.

II. Bodies of water on South Sakhalin

It should be stressed that the study of aquatic Oligochaeta on South Sakhalin has, in effect, only just begun. Certain publications by Japanese authors refer to only four species: three species of the Naididae [N.variabilis Pig., N.barbata Müll. and S.appendiculata (d'Udek.)] and Lumbriculus multiatriatus Yamaguchi (Yamaguchi, 1937, 1953).

An impoverished Amur fauna is encountered on South Sakhalin (Table 3). Sino-Indian faunistic elements are absent here, but
another species, Lumbriculus multiatriatus, is present, as is 58
Lumbriculus sachalinicus Sok., described from South Sakhalin, which is closer to L.japonicus Yam. than other species. There is an association of brackish waters forms which includes Paranais litoralis orientalis Sok., some of whose features brings it closer to American rather than Palearctic members of the species (Sokol'skaya, 1964a),

Nais borutskii Sok. and Isochaetides suspectus (Sok.).

Table 3

AQUATIC OLIGOCHAETA OF SOUTH SAKHALIN

Species	Geographic range
Fam. Naididae	
Slavina appendiculata (d'Udekem)	Cosmopolitan species
Nais variabilis Piguet*	Cosmopolitan species
N.barbata Müller*	Holarctic, Asia
N.borutzkii Sokol'skaya	Sakhalin, Kamchatka
Specaria josinae (Vejdovsky)	Holarctic
Uncinais uncinata (Orsted)	Holarctic
Paranais litoralis (Müll) = orientalis Sokol'skaya	South Sakhalin
Fam. Tubificidae	
Rhyacodrilus coccineus (Vejdovsky)	Holarctic, Australia, South Georgia
Rhyacodrilus sp.	Sakhalin, Amur basin, Maritime Territory
Ilyodrilus templetoni (Southern) (= Tubifex lastočkini Sok.)	Holarctic
Aulodrilus limnobius Bretscher	Holarctic
Limnodrilus udekemianus Claparède	Holarctic, Sino-Indian region
L.helveticus Piguet [= L.profundicola (Verrill)?]	Holarctic (?)
L.Claparedeanus Ratzel	Holarctic, Sino-Indian region
Limnodrilus sp. (juv.)	South Sakhalin
Isochaetides suspectus (Sokol'skaya)	South Sakhalin
Peloscolex nikolskyi Last.	Amur basin, Sakhalin, Kunashir
P.apapillatus Last.	Amur basin, Sakhalin
Fam. Lumbriculidae	
Lumbriculus multiatriatus Yamaguchi*	South Sakhalin, Japan
L.sachalinicus Sokol'skaya	South Sakhalin

*Species not found in the collections processed by us but known in South Sakhalin (Yamaguchi, 1937, 1953)

All the species of aquatic Oligochaeta found in South 59
Sakhalin, with the exception of the Holarctic Ilyodrilus templetoni (South.), the above-mentioned association of species from brackish waters and elements related to the Japanese fauna, are common in the basin of the Amur River. The highest incidence and abundance indices are recorded for Ilyodrilus templetoni and the Amur endemic species

Peloscolex apapillatus and P.nikolskyi, the last-mentioned of which is particularly abundant (Sokol'skaya, 1964c). The Amur connections of the oligochaete fauna of Sakhalin are in excellent agreement with Lindberg's data (1946) concerning the system of the Paleoamur: the ancient bed of the Amur River lay along the east shore of Sakhalin and the bodies of water on the island were incorporated in its basin in the recent past.

III. Kunashir Island (South Kuril Islands)

The small collection of oligochaetes (47 samples, 578 specimens) from three lakes of lagoon type (Peschanoe, Lagunnoe, Serebryanoe) give only a sketchy idea of the fauna of Kunashir Island. They are nonetheless referred to here since they give the first information about the species composition of aquatic oligochaetes in the Kuril Islands. The works of Japanese authors provide information only about the total biomass of Oligochaeta in different lakes (Miyadi, 1933, 1937, 1938). Ten oligochaete species were found in the investigated lakes of Kunashir Island (Table 4). All species of the Naididae mentioned and the majority of the Tubificidae are Holarctic or even more widely distributed species. The Amur endemic species Peloscolex nikolskyi Last. and the species Ilyodrilus orientalis Sok. (Sokol'skaya, 1969a), whose discovery on Kunashir Island is of definite zoogeographical interest, are exceptions. The genus Ilyodrilus Eisen includes only one species with a wide range, the Holarctic I. templetoni (Southern). All the others, previously known species are North American, or, more correctly, Californian (I.perrieri Eisen, I.fragilis Eisen and the recently described

I. frantzi Brink.). One other species of the genus, the Kunashir species, which evidently also has a narrow range, has now become known.

Our material did not include specimens which would enable us to establish the connections between the oligochaetes of Kunashir Island and the Japanese fauna, which is probably a matter for the future. The geographic proximity of the islands of Kunashir and Hokkaido (the minimum distance between them is 1.6 km) and information about other animal groups (Miyadi, 1938) lead us to expect this.

IV. The aquatic Oligochaeta of Kamchatka

Eighty-one samples (1604 specimens) were processed (in addition to samples the results of which have been published). As a result the number of species of aquatic oligochaetes of the peninsular has been almost doubled by comparison with published information (Michaelsen, 1929; Sokol'skaya, 1961c) (Table 5).

Table 4

AQUATIC OLIGOCHAETA OF KUNASHIR ISLAND 60

Species	Geographic range
Fam. Naididae	
Nais barbata Müller	Holarctic, Asia
Specaria josinae (Vejdovsky)	Holarctic
Amphichaeta sp.	Kunashir Island
Chaetogaster langi Bretscher	Holarctic, Sino-Indian and neo-tropical regions
Fam. Tubificidae	
Rhyacodrilus sp.	Kunashir Island
Ilyodrilus templetoni (Southern)	Holarctic
Ilyodrilus orientalis Sokol'skaya	Kunashir Island
Limnodrilus udekemianus Claparède	Holarctic, Sino-Indian region
Limnodrilus hoffmeisteri f. typica Claparède	Holarctic, Sino-Indian, Ethiopian, and Neotropical regions, Java
Peloscolex nikolskyi Last.	Amur basin, Maritime Territory, Sakhalin and Kunashir Islands

Table 5

AQUATIC OLIGOCHAETA OF KAMCHATKA

Species	Recorded by Michaelsen 1929	Our data	Geographic range
Fam.Naididae			
Stylaria lacustris (L.)	+	+	Holarctic, East Asia
Slavina appendiculata (d'Udekem)	-	+	Cosmopolitan species
Vejdovskyella comata (Vejdovsky)	-	+	Holarctic
Nais communis Piguet	+	+	Cosmopolitan sp.
N.variabilis Piguet	-	+	Cosmopolitan sp.
N.barbata Müller	-	+	Holarctic, Asia
N.borutzkii Sokol'skaya	-	+	Kamchatka,Sakhalin
Specaria josinae (Vejdovsky)	-	+	Holarctic
Uncinais uncinata (Örsted)	+	+	Holarctic
Paranais sp.	-	+	Kamchatka
Homochaeta naidina Bretscher	+	-	Palearctic
Chaetogaster diaphanus (Gruithuisen)	-	+	Holarctic, Sino-Indian region
Fam.Tubificidae			61
Alexandrovia ringulata (Sokol'skaya)	-	+	Kamchatka
Rhyacodrilus coccineus (Vejdovsky) (= Rh.riabuschinskii Michaelsen	+	+	Holarctic, Australia, South Georgia
Ilyodrilus templetoni (Southern)	-	+	Holarctic
Limnodrilus udekemianus Claparède	-	+	Holarctic, Sino-Indian region
L.helveticus Piguet [= L.profundicola (Verrill)?]	-	+	Holarctic (?)
Peloscolex kamtschaticus Sokol'skaya	-	+	Kamchatka
P.kurenkovi Sokol'skaya	-	+	Kamchatka
Peloscolex sp. (juv.)	-	+	
Fam. Enchytraeidae			
Propappus volki Michaelsen	-	+	Palearctic
Mesenchytraeus armatus Levinsen	-	+	Palearctic
Lumbricillus kamtschatkanus (Michaelsen)	+	-	Kamchatka
Fam. Lumbriculidae			
Lumbriculus variegatus (Müller)	+	+	Holarctic
Styloscolex opisthothecus Sokol'skaya	-	+	Kamchatka
Lumbriculidae gen. sp.*	-	+	Kamchatka
Haplotaxis gordioides (Hartmann)?	+	+	Holarctic

*Very unusual worms evidently belonging to a new genus of the family.

The nature of the material from Kamchatka does no more than enable us to analyse the qualitative composition of the oligochaete fauna. More than half the species of aquatic Oligochaeta of Kamchatka have very wide ranges: 26% of the species are distributed throughout the Holarctic and 30% are distributed even more widely and include several cosmopolitan species. There are only a few Palearctic species (11%), but a sizeable group of endemic species (22%). Endemism is manifested in different oligochaete families: among Enchytraeidae [*Lumbricillus kamtschatkanus* (Mich.)], Lumbriculidae (*Styloscolex opisthothecus* Sok.), Tubificidae 62
[*Alexandrovia ringulata* (Sok.), *Peloscolex kamtschaticus* Sok. and *Peloscolex kurenkovi* Sok.] .

Species genetically endemic to Kamchatka are genetically related to different faunistic elements. In the opinion of Michaelsen, who described *L.kamtschatkanus* (Michaelsen, 1929), this species is close to the North European *L.pagenstecheri* (Ratzel) whose wide range extends from Spitzbergen in the North and along the shores of Europe (Nielsen and Christensen, 1959). The species closest to *A.ringulata*, namely *A.onegensis* Hrabě (Hrabě, 1962) was described from Lake Onega (the genus *Alexandrovia* Hrabě includes only the two above-mentioned species). However, the genetic connections of this genus extend to California to the genus *Telmatodrilus* Eisen. Even if the closest connections of *A.ringulata* are thus within the Palearctic, it nonetheless has admittedly less obvious links with the American continent.

Peloscolex kamschaticus is undoubtedly allied to the Amur species *P.apapillatus*. *P.kurenkovi* is a fairly independent species. The East Asian range of the genus should be mentioned in connection with _Styloscolex opisthothecus_, whose closeness to _S.tetrathecus_ Burow found in eastern Baikal and northeastern China should be stressed. The differentiation of this species from other _Styloscolex_ Mich. species (_S.japonicus_ Yam. from Hokkaido Island and _S.baicalensis_ Mich., _S.kolmakovi_ Burow, _S.swarczewskii_ Burow, _S.asymmetricus_ Isossimoff and _S.choryoidalis_ Isossimoff from Baikal) should also be emphasised (Sokol'skaya, 1969b).

In summing up this brief survey of the genetic relationships of the endemic elements of Kamchatka, we note that they are closer to the Palearctic and particularly the East Asian fauna than to the American fauna. It must, however, be stipulated that the oligochaete fauna of Alaska, to which the Kamchatkan fauna can be related in the first instance, has been very poorly investigated. In fact we possess information about only the one family, Enchytraeidae, which, though inadequately represented in our material, has been substantially investigated by Eisen from collections made by Harriman's Alaska expedition (Eisen, 1910).

We conclude with a brief mention of the most important tasks in the study of the aquatic Oligochaeta of the Soviet Far East.

There is a need for further collections and the processing of material on the family Naididae from the South of the Maritime Territory and especially from bodies of water in the lower Amur. These investigations should provide the final answer to the problem of the difference in the fauna of these regions and should confirm new connections with Sino-Indian fauna, which are known only in outline (_Dero_ sp., _Pristina_ sp.).

The almost unknown oligochaete fauna of Yakutia awaits investigation. Only a thorough knowledge of this fauna will permit us to make confident statements concerning the extent of endemism in the Oligochaeta of Kamchatka and to evaluate the endemism of the Oligochaeta of the Amur basin.

Further study of the fauna of aquatic Oligochaeta in Kamchatka and especially on the Kuril Islands is necessary. Study of the Naididae and the Haplotaxidae is particularly important in relation to Kamchatka. Data on the latter family are not yet complete since there were no sexually mature individuals either in the collections processed by Michaelsen (Michaelsen, 1929) or in collections at our disposal, probably by virtue of the special reproductive characteristics of members of this family.

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AQUATIC OLIGOCHAETA OF THE SOVIET FAR EAST

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Summary.

The article sets out the first results of the investigation of the aquatic oligochaete fauna of the Soviet Far East.

The oligochaete fauna from the basin of the lower reaches of the Amur River and the Maritime Territory includes not only very widely distributed species, but also Sino-Indian elements, endemic species and one Chinese species. The species composition, the data on the frequency of occurrence of different faunistic groups and an analysis of the genetic relationships of the endemic species lead us to include the Amur basin and the Maritime Territory in the Holarctic region as a subregion (the Amur subregion), while emphasizing the transitional nature of its fauna.

Apart from species with a very wide range, the fauna of South Sakhalin contains endemic Amur species and a Japanese species. Brackish water forms genetically linked to various faunas (Japanese, Kamchatkan) and unique forms have also been noted.

The first data on the species composition of aquatic oligochaetes from the South Kuril Islands (Kunashir) indicate the presence of the Amur endemic species Peloscolex nikolskyi Last. and of the species Ilyodrilus orientalis Sok., known only from this island, as well as of a few Holarctic or even more widely distributed species.

More than half the Kamchatkan oligochaetes are distributed

throughout the Holarctic or even more widely. The group of endemic species is large (22% of the species). The endemic elements of Kamchatka are more closely related to Palearctic and East-Asian fauna than to North American fauna.

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OLIGOCHAETA IN THE BRACKISH WATERS OF THE BLACK SEA AND CASPIAN BASINS

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Brackish waters represent a special zone of life with its own distinctive ecological conditions and a fauna with a specific character which distinguishes the zone both from sea water and from fresh water. According to the classification of bodies of water adopted in 1959 in Venice (Final resolution..., 1959), brackish waters are divided into 66
the categories oligohaline [0.5 - 2(5)‰], meiomesohaline [2(5) - 8(10)‰], pleiomesohaline [8(10) - 18‰] and polyhaline [18 - 30‰].

Although very many works have been devoted to study of the formation of a brackish-water fauna and of the interrelationship between the organism and the salinity factor, there is a wide range of questions still to be solved in connection with the study of the population of brackish waters (including identification of the faunistic association of brackish waters, their osmoregulatory capacity and the mechanisms of osmotic regulation, the influence of salinity on the most important vital processes, types of adaptation and the salinity limits of the existence of species) and information about these questions remains fairly scanty for some groups of organisms. The Oligochaeta, one of the largest limnic groups successfully occupying the brackish zone and inshore areas of the sea, are a case in point. There are among the families Naididae, Tubificidae and Enchytraeidae dozens of freshwater euryhaline species which penetrate deep into the oligohaline and

and frequently even the mesohaline region; more than 100 species belonging to 30 genera are now known to be predominantly or exclusively inhabitants of brackish water and sea water. It must also be noted that our knowledge of the species composition of the oligochaete fauna from brackish waters continues to increase thanks to recent studies of brackish-water and marine basins. A number of new and distinctive species from brackish waters have been described quite recently by Marcus (1965) and Hrabě (1965, 1967).

The purpose of the present work is to examine the oligochaete fauna of the estuarine systems and lagoons of the Black Sea and the Caspian, as well as of the seas themselves.

The first mention of oligochaetes in these bodies of water is made in the works of Grebnitskii (1873 - 1874) and Shmankevich (1873), who list several species for the Dniester, Berezanskii and Sukhoi lagoons. Somewhat later (1876) Grimm announced the discovery of five species in the Caspian Sea. In 1897 Ostroumov discovered Psammoryctides deserticola (one of the Caspian species) in the Dniester lagoon. Chernyavskii lists 26 species for the Black Sea and its lagoons, but the real existence of most of these species was correctly queried by Michaelsen (1900). Subsequent investigations considerably increased available material on the oligochaete fauna of the Ponto-Caspian region. Works by the following authors were published: Lastochkin (1937), Malevich (1937), Bening (1938), Černosvitov (1935, 1937), Hrabě (1950), Caspers (1951) and Yaroshenko (1948, 1957). Study of the oligochaete fauna of this region continues to be of interest. Recent years have witnessed the publication of works by Hrabě (1964, 1965, 1967) and by the Romanian scientists Popescu and Botea (1962) and Popescu-Marinescu, Botea and Brezeanu (1966). The present author has investigated the oligochaete fauna of the lower reaches of the Danube (Finogenova, 1968a), the Southern Bug, the Gulf of Taganrog, the Dnieper-Bug lagoon (unpublished data) and the Black Sea and the Sea of Azov (Finogenova, 1968b).

Let us look at the environmental conditions of aquatic Oligochaeta in the Ponto-Caspian region and at the nature of their distribution.

It should be noted that many of the generic and species 67
names of oligochaetes have recently undergone certain changes and alterations. The names of taxa given here are to be understood as defined by Chekanovskaya (see the first article in this symposium).

Estuaries of Ponto-Caspian Rivers

The oligochaete fauna has been adequately investigated only in the lower reaches of the Dnieper (Fomenko, 1962a, 1962b), the Southern Bug (Grigor'ev and Finogenova, 1967) and the Danube (Popescu and Botea, 1962; Popescu-Marinescu, Botea and Brežeanu, 1966; Finogenova, 1968a). Information about the lower reaches of the rivers Ural (Bening, 1938; Hrabě, 1950) and Don (Mordukhai-Boltovskoi, 1940) is extremely scarce and there is practically no information about the extensive delta of the Volga.

The salinity situation in the estuaries depends on the height of water in the rivers. In the estuaries of the Don, Danube and other rivers with a large discharge, the salinity is almost negligible because of the great pressure of fresh water. As a rule the sea surges do not reach far into the estuaries. A rich freshwater fauna (more than 40 species) abounds in these waters and its biotopic distribution depends entirely on flow rate and on the quality of the bottom material. It is joined by certain oligohaline-freshwater species of Ponto-Caspian origin, for example Euilyodrilus vejdovskyi, E.danubialis, E.bavaricus, E.mrazeki and Psammoryctides deserticola. The situation is different only in the narrow zone of direct contact between river and sea water as, for example, in the Kiliya delta of the Danube. The number of freshwater species decreases as salinity increases. Thus of the 18 species found in the slightly saline Lebedinka and Lazor'kin Bays only the five most euryhaline forms remain in the mesohaline (4.6 - 12.2‰) Solenyi and Pereboina Bays. But marine and brackish-water species - Tubifex costatus, Paranais litoralis, P.friči and Amphichaeta sannio - develop here in great numbers. The broadly euryhaline marine species P.litoralis and the brackish-water P.friči and P.sannio spread from here into completely fresh waters. Some exchange of heterogeneous faunas thus takes place.

The oligohaline zone of the lower reaches of the Southern Bug is very long because of the low discharge of the Bug, and our observations here show that salinity influences the quantitative development of its euryhaline freshwater fauna. The trend towards a higher winter salinity results in contraction of the range of the freshwater species Limnodrilus claparedeanus, L.hoffmeisteri, L.udekemianus and Psammoryctides albicola and even in the death of oligochaetes when salinity rises sharply. The variety of ponto-caspian species is greater and their populations are more numerous than in rivers with a high discharge. Psammoryctides deserticola, Euilyodrilus vejdovskyi, E.danubialis, E.mrazeki, E.bavaricus, E.caspicus and Paranais friči, Ponto-Caspian relict species, are very common in benthic biocoenoses in the lower reaches of the Southern Bug.

The influence of salinity on the oligochaete fauna 68
in the estuarine areas of large Ponto-Caspian rivers is therefore limited and confined to the narrow zone of mixing of river and sea waters. Within this zone freshwater species of Oligochaeta are replaced by brackish-water and marine species. It has been noted that the ranges of freshwater species are variable in rivers with a low discharge as a result of the seasonal fluctuations in salinity. All the rivers are characterised by the development of an association of halophilous Ponto-Caspian species.

Lagoons

Some Black Sea and Azov rivers (Dniester, Don, Dnieper, Southern Bug) do not discharge directly into the sea, but into lagoons or bays in which the following zones may be distinguished: oligohaline, contiguous to the estuary, meiomesohaline and pleio-mesohaline. The physical and chemical conditions in these bodies of water are characterized primarily by the unusual complexity and instability of the salinity regime, which depends on the relationship between river discharge and the compensatory and wind currents. Only the Gulf of Taganrog shows a comparatively even gradient of salinity, which increases between the Don delta and the open sea and equals 8 - 12‰ where the river enters the sea. All the lagoons and bays are characterized by a seasonal shift in the boundaries of brackish zones.

Our knowledge of the oligochaete fauna of lagoons is very uneven. Yaroshenko (1957) lists nine species for the Dniester lagoon. Nineteen species, including Psammoryctides deserticola and *Euilyodrilus caspicus*, were found by the author among the 18 samples sent to her by M.Ya. Nekrasova (unpublished data).

The features of the lagoon association of Oligochaeta are most readily apparent when we examine the fauna of the most thoroughly investigated Dnieper-Bug lagoon. Yaroshenko (1948) lists 28 species without indicating where each is to be found in the lagoon, identifying some of them only generically and describing five as new species. As a result of revision by Chekanovskaya (1962) and Hrabě (1964) three of these have been recognised as synonyms of existing species. Chekanovskaya reduced *Ilyodrilus lastočkini* and *I.raduli* to synonyms of *Euilyodrilus vejdovskyi* and *Psammoryctides deserticola*, while Hrabě identified *Tubificoides svirenkoi* with *Peloscolex svirenkoi*. The author, who has investigated more than 700 samples from the 1966 - 1967 collections so kindly placed at her disposal by the director of the Dnieper-Bug biological station, B.F. Grigor'ev, found among them 55 species from 7 families.

The distribution of salinity in the lagoon at this time of the investigations in 1966 - 1967 (years when water amounts were large) was as follows(hydrochemical data supplied by B.F.Grigor'ev). The eastern section (Dnieper arm to Stanislav) was almost completely freshened. Only in the autumn, at depths exceeding 5 m did salinity reach 2.8 - 4.9‰. In the central section (between Stanislav, Cape Saken and Adzhigiol) salinity did not exceed 1 - 3‰
for most of the year, rising to 5 - 7‰ in late autumn and winter. 69
In the Bug section (from Nikolaev to Cape Saken) salinity stayed between 2 - 6‰ but rose to 12 - 15‰ along the central trench at depths exceeding 7 m. Finally, salinity in the western section

(west of Adzhigiol to the Kinburi strait which joins the lagoon to the Black Sea) was 1 - 8.3‰ in the inshore areas and 8 - 18‰ along the fairway. In the greater part of the lagoon (eastern and central sections and almost the entire Bug section), therefore, the Oligochaeta lived under conditions typical of the oligo-meiomesohaline zone while in the western section they lived under pleiomesohaline conditions.

Even on first acquaintance with the oligochaete fauna of the Dnieper-Bug lagoon our attention is drawn to the combination of ecologically heterogeneous elements in its composition, which includes freshwater species, halophilous Ponto-Caspian relicts, brackish-water and marine species.

Freshwater species, which penetrate into the lagoon from the Dnieper and the Southern Bug and develop in it in large numbers, form the largest group. Some of these species are sensitive to even a slight increase in salinity and Stanislav is the western limit of their distribution. These species, which are concentrated above the delta, are: Isochaetides newaensis, Limnodrilus hoffmeisteri, L.claparedeanus, L.helveticus, L.udekemianus, Peloscolex ferox, Haplotaxis gordioides, Pristina bilobata, P.longiseta and Nais simplex. The great majority of the oligochaetes are, however, euryhaline forms of freshwater origin. The freshwater species Euilyodrilus hammoniensis, E.heuscheri, E.moldaviensis, Psammoryctides barbatus and Isochaetides michaelseni are the dominant forms in oligo- and meiomesohaline waters. When Isochaetides michaelseni finds itself under the conditions of the meiomesohaline zone (> 3‰) it is modified in various ways; the setae are reduced in number and altered in shape, the tissues become transparent, there are certain changes in the proportions of the reproductive organs and the number of segments is reduced. These changes are undoubtedly due to the influence of salinity on this species. Less common are *Euilyodrilus bedoti*, *Psammoryctides albicola* and *Tubifex svirenkoi* which was until recently known only in the reservoir of the Dnieper Hydroelectric Power Station (Lastochkin, 1937).

The oligohaline waters yielded *Tubifex speciosus* and *Tubifex tubifex blanchardi*, which are rare in the Soviet fauna but previously recorded in the lower reaches of the Southern Bug (Grigor'ev and Finogenova, 1967). A rich selection of freshwater naidids is found in the coastal weed beds, some of which (*Stylaria lacustris*, *Chaetogaster diaphanus*, *Ch.diastrophus*, *N.communis*, *Vejdovskyella intermedia*, *V.comata*) were recorded in the oligohaline zone, while *Nais elinguis* and *Chaetogaster langi* extend into the meio- and pleiomesohaline zones.

A typical feature of the Oligochaeta in the lagoon is the exceptional abundance of relict forms of Ponto-Caspian origin which live together with freshwater species in the freshwater oligo- and meiomesohaline zones. They find their most favourable conditions (2 - 6‰) in the Bug section, where they are most developed. It was Ostroumov (1897) who, on first encountering the diversity of the relict fauna in the Bug lagoon, called it "a corner of a Pliocene basin left behind deep within the mainland and slightly renovated". 70
Euilyodrilus caspicus is the most abundant of the Ponto-Caspian species. It is undoubtedly identical to the species *Limnodriloides dnieprobugensis* described from here in 1948 by Yaroshenko.

Psammoryctides deserticola, which was previously widely distributed in the lagoon (Yaroshenko, 1948), was found only once in our material, from the central section at a salinity of 1.5‰. Here it is represented by a subspecies newly described by the author, which is distinguished from the typical form by the absence of hair-setae and fan-shaped setae and by its smaller size. The characters of this subspecies coincide with those given by Yaroshenko for another species, Limnodrilus lastočkini, and we have therefore named it Psammoryctides deserticola subsp. lastočkini. It is particularly abundant in the oligohaline zone but can also tolerate meiomesohaline conditions. Among the Ponto-Caspian species we have also included Euilyodrilus mrázeki, E. danubialis, Paranais friči and P. simplex, which are fairly common, but recorded in the lagoon for the first time, as well as the previously known Euilyodrilus vejdovskyi and E. bavaricus. All these species are very similar in the nature of their range and in ecological features to the Ponto-Caspian relict fauna. Although capable of forming considerable populations in completely fresh water, they nonetheless develop primarily in the brackish waters close to the sea in the Black Sea, Aral and Caspian region or in the region of the Black Sea and the Sea of Azov. But in the present case the extraordinary extent of their distribution and abundance in brackish waters can hardly be explained by reduced competition between species resulting from the elimination of some freshwater species, since the species composition of Oligochaeta in the habitats of the Ponto-Caspian species is very varied and includes several large and abundant freshwater species: Euilyodrilus moldaviensis, E. hammoniensis, E. Heuscheri, Psammoryctides barbatus and Isochaetides michaelseni.

With the exception of the extremely euryhaline *Nais oliguis*, there are no freshwater species in the fauna of the pleiomesohaline zone, which occupies a small expanse of the lagoon (the fairwater of the Bug section and the deepwater regions of the western section). Of the Ponto-Caspian species also only one, *Paranais frici*, remains. The emphasis is shifted to a brackish-water and marine fauna with very few species in its composition. The marine species *Tubifex costatus* and *Paranais litoralis*, together with the brackish-water species *Peloscolex svirenkoi*, form mass colonies in oozes. The euryhaline *P.litoralis* expands from here throughout the lagoon, while P.svirenkoi spreads as far as the oligohaline zone, where its abundance is sharply reduced. *T.costatus* is confined to the pleiomesohaline zone. Several enchytraeid species are found in the sands, including the holeuryhaline *Enchytraeus albidus* and *Lumbricillus lineatus*, *Marionina argentea* from brackish waters and two very small (2 - 4 mm) enchytraeid species new to science which belong to the genus *Marionina*.

The oligochaete fauna of the lagoon, which is very rich in composition, thus consists of freshwater, brackish-water and halophilous Ponto-Caspian and marine species, which combine in different proportions, depending on the salinity. At the same time the Oligochaeta do not have the minimum of species in the meiomesohaline zone, which is characteristic of many groups of animals. This can be seen schematically as follows:

Salinity ‰....	0 - 5	5 - 8 (meiomesohaline zone)	>8
No. of oligochaete species	50	25	10

As salinity increases the first sharp reduction in the number of oligochaete species takes place on transition to the meiomesohaline zone by the elimination of most freshwater species. The second reduction takes place in pleiomesohaline waters as the remaining freshwater and Ponto-Caspian species disappear, leaving only Paranais friči which can tolerate salinity even greater than 8‰. The poor species composition of the pleiomesohaline zone is explained by the paucity of marine and brackish-water forms.

Black Sea and Caspian

The Black Sea and the Caspian should be included in the pleiomesohaline region since the salinity of the Caspian Sea is approximately 13‰, that of the Sea of Azov is 9 - 12‰ and that of the Black Sea is 17 - 18‰.

The oligochaete fauna of these seas is very specific.

The fauna of the Caspian is well known to be unique and this also applies to the Oligochaeta. In addition to the euryhaline marine species Paranais litoralis and the species Nais elinguis and Stylodrilus parvus known from fresh waters, seven other species are found here. These are Psammoryctides deserticola, Euilyodrilus caspicus, E.grimmi, E.moldaviensis subsp.mitropolskiji, Stylodrilus černosvitovi, Tubificidarum gen. sp. and Limnodrilus sp.[1] described by Grimm (1876), Lastochkin (1937) and Hrabě (1950).

Caspian species are of freshwater origin (Hrabě, 1950) and are, it seems, ecologically close to the freshwater fauna. This is supported by the interesting fact that the Caspian Psammoryctides deserticola and Euilyodrilus caspicus are also found in the Black Sea and Azov lagoons where they exist under conditions of lesser salinity. Both these species, like freshwater species, are found to inhabit fresh water and oligo- and meiomesohaline

[1]Hrabě does not give a full description of *Tubificidarum* gen. sp. and *Limnodrilus* sp. because of the lack of sufficiently mature specimens, but a number of characters (the shape and number of setae, body size) characterise them as independent species.

water in the two seas, but no stable populations have been found in the pleiomesohaline zone. Beklemishev (1922) explains the fact that the same species have a different relationship to salinity in the Caspian and in the Black Sea - Sea of Azov by the special composition of salts in Caspian water. By comparison with normal sea water, Caspian water has a lower chlorosity and an increased quantity of sulphates and Ca^{2+} and Mg^{2+} cations, which is a characteristic of fresh water.

The fauna of the genetically connected Black Sea and Sea of Azov differs profoundly from that of the Caspian. With the exception of the earlier known holeuryhaline species *Enchytraeus* 72
albidus and *Lumbricillus lineatus*, the broadly euryhaline marine species *Paranais litoralis* and the marine *Tubifex costatus* discovered by the author, the fauna of the Black Sea and the Sea of Azov is typically mesohaline and found only in brackish waters. Its existence in the Black Sea at depths reaching 100 m only became known recently, mainly due to the work of Hrabě (1964, 1965, 1967) who found a number of interesting forms here. These are: *Monopylephorus (Rhizodrilus) ponticus* (V.V.Izosimov reports the discovery of another species, *Monopylephorus rubroniveus* near Novorossiisk), *Peloscolex euxinicus*, *Limnodriloides agnes*, *Tubificidarum* genus sp. and *Peloscolex svirenkoi* with the synonyms established by Hrabě - *Pristina papillosa* Cernosvitov, *Tubificoides heterochaetus* Lastočkin and *T.svirenkoi* Jaroschenko. *Peloscolex*

svirenkoi was in large numbers in collections made in the Black Sea and the Sea of Azov at depths of from 4 to 130 m and given to the author by M. Ya. Melrasova and N. I. Kiseleva. In the Black Sea the author found a new enchytraeid species belonging to the genus *Marionina*, which has also been recorded in the Dnieper-Bug lagoon.

Consequently, we ought, under the mesohaline conditions of the Black Sea and the Caspian to distinguish between the truly mesohaline Ponto-Azov fauna and a relict Caspian fauna ecologically akin to a freshwater fauna, which exists in the pleiomesohaline zone of the Caspian owing to special silt composition of its water.

When the oligochaete fauna of the Ponto-Caspian region is compared with that of the Baltic, another large brackish-water basin, quite a few differences in the species composition may be observed. Mesohaline Ponto-Azov forms and elements of the Caspian species association are (with the exception of *Monopylephorus rubroniveus*) absent from the Baltic. Only a few widely distributed marine forms and the majority of the euryhaline freshwater forms are common to both basins. But the Baltic basin has its own very unusual fauna, whose distribution depends on salinity. Species of the fam.Enchytraeidae are richly represented here, a number of tubificid forms have been described and interstitial species are of great interest.

It can thus be concluded that both these brackish-water basins possess a varied and specific oligochaete fauna the study of which is highly relevant to our knowledge of environmental conditions in the brackish-water zone.

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OLIGOCHAETA IN THE BRACKISH WATERS OF THE BLACK SEA AND CASPIAN BASINS

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Summary.

The article contains an analysis of the oligochaete 186
fauna of estuaries, lagoons of the Black Sea and the Caspian and of the seas themselves. The estuaries of the Ponto-Caspian rivers are inhabited by a rich freshwater fauna (more than 40 species). The influence of salinity is confined to the narrow zone in which river water and sea water mix and within which freshwater species disappear and brackish-water and marine species develop. The association of relict Ponto-Caspian species *Psammoryctides deserticola*, *Euilyodrilus caspicus*, *E. mrázeki*, *E. danubialis*, *E. vejdovskyi*, *E. bavaricus*, *Paranais friči* and *P. simplex* is here widely distributed, both in fresh and brackish water.

The oligochaete fauna of the lagoons and bays of the Black Sea and the Sea of Azov consists of ecologically heterogeneous elements (freshwater, halophilous Ponto-Caspian, brackish-water and marine elements) which combine in different proportions depending on the salinity. *Limnodriloides dnieprobugensis*, described from the Dnieper-Bug lagoon in 1948 by Yaroshenko, is identical to *Euilyodrilus caspicus*, while *Limnodrilus lastočkini* Jaroschenko is identical to *Psammoryctides deserticola* subsp. *lastočkini*.

Caspian Oligochaeta are ecologically close to freshwater fauna.

The Black Sea and the Sea of Azov, on the other hand, are inhabited by a true mesohaline fauna to which widely distributed marine and euryhaline species are added.

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SYSTEMATICS AND DISTRIBUTION OF OLIGOCHAETA IN LAKE SEVAN

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Aquatic Oligochaeta occupy one of the most important 75 positions among the benthic fauna of Lake Sevan as regards quantitative indices. Thus, according to Fridman's data (1950), Oligochaeta account for up to 59.2% of the gross biomass of the benthos, and in the abyssal benthos for up to 99.6% of the gross biomass, thanks to the extensive areas with an ooze bottom. Analogous data have been obtained by Markosyan (1959).

Many authors refer to the significant role of oligochaetes in the feeding of the fishes and benthic invertebrates of some bodies of water (Luferov, 1956; Shilova, 1959; Monakov, 1959; Chekanovskaya, 1962; Grigyalis, 1961, 1962; Poddubnaya, 1962, 1965; Ekaterininskaya, 1960, et al.). It is noted in the works of Willer (1924), Klust (1935), Menyuk (1955) and others that oligochaetes are an important food item of whitefishes. All this applies to the oligochaetes of Lake Sevan. We have found that the oligochaetes in the lake provide food for abundant forms of benthic invertebrates - gammarids, chironomids, leeches and hydras. The possibility that juvenile tubificids and naidids may also be consumed by certain predators in the zooplankton, for example Acanthocyclops gigas and Acanthocyclops viridis which inhabit the benthopelagic layers of the water, cannot be excluded.

The setae of Oligochaeta have been discovered in the stomachs of Lake Sevan whitefishes and of trout from Lake Kari-Lich.

Considerable changes in the composition of the benthos have taken place over the years during which the level of the lake has been falling. The abundance of gammarids, which constitute up to 90% of the food of Sevan fishes, has fallen and the importance of pelophilous forms - chironomids and oligochaetes - has increased (Markosyan, 1966). The latter are characterized by strong annual variations in biomass. In 1955, for example, the oligochaete biomass in Greater Sevan (Bol'shoi Sevan), according to Markosyan's data, was three times greater than in 1947, while in 1962 the biomass was found to have been reduced by almost three quarters, in spite of the fact that in Lesser Sevan (Malyi Sevan) it continued to increase. Markosyan sees the reason for this in the increasing abundance of whitefishes whose diet includes oligochaetes.

It is well known that the general principles of dynamics of a benthic population cannot be elucidated until the population dynamics of its individual species have been established. Data on the development dynamics of the main benthic groups in Lake Sevan have already been published (Markosyan, 1948; Shironov, 1951; Meshkova, 1957, 1962, et al.). Though oligochaetes play a very important role in the benthic fauna of the lake they have yet to be satisfactorily investigated.

We are now engaged on a detailed study of the oligochaete fauna. The present article presents some of the material on the systematic composition and distribution of the oligochaetes and on some features in the biology of abundant forms.

Information on the species composition of Lake Sevan

oligochaetes is given by Malevich (1929), who concentrated on 76
the inshore zone of the lake and its affluents, and by Fridman (1948, 1950). These authors discovered 15 oligochaete species in the lake. Malevich records seven species. One of these belongs to the fam. Aeolosomatidae (*Aeolosoma hemprichi*) and six species to the fam. Naididae (*Nais variabilis*, *N.pardalis*, *N.communis*, *N.pseudobtusa*, *Chaetogaster diastrophus* and *Ch.langi*). These species were encountered in the inshore zone among beds of *Phragmites*, *Ceratophylum* and other plants. Further investigation by Fridman, who studied not only the inshore areas but also the open lake down to the maximum depth, led to the discovery of large numbers of another naidid species, *Chaetogaster limnaei* (found on the mollusc *Limnaea ovata*), in the inshore zone of Sevan (Elenovskaya) Bay and seven species from the families Tubificidae, Haplotaxidae and Lumbriculidae.

Four species, namely *Tubifex tubifex*, *Euilyodrilus hammoniensis*, *Limnodrilus hoffmeisteri* and *Haplotaxis gardioides*, are widely distributed, while two species and one variety, namely *Rhyacodrilus pectinatus* Sv., *Trichodrilus minutus* Sv. and *Euilyodrilus hammoniensis* var. *caesa* Sv., have been recorded as endemic to the lake. The most widely distributed and abundant tubificids were *E.hammoniensis*, *E.hammoniensis* v. *caesa* and *Rh. pectinatus*, discovered at depths between 1 and 80 m on a sandy bottom in the zone of beds of higher water plants, in the moss and stonewort (*Chara*) zone on productive ooze, on the silty bottom and on crystals. In Lake Sevan they were found to be eurybathic and eurydaphic forms. *T.tubifex*, discovered at depths between 3 - 5 and 35 m, was encountered rarely. *L.hoffmeisteri* usually in small numbers, inhabited the moss and stonewort zone on productive oozes. Trichodrilus minutus, which only inhabits the the lower profundal on a crystalline bottom, was ranked among organisms with a limited range; only a few examples of this species were encountered. Svetlov recorded Haplotaxis gordioides, but queried it, since it might have been present in the lake by chance (carried into it from the Gavaraget River).

The species of the families Aeolosomatidae and Naididae found in Fridman's collections (1948) in the Sevan Bay are typical of the zone of inshore macrophyte beds and of algal foulings on stony and sandy-silty bottoms.

G.M. Fridman notes that Oligochaeta are qualitatively fairly poor in the lake and that E.hammoniensis and Rh.pectinatus are the dominant species.

The following species were found among our material:

Fam. Aeolosomatidae

1. Aeolosoma hemprichi Ehrbg. Encountered in considerable numbers among macrophytes and on coarse-grained sand with gravel in the littoral zone (Ardanish Bay, Gyunei coast).

A single specimen of Aeolosoma sp. was found at depth 31 m 77
near Gël' village.

Fam. Naididae

2. Nais communis Piguet. Isolated specimens were found in inshore zone near the mouth of the Gavaraget River on slightly silted fine white sand at depths of 0.3 m or less.

3. Nais pardalis Piguet. Isolated specimens were found in the Norashen area near the shore on rocks in diatom foulings.

4. Nais elinguis Müller. The species is fairly widely

distributed in the lake and is found in almost all samples taken from different bottom materials (sand, silt-sand, silt) in the inshore zone, most frequently among macrophytes and algal foulings, between the water's edge (at depths above 0.3 m in the area of the Gavaraget River) and great depths (30 m in Lesser and Greater Sevan and between 26 and 50 m in Lesser Sevan where the bottom is crystalline). The species is most abundant (270 specimens per m^2) found in the moss and stonewort zone.

5. Uncinais uncinata (Oersted). A common species found in Lake Sevan at depths between 0.3 and 30 m. It inhabits the most varied biotopes: slightly silted sand very near the water's edge, sandy ooze with fine detritus in the moss and stonewort zone, silty bottom material at great depths (30 - 40 specimens/m^2) and the crystalline slightly silted bottom in Lesser Sevan (to depths of 26 m). The species prefers silted sand and sandy ooze in macrophyte beds. The maximum abundance of the species, 590 specimens/m^2, was observed in the moss and stonewort zone. In the canal leading out of the lake it inhabits macrophyte beds and silty bottom material at depths between 0.5 and 9 m, where it has to withstand a considerable current. It is found throughout the year. The appearance of sexually mature individuals of this species and their cocoons is observed in the inshore zone of the lake in August at a temperature of 19.6°C. We recorded finds of cocoons with embryos in the second half of March at a temperature of 3.9°C. The young of this species appear in quantity in late May at a temperature of 8.1°C.

6. Ophidonais serpentina (Müller). The species was found in collections from the canal, where it flourishes on silt-sand and ooze bottoms where there are the greatest concentrations of various

kinds of organic matter. It was usually found in association with large numbers of *Tubifex tubifex* and *Limnodrilus hoffmeisteri*. In such an association *Ophidonais serpentina* can serve as an indicator of the saprobicity of the water, as we found repeatedly confirmed during investigations of certain Armenian bodies of water (the Aparan and Mantash reservoirs and the Arpa and Kasakh rivers), where this association was found where there were the greatest concentrations of decomposing plant detritus and other debris. Large numbers of sexually mature individuals are encountered in August.

7. *Amphichaeta leydigi* Tauber. It is of interest that this species was discovered on the most varied bottom materials and at the most varied depths in the lake and the canal, where it experiences quite a strong current. It inhabits macrophyte beds
and is found in considerable quantities at depths of 0.5 - 15 m on 78
the sandy bottom in the inshore zone of the lake where the canal begins (the Gyunei coast, the mouth of the Gavaraget River near the villages of Pambak and Babadzhan). It has also been found on silty bottoms at greater depths, reaching 30 m (near Tsovagyukh village in Lesser Sevan and near Gël' village in Greater Sevan) and in areas with a crystalline bottom at depths between 26 and 59 m in Lesser Sevan.

8. *Chaetogaster diastrophus* (Gruith.). The species is found in the lake on stony and sandy bottoms and has also been recorded in the macrophyte zone at depths between 0.5 and 6 - 7 m, often accompanied by *Amphichaeta leydigi*. It is sometimes very abundant (near canal entrance, near the Gyunei coast and the mouths of the Dzyknaget and Gavaraget rivers, near Babadzhan village and Cape Sary-kaya).

9. Chaetogaster diaphanus (Gruith.). Common at all depths between 1 and 60 m. Usually found in small numbers, 10 - 30 specimens/m^2; up to 70 specimens/m^2 were found in the moss and stonewort zone on silt. Up to 80 specimens/m^2 were recorded among the macrophytes in the canal at a depth of 9 m, also on silt. The species feeds on small oligochaetes, nematodes and benthic Cyclops.

10. Chaetogaster limnaei K.Baer. Discovered in the canal in the outwash from the vegetation along the bank where Limnaea ovata was plentiful.

11. Pristina rosea (Piguet). Found in the canal in the outwash from the vegetation and in Ardanish Bay in the outwash from coarse-grained sand and gravel at depths between 0.3 and 1 m.

Fam. Tubificidae

12. Aulodrilus pigueti Kowalevski. So far only found at a depth of 12 m and on silty sand near Babadzhan village.

13. Rhyocodrilus coccineus (Vejdovsky). One of the most widely distributed species in the lake, it mostly inhabits sandy-silty bottoms, but is also encountered fairly frequently on the crystalline, slightly silted bottom at depths between 26 and 50 m. Conditions are best suited to its development in the moss and stonewort zone, where its abundance is greatest (Gyunei coast, central region of Lesser Sevan, around the Gavaraget and Sary-kaya rivers near Gël' village)

Rhyacodrilus sp. usually has 4 to 5 penial setae and is found with Rh.coccineus, but more often at depths of 3 - 5 m on silty-sandy bottoms in macrophyte beds (Gyunei shore).

14. Limnodrilus hoffmeisteri f. typica Claparède. A commonly found species in inshore vegetation and in the moss

and stonewort zone on fertile ooze or silty sands. Encountered at depths between 3 and 20 m. The biomass of this species was 17.8 g/m^2 and the abundance 60 - 800 specimens/m^2 in the canal where there were large accumulations of organic remains along macrophytes at a depth of 9 m (in the canal, near Tsovagyukh village, around the Gavaraget and Sara-kaya rivers, near Babadzhan village). The start of reproduction (appearance of the first cocoons) was observed in the second half of March at a temperature of 3.2°C at depths between 5 and 9 m. Isolated cocoons were found in September.

15. *Limnodrilus hoffmeisteri* f. *parva* Southern. Encountered 79
in small numbers on sandy-silty bottoms at depths between 7 and 20 m. Maximum abundance, 560 specimens/m^2 with the insignificant biomass of 0.09 g/m^2, was observed at a depth of 12 m near Babadzhan village.

16. *Euilyodrilus hammoniensis* (Michaelsen). This, the most widely distributed and abundant species, inhabits all parts of the lake and a great variety of bottom material: sand, silty sand, crystals and abyssal ooze in the profundal, where it develops most prolifically (the highest biomass of this species, 10.3 g/m^2, at an abundance of 3840 specimens/m^2, was recorded in March). In the inshore zone and to a depth of 30 m in Greater Sevan the commencement of reproduction coincided with the first heating of the benthopelagic layers, when the temperature was 3.9°C in the second half of March; reproduction was largely completed in September, when the temperature was 15.9°C. Isolated cocoons were found in November samples. Mass reproduction was observed in March and April at temperatures of 7 - 15°C. The largest numbers of young and of individuals with sexual products undergoing resorption were recorded in August. Winter reproduction was recorded at depths of

30 - 60 m in Lesser Sevan when the temperature variations were slight. Cocoons with embryos were found at a depth of 30 m in January and February and in July and August (annual temeperature variations at this depth ranged between 2.6 and 8°C). The mass appearance of cocoons at a depth of 60 m was observed 3 times a year: in February, at a temperature of 2.6°C; in June-July at a temperature of 4.6 - 4.8°C and in October, at a temperature of 4.9°C, when the greatest number of cocoons appeared.

17. Tubifex tubifex (Müller). The species is fairly widely distributed in the lake; it is most often found at depths above 20 m, below which its abundance declines. In the inshore zone it inhabits slightly silted sandy bottoms with macrophyte beds, and in the moss and stonewort zone it is found on silty-sandy or sandy-silty bottoms. In the canal the species is commonly found, with L.hoffmeisteri, on silty bottoms rich in organic remains. In the inshore zone of Greater Sevan reproduction begins in the second half of March at a temperature of 3.9°C. Isolated cocoons are found until the second half of September at a temperature of 17.3°C. The mass appearance of young is to be observed in April at a temperature of 5.0°C and in July at a temperature of 17.8°C. Reproduction mostly ends in August.

18. Tubifex sp. Often found in small numbers. Recorded in almost all parts of Lesser Sevan and in some parts of Greater Sevan on sandy, silty-sandy and silty bottoms at depths ranging from 3 to 60 m.

Fam. Enchytraeidae

19. Enchytraeidae gen. sp. Members of this family are found in small numbers, up to 70 individuals/m^2 on silted sand in

the moss and stonewort zone along the Gyunei coast.

Fam. Lumbriculidae 80

20. *Lumbriculidae* gen. sp. Most probably the species previously identified by P. G. Svetlov as *Trichodrilus minutus* Sv.

Found only on the crystalline bottom at depths between 26 and 59 m. Sexually mature individuals and their cocoons were found in December and July when temperature variations were slight, between 2.6 and 4.9°C. It is of little importance in the biomass of the Oligochaeta because of its low abundance and small size.

Our materials show that the oligochaete fauna of Lake Sevan is richer than was previously known and that the distribution of Oligochaeta there has certain unusual features. Ten naidid species were identified in our collections. Of these, six species were recorded in the lake for the first time (*Nais elinguis*, *Uncinais uncinata*, *Ophidonais serpentina*, *Amphichaeta leydigi*, *Chaetogaster diaphanus* and *Pristina rosea*). Three species recorded there by I.I. Malevich, *Chaetogaster langi*, *Nais variabilis*, *N. pseudobtusa*, have yet to be found.

The following tubificids have been recorded in the lake for the first time: *Rhyacodrilus coccineus*, *Aulodrilus pigueti* and *Limnodrilus hoffmeisteri* f. *parva*. *Tubifex* sp. must also be a species new to Lake Sevan.

Enchytraeid finds have also not been previously recorded for this lake.

The distribution of Oligochaeta in the lake mostly remains as before, but the penetration of Naididae into the deeper zones is of great interest. According to published data, members of this family have been recorded to depths of 36 m in the Tbilisi reservoir (Pataridze, 1963), to depths of 20 m in Lake Baikal (Sokol'skaya, 1962) and in the sublittoral zone in Lake Okhrida (Šapkarev, 1961).

The fact that winter reproduction at a temperature of 2.6°C was observed in the Tubificidae at great depths where the annual temperature variation was slight while Lumbriculidae bred not only in the winter (December) but also in the summer (July), also deserves attention.

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SYSTEMATICS AND DISTRIBUTION OF OLIGOCHAETA IN LAKE SEVAN

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Summary.

Information is given on the 19 species of 5 families found in the lake. Nine species are described from Lake Sevan for the first time.

Bibliography: 24 titles.

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COLLECTIONS OF OLIGOCHAETES MADE IN THE ARAL SEA DURING THE NAVIGATION PERIOD IN 1964 AND 1965

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There is very little information on the oligochaetes of the 82
Aral Sea, essentially two works by Beklemishev (1922) and Hrabě (1936). Beklemishev collected oligochaetes in the Aral Sea in 1920 and these were processed by Lastochkin. A member of fam. Aeolosomatidae, not identified to the species level, and two species of fam. Naididae, namely *Paranais litoralis* (O.F. Müller) and *Nais aralensis* Last., were found in these collections. No members of other oligochaete families were discovered. The second investigator (Hrabě) processed collections made by Nikitinskii in 1930 and by Bening in 1932. Hrabě found more oligochaete species and families in the Aral Sea than had been noted by Beklemishev and Lastochkin: Naididae - *Paranais simplex* Hrabě [which, as he established, corresponds to *Paranais litoralis* (O.F. Müller) according to the data of D.A. Lastochkin] and *Nais elinguis* Müller (which corresponds to Lastochkin's *Nais aralensis*); Tubificidae - *Euilyodrilus bavaricus* (Oeschmann), *Psammoryctides albicola* (Michaelsen) and *Limnodrilus helveticus* Piguet; Enchytraeidae - *Lumbricillus lineatus* (Müller).[1]

[1] The names given to the species are those currently accepted.

The material at Hrabě's disposal consisted of 53 samples covering almost the whole of the sea [as is apparent from the map

of the collections given by Nikitinskii (1933) and Bening (1934)], 83
whereas Beklemishev's collections were made in the small northern part of the Aral Sea separated from the main part by a large island. These two works practically exhaust all the information on the oligochaetes of the Aral Sea. Den'gina (1959) records Paranais simplex Hrabě and Lumbricillus lineatus (Müll.) for the Karabaili archipelago.

According to Hrabě's data, members of fam. Naididae predominate in the Aral Sea and are encountered more frequently than species of other families. According to Hrabě, the species E. bavaricus predominates from among fam. Tubificidae. The only member of fam. Enchytraeidae in the Aral Sea (L. lineatus) occupies an insignificant place in the collections: it was found in collections at only two stations, which is 3.8% of the number of collections.

The Aral Department of the Kazakh Fisheries Research Institute (the former Aral Scientific Station of the All-Union Research Institute for Sea Fisheries and Oceanography) made collections of benthos on its research vessels in 1964 and 1965 over a permanent network of hydrobiological stations covering the entire area of the sea and its inlets. The collections were made with a Petersen grab (area of bite 0.1 m^2) and were subsequently washed through a Capron sieve of No. 11 gauze. The number of stations occupied on each cruise was 107 in 1964 and 103 or 104 in 1965. Collections were made three times during the navigation period: 1) in May, 2) in July - August and 3) in October. In all 321 samples were collected in 1964 and 311 in 1965 (at a slightly smaller number of stations). oligochaetes were found at 13 stations (or in 4.05% of the collections) in 1964, of which 3 were in May, 3 in July - August and 7 in October. In 1965 they were found at 12 stations (or in 3.8% of the collections), of which 3 were in July - August and 5 in October. The present author was able to examine the oligochaetes from the material collected and to identify the species to which they belong. The relative predominance of individual species emerges differently from the material examined by us than it appeared to previous investigators, since the family Tubificidae stood out in terms of the number of collections (frequency of occurrence) and of the quantity of individuals taken. and the most abundant species in this family was not E. bavaricus, as noted by Hrabě, but Psammoryctides albicola. The only member of the family Naididae found in the material occupied an insignificant place in the collections, in contrast to Hrabě's data. It is evident from the material collected in 1964 and 1965 by the Aral Department of the Kazakh Research Institute for Sea Fisheries and Oceanography (KazNIIRKh) that the dominant species in the oligochaete fauna of the Aral Sea is P. albicola (Tubificidae).

The following species were found in the 13 samples in 1964: 1 specimen of Paranais simplex Hrabě, 73 of Psammoryctides albicola, 2 of Euilyodrilus bavaricus[2] and 2 of Lumbricillus lineatus. The 12 samples in 1965 were found to contain 44 specimens of P. albicola and 1 of L. lineatus.

[2] I should like to take this opportunity of thanking N.L. Sokol'skaya (Zoological Museum, Moscow University) who identified the specimen of Euilyodrilus bavaricus.

Oligochaetes are a very insignificant proportion of the total biomass of zoobenthos in the Aral Sea - less than 1%. Oligochaetes are not represented in records of fish food in this body of water. 84

We know that the level of the Aral Sea has been systematically reduced in recent years in connection with the amount of water diverted from its affluents, the Amudar'ya and Syrdar'ya (Volodkin, 1961, 1964; L'vov, 1964; Pavlov, 1964). This circumstance is undoubtedly reflected in all aspects of the life of the sea, including the oligochaetes. It is possible that the distribution of oligochaetes in the Aral Sea now appears different to what it was when Nikitinskii and Bening made their collections. The predominance of the family Tubificidae and especially of the species Psammoryctides albicola may possibly be related to an alteration of environmental conditions in the Aral Sea (an increase of overall salinity and other changes due to reduction in the level of the sea), i.e., the family Tubificidae and the species Psammoryctides albicola were probably not dominant previously. Unfortunately, it is now impossible to make comparison with the former proportions of oligochaete species in the Aral Sea because of the lack of sufficiently convincing data, since the collections of Nikitinskii and Bening covered less of the area of the sea than was covered on the vessels of the Aral department of KazNIIRKh in 1964 and 1965. It can only be regretted that the oligochaete fauna of the Aral Sea was not previously studied more attentively.

The oligochaetes of the Aral Sea now number 7 species (we add to the 6 species of the families Naididae, Tubificidae and Enchytraeidae listed by Hrabě, 1 species of the family Aeolosomatidae listed by Beklemishev, according to Lastochkin). This number is small by comparison with other bodies of water in which the oligochaete fauna has been investigated. We may mention that Lake Baikal has 62 species of oligochaetes (Kozhov, 1962) out of a total of 709[1] species of benthic invertebrates, while Lake Teletskoe has 16 out of a total number of 255 species and 11 varieties of benthic invertebrates (Zhadin and Gerd, 1961). The total number of species in the zoobenthos of the Aral Sea is 54 (Zenkevich, 1964, gives 50, but oligochaetes number only 3 species).

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[1] Ten species of sponges, 2 coelenterates, 90 turbellarians, 10 free-moving nematodes, 1 polychaete, 62 oligochaetes, 17 leeches, 5 bryozoans, 43 harpacticoids, 33 ostracodes, 2 bathynellids, 5 isopods, 240 gammarids, 6 ticks, 36 caddis flies, 2 stone flies, 60 chironomids, 1 water bear and 84 molluscs.

The relationship of the number of oligochaete species to the total number of species in the benthic fauna in these bodies of water is as follows: 8.8% in Baikal, 6% in Lake Teletskoe and 12.9% in the Aral Sea. The ratio of the number of oligochaetes species to the total number of benthic species is higher in the Aral Sea than in the other bodies of water mentioned. Consequently, it may be that subsequent additions to the species composition of the oligochaetes of the Aral Sea will not be very great.

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Collections of Oligochaetes made in the Aral Sea during the navigation period in 1964 and 1965.

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Summary

Oligochaetes were found in 13 collections (4.05% of the total number) made in 1964 at fixed stations during three cruises of expedition vessels. In 1965 oligochaetes were found in 12 collections (3.8% of the total number) during three cruises. Paranais simplex Hrabě, Psammoryctides albicola (Mich.), Euilyodrilus bavaricus (Oeschm.) and Lumbricillus lineatus (Müll.) were recorded in 1964 and P. albicola and L. lineatus in 1965. The number of oligochaete species in the Aral Sea is 12.9% of the total number of benthic species (7 and 54). Oligochaetes account for less than 1% of the total biomass of the zoobenthos in the Aral Sea and they have not been recorded in the diet of fishes.

Bibliography: 12 titles.

III. ECOLOGY AND BIOLOGY

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CHARACTERISTICS OF TUBIFICID AND NAIDID LIFE CYCLES

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Among the freshwater Oligochaeta, which are wide ranging and highly abundant, the families Tubificidae and Naididae contain the largest number of species.

Since tubificids and naidids belong to different ecological groups, the characteristics of their life cycles differ. A knowledge of life cycles is important for the evaluation of intraspecific relationships in different river, lake and reservoir biocoenoses, for an understanding of trophic links between different groups of hydrobionts and for clarification of the role of oligochaetes in productive biological processes.

A number of general works (Vejdovsky, 1884; Stolte, 1955, 1962; Sperber, 1948 - 1950; Stephenson, 1030; Chekanovskaya, 1962 et al.) and various articles devoted to specific ecological problems provide some information on the biology of certain tubificid and naidid species. Detailed investigation of life cycles is a relatively recent phenomenon (Poddubnaya, 1958, 1959, 1962; Timm, 1962, 1964; Brinkhurst, 1964a, 1964b; Brinkhurst and Kennedy, 1965; Kennedy, 1965, 1966a, 1966b).

The life cycle of oligochaetes is fairly simple. The embryonic period, which covers the development of the eggs in the cocoon, last in different species for between a few days and six months, including embryonic diapause. The postembryonic period begins after emergence from the cocoon and terminates with natural death. Depending on conditions in the body of water this can be a period of months (naidids) or several years (tubificids). During this period, as the worm grows and develops, it reaches sexual maturity, takes part in reproduction once or more than once and then dies. We know that naidids reproduce both asexually and sexually. Most of them reproduce paratomically throughout the year in bodies of water which do not freeze over, but only during the autumn and summer in those which do. Sexual naidid individuals were encountered in different months of the year, between May and December. Sexual reproduction usually commences in the autumn, in September and October. It is assumed that naidids produce several asexual generations and one sexual generation a year and that the latter is important for the formation of overwintering stages - cocoons.

The life span of sexual chains and sexual individuals 88
is known for very few naidid species. According to the data of Stolte (1955) a chain of the sexually immature zooids of *Stylaria lacustris* L. lives one month under optimum feeding conditions. The life span of a sexual zooid is one to two months. Sexual reproduction is observed for four weeks. Gruffydd (1965), who examined the life cycle of parasitic species (*Chaetogaster limnaei limnaei* and *Ch. Limnaei vaghini*), showed the very interesting relationships between these species and the host, the snail *Limnaei peregra*, in whose kidneys the worms live. Both species reproduce paratomically throughout the year. No sexual individuals of

Ch.limnaei limnaei were found. Only very few individuals of Ch. limnaei vaghini reached sexual maturity and their reproduction period commenced in November or December and continued throughout the winter and spring without interruption. Cocoons were found in the kidney of the snail. The incubation period lasted 30 - 50 days. The worms became temporarily free-living during the transition period from one snail generation to another. The present author, who was able to follow the asexual and sexual reproduction of Ch.diaphanus (Gr.) under experimental and natural conditions (in various reservoirs on the Upper Volga), found that asexual reproduction began in spring, at the end of May, when water temperature was 7 - 8°C, and continued until October. Both in a body of water and under experimental conditions isolated individuals grow into 24 - zooid chains in an average of 10 days at a water temperature of 8 - 10°C. We described these chains as "initial chains". Under experimental conditions they gave rise to 5 to 7 asexual generations, the life span and fecundity of which were determined.

The division of the intitial chains began in the first five days of June at a water temperature of 10 - 17°C and continued at different rates for an average of 47 days. At first the intitial chains divided every 24 to 36 hours. After each successive division new zooids began to grow on the remaining 12 - 16 zooids and a new division took place as soon as the total number of zooids in the chain reached 20 - 24. In the second half of June, despite higher water temperatures, the rate of division fell to one every three days and no more than 16 zooids were formed in the chains. The initial chains began to die in the first decade of July, evidently as a result of physiological ageing. No new zooids were formed after the separation of the last viable chain and a few hours later the initial chain divided abruptly in the region of the ninth segment and both its parts then died. The 10 initial chains in the experiment divided 12 -18 times in their 40 - 50 day life and each left behind 15 first generation chains on average. The results of observations on the 1st to 4th generations are set out in the Table. It can be seen that first chains of a generation are always more fecund than subsequent ones. The chains of subsequent generations live longer than the preceeding ones. The rate of division falls as the life span increases, and this is evidently connected with the onset of sexual maturation. The chains divided 12 - 14 times on average.

Thus the life span of the chains ranges between 42 and 62 days. Between 10 and 70 chains separate from the intitial individual during this period. Sexual maturity is achieved by 89
20% of the penultimate and ultimate chains of the first generation and by 90% of the chains of the 2nd and all succeeding generations.

1 Продолжительность жизни и плодовитость четырех поколений цепочек Chaetogaster diaphanus (Gruith.)

2 Показатель	3 Первые цепочки				Последние цепочки 4			
	5 Поколение							
	I	II	III	IY	I	II	III	IY
6 Продолжительность жизни, дни	42	48	52	60	42	42	49	62
7 Плодовитость, количество цепочек	14	16	16	17	10	11	12	10
8 Интервал времени между делениями, дни	3,0	3,0	3,2	3,5	3,2	3,8	4,0	6,2

Key to Table on p. 89: 1. The life span and fecundity of four generations of Chaetogaster diaphanus (Gruith.) chains; 2. Indicator; 3. First chains; 4. Last chains; 5. Generation; 6. Life span, days; 7. Fecundity, number of chains; 8. Time between divisions, days.

For Chaetogaster diaphanus sexual reproduction is a seasonal phenomenon which takes place at the same time every year, during September-October. The sexual system which begins to form from the middle of August, is completely ready to function by the first days of September. Paratomy continues normally during this period. During the pairing of the worms and the maturation of the eggs paratomy continues, though less intensively, and ceases with the commencement of the mass laying of cocoons.

The worms pair even before mature eggs form. The eggs are usually at an early stage in yolk accumulation at the time of pairing and take another 6 to 7 days to mature. The accumulation of yolk in the egg is regulated by feeding conditions. When feeding conditions are unfavourable the eggs are smaller (maximum size 300μ) and mature faster, and the laying of cocoons commences earlier. When food is abundant the accumulation of yolk in the eggs is intensified, the eggs reach 600μ and the cocoon-laying periods are slightly extended.

The laying of cocoons begins in the second half of September and lasts for 25 - 35 days. According to our data the worms usually lay the cocoons in a day, although sometimes the period is prolonged to a maximum of four days. This depends on the maturity of the eggs, which is why the whole cocoon-laying period is somewhat drawn out. The number of cocoons laid by one worm is between 5 and 9, with an average of 7 cocoons. The reproductive system is not resorbed after the laying of the cocoons and the worms die one to two weeks later.

The reproduction of tubificids differs from that of naidids in that it is exclusively sexual. A number of authors (Poddubnaya,
1963; Timm, 1964; Brinkhurst, 1964a; Brinkhurst and Kennedy, 1965; 90

Kennedy, 1965, 1966a, 1966b; Matsumoto and Jamamoto, 1966) have obtained information on the life cycles of *Limnodrilus udekemianus* Clap., *L.hoffmeisteri* Clap., *L.claparedeanus* Ratz., *Euilyodrilus hammoniensis* (Mich.), *Psammoryctides barbatus* (Grube), *Tubifex tubifex* (Müll.), *T.costatus* (Clap.), *Peloscolex ferox* (Eisen) and *Isochaetides newaensis* (Mich.).

The life cycles of the various species in a body of water are studied on the basis of seasonal collections of oligochaetes. Most of the authors took no more than one sample per month and only the life cycle of *I.newaensis* was studied from no fewer than 4 - 5 collections per month. Four categories of worms were distinguished among the population caught: 1) juveniles, without a reproductive system, 2) individuals with a developing reproductive system, 3) sexually mature worms and 4) individuals with a clitellum. Samples taken in the natural environment have permitted very approximate determination of certain details of the life cycle and definition of the time at which the young appear, etc. In addition to field observations, life cycles have also been studied under laboratory conditions. As a result of the observations it has been found that tubificid species form two groups, one of which requires a very long time (at least 9 - 12 months) for the young to reach sexual maturity while the young of the second group reach maturity in a relatively short time (1 - 6 months).

Limnodrilus udekemianus, *Euilyodrilus hammoniensis*, *Peloscolex ferox*, *Psammoryctides barbatus*, *Tubifex costatus* and *Isochaetides newaensis* constitute the first group and *L.hoffmeisteri* and *T.tubifex* the second. In general, species with a longer maturation period reproduce once a year in the first half of the summer (May - July). The reproductive period lasts 2 months. In some more productive English bodies of water L.udekemianus may reproduce in the winter months (December, January), but also only once a year. It is interesting to note that even in bodies of water with completely different conditions (England, the Central zone of the European regions of the USSR and the Baltic) and under experimental conditions L.udekemianus and I.newaensis always reach sexual maturity by the 10th and 11th month of life. Among species which mature earlier, individuals with a clitellum are encountered throughout the year. These species are capable of reproducing at different times, but there is a single peak of reproduction in the spring, autumn or winter.

Under natural conditions L.hoffmeisteri has one generation a year, usually a spring-summer one, although it may also reproduce in the winter (English bodies of water); under experimental conditions the species reproduces twice a year. T.tubifex lays cocoons twice a year, in the spring and winter; in Japan it also lays twice yearly, but in March-July and September-October. The natural reproductive rhythm is maintained under experimental conditions.

We possess very little information on the fecundity of Tubificidae. Timm (1966) states that one T.tubifex individual can produce between 14 and 44 (more commonly 30 - 35) young individuals. According to Matsumoto's observations (Matsumoto and Jammoto, 1966) one T.tubifex individual lays about 38 cocoons in the course of the reproductive period and each contains 12 eggs on average, i.e. a total of 456 eggs.

We know from the works of Černosvitov (1930) and Hrabě 91
(1939) that the worms do not die after laying of cocoons, but that their reproductive system is resorbed and then regenerated and that they are capable of reproducing for the second time.

On this basis it is assumed that the life span of tubificids is several years (especially in species requiring at least 10 - 12 months to reach sexual maturity).

Our data show that in I.newaensis resorption of the reproductive system commences in July after the deposition of cocoons, and lasts a fairly short time. The walls of the ampulla in the spermathecae converge and the duct is severely shortened. The same happens in the ampulla of the atrium, the vasa deferentia disintegrate completely and epidermal tissue overgrows the male and female pores. Resorption of the reproductive system is not complete; groups of cells remain on the site of the spermatheca, gonads and gonoducts. Cells in which nuclear mitosis is taking place, i.e. in which regeneration is beginning, may be found among them. Like the resorption which precedes it, this process is fairly intensive and is completed in 10 to 15 days. By the beginning of September the reproductive system was found to be regenerated in all the worms in the samples and clitella were formed by the end of the month. No worms with spermatozeugmas in the spermathecae were found in the autumn, which indicates that the pairing of worms does not take place immediately after the regeneration of the reproductive system, but in the spring after overwintering and directly before reproduction. In addition to the worms whose reproductive system undergoes resorption, which constitute 70% of the sexually mature part of the I.newaensis population, the samples always contained young and dying individuals of as yet undetermined age. It can thus be assumed that the majority of I.newaensis individuals do not live more than two years and take part in reproduction twice. For late-maturing tubificids two years is evidently not the maximum life span. According to T. Timm (1966), *L.udekemianus* lived seven years (admittedly without reproducing) under experimental conditions.

The time and duration of reproduction in *L.hoffmeisteri*, *Euilyodrilus hammoniensis*. *I.newaensis* and *T.tubifex* are related to temperature conditions. Pairing and the laying of cocoons begin at a minimum temperature of 8 - 10°C and at a maximum temperature of 23 - 25°C. Temperatures above or below these have an inhibiting effect. Kennedy (1966b) considers that variations in the time and duration of the reproductive period in different habitats may be related to the natural productivity level in bodies of water, while seasonal variations in population abundance may be related to the rate of reproduction. We have very little information on the precise influence of various environmental factors on the life cycles of tubificids, but for some species, (*L.udekemianus*, *L.hoffmeisteri*, *T.tubifex* and *I.newaensis*) the composition and quantity of food and also the temperature regime during the period of intensive development and growth have been shown primarily to have a decisive influence on the stages of the life cycle.

In short, it should be noted that no serious general
conclusions can as yet be drawn on the basis of the inadequate 92
knowledge gained from investigation of oligochaete life cycles. In our opinion, the basic questions meriting particular attention in the immediate future include the following: 1) the actual and potential fecundity of individuals of different species and the conditions responsible for variations in this factor (life span, number of resorptions and regenerations of the reproductive system, availability of food, physical and chemical environmental factors, natural mortality and consumption); 2) factors responsible for the

transition from asexual reproduction (temperature and gas regime, illumination, feeding conditions and the physiological state of the individual); 3) development of age-determination methods, applicable to the Oligochaeta and necessary for the acquisition of accurate data on the dynamics of age groups in population of long-lived species, and for assessment of the factors behind such dynamics.

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CHARACTERISTICS OF TUBIFICID AND NAIDID LIFE CYCLES

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Summary. 187

Consideration is given to life cycle characteristics of members of the different ecological groups in the Naididae and Tubificidae. The Naididae reproduce asexually and sexually. Most species have several asexual generations and one sexual generation a year. The Tubificidae reproduce only sexually. Two groups of species have been detected: 1) species with a long life cycle (Limnodrilus udekemianus, Euilyodrilus hammoniensis, Peloscolex ferox, Psammoryctides barbatus, Tubifex costatus, Isochaetides newaensis), whose young require at least 9 months to reach sexual maturity in the body of water, 2) species with a short life cycle (Limnodrilus hoffmeisteri, Tubifex tubifex), which take from 1 to 6 months to mature, depending on conditions in the body of water.

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ECOLOGICAL GROUPS OF OLIGOCHAETA IN THE DNIEPER

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The ecology of Oligochaeta, particularly their distribution 94
in bodies of water, is one of the little investigated aspects of the life of this important and comparatively poorly studied group of organisms. Chekanovskaya (1962) wrote in her monograph: "...as regards the problems...of the ecology of aquatic oligochaetes, in the majority of cases only preliminary conclusions may be drawn" (p.4). Most of the members of this group are considered to be species with a wide range of environmental conditions. However, the concept of wide ecological plasticity in oligochaetes has been considerably exaggerated, partly because there have been few quantitative studies. A mere statement of the existence of a species under certain conditions does not tell us much about its ecology. It is well known that each species possesses a definite ecological range within which there is an optimum zone, i.e. that combination of factors which is qualitatively and quantitatively most favourable to its existence as a species (Naumov, 1963). Many oligochaetes, although encountered in bodies of water with a great variety of conditions, develop to the greatest extent when fairly definite values of these conditions are combined in a fairly definite way. What constitute the most typical and optimal habitats for a species

can be found only through a quantitative approach both to the organisms themselves and to their living conditions.

The quantitative investigation of oligochaete distribution in the Dnieper and in the bodies of water on its flood plain has made it possible to distinguish separate groups of species which are similar in certain environmental factors or in definite combinations of such factors. The Dnieper system contains a great variety of bodies of water and of biotopes in them which differ in the degree of through flow: these range from bodies of water most clearly of river type (the median line of the main channel in the middle reaches) totally stagnant ones (alluvially almost independent bodies of water of the flood plain, in the definition of Markovskii, 1939). With reference to the two main categories of bodies of water and to the types of their biotopes, i.e. flowing or stagnant, we may distinguish among the Dnieper oligochaetes species adapted to life in flowing water (rheophilous)[1] and species preferring the conditions of stagnant bodies of water (limnophilous) (Table 1).

[1]The term "rheophilous" is here used in the sense defined by Neizvestnova-Zhadina and Lyakhov (1941, p.202).

Key to Table 1: 1. Table 1 2. Frequency and qualitative development of different groups of oligochaetes under different flow conditions 3. Oligochaetes 4. Bodies of water 5. Biotopes 6. Channel and arms(14)* 7. Bodies of water on flood plain (208)* 8. Rheobiotopes (122)* 9. Limnobiotopes (92)* 10. Pure sand, current velocity above 0.3 m/sec 11. Slightly and moderately silted sand, current velocity below 0.3 m/sec. 12. Deep silt (not mixed with sand), no current 13. Abundance 14. Biomass 15. No. of samples in which found 16. Frequency, % 17. Average 18. Percentage of total average 19. Maximum 20. Limnophilous 21. Rheophilous 22. Typically limnophilous 23. Limno-rheophilous 24. Meso-rheophilous 25. Poly-rheophilous 26. β - meso-rheophilous 27. α - meso-rheophilous 28. Note. * - number of samples processed; x - found in qualitative samples

Таблица 1

Встречаемость и количественное развитие отдельных групп олигохет в условиях различной проточности

Олигохеты	Водоемы: русло и устья	Водоемы: пойменные водоемы (208)*	Биотопы: реобиотопы (122). Чистый песок, течение выше 0,3 м/сек: встречаемость, %	численность: средняя	численность: % к общей средней	численность: максимум	биомасса: средняя	биомасса: % к общей средней	биомасса: максимум	Слабо и среднезаиленный песок, течение ниже 0,3 м/сек: встречаемость, %	численность: средняя	численность: % к общей средней	численность: максимум	биомасса: средняя	биомасса: % к общей средней	биомасса: максимум	лимнобиотопы (92)*. Глубокие илы (без примеси песка), течение отсутствует: встречаемость, %	численность: средняя	численность: % к общей средней	численность: максимум	биомасса: средняя	биомасса: % к общей средней	биомасса: максимум
	в каком числе проб встречен																						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Rheomorpha neiswestnovae (Last.)	2	–	12,0	94	–0,6	170	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Potamodrilus stephensoni (Last.)	6	–	24,0	163	0,9	250	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nais behningi Mich.	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
N. bretscheri Mich.	9	–	6,0	3	0,0	30	–	–	–	2,9	x	–	–	–	–	–	–	–	–	–	–	–	–
Chaetogaster krasnopolskiae Last.	8	–	24,0	50	0,4	190	–	–	–	2,9	x	–	–	–	–	–	–	–	–	–	–	–	–
Ch. setosus Svetl.	1	–	–	–	–	–	–	–	–	1,0	x	–	–	–	–	–	–	–	–	–	–	–	–
Propappus volki Mich.	27	3	94,0	16524	96,8	67500	0,45	66,6	1,8	13,3	438	15,2	6200	0,01	0,0	0,2	–	–	–	–	–	–	–
Aeolosoma travancorense Aiyer	16	5	–	–	–	–	–	–	–	13,3	1200	41,3	62500	–	–	–	–	–	–	–	–	–	–
Vejdovskyella intermedia (Bretsch.)	19	1	–	–	–	–	–	–	–	17,1	76	2,6	1200	–	–	–	–	–	–	–	–	–	–
Nais pardalis Pig.	34	20	18,0	x	–	–	–	–	–	25,7	116	4,0	5900	–	–	–	–	–	–	–	–	–	–
Specaria josinae (Vejd.)	9	4	–	–	–	–	–	–	–	8,6	11	0,3	600	–	–	–	–	–	–	–	–	–	–
Piguetiella blanci (Pig.)	6	1	12,0	214	1,3	2530	–	–	–	3,8	2	0,1	100	–	–	–	–	–	–	–	–	–	–
Uncinais uncinata (Oerst.)	11	3	6,0	44	0,3	530	–	–	–	10,5	27	0,9	1100	–	–	–	–	–	–	–	–	–	–
Paranais litoralis (Müll.)	8	2	6,0	x	–	–	–	–	–	8,6	11	0,3	700	–	–	–	1,1	x	–	–	–	–	–
Amphichaeta leydigi Taub.	24	6	12,0	x	–	–	–	–	–	25,7	79	2,7	2700	–	–	–	–	–	–	–	–	–	–
Aulodrilus pigueti Kowal.	17	2	–	–	–	–	–	–	–	17,1	179	6,1	7500	–	–	–	–	–	–	–	–	–	–
Isochaetides michaelseni (Last.)	45	20	24,0	23	6,4	137	0,01	1,4	0,04	46,6	337	6,9	7000	0,95	5,9	14,2	–	–	–	–	–	–	–
I. newaensis (Mich.)	48	20	36,0	28	7,8	87	0,13	19,1	0,74	53,2	856	17,6	16800	9,15	56,4	266,0	1,1	x	–	–	–	–	–
Limnodrilus parvus South.	22	5	24,0	63	17,6	300	0,01	1,4	0,02	16,2	38	0,8	1000	0,02	0,1	0,35	4,4	3	0,1	100	0,00	0,0	0,02
Euilyodrilus moldaviensis (Vejd. et Mraz.)	48	19	24,0	234	65,3	2500	0,06	8,7	0,9	47,5	554	11,4	10300	0,42	2,6	12,1	31,9	15	0,5	400	0,02	0,5	0,4
Rhyacodrilus coccineus (Vejd.)	4	10	–	–	–	–	–	–	–	1,0	1	0,0	100	0,00	0,0	0,02	1,1	x	–	–	–	–	–
Psammoryctides albicola (Mich.)	23	43	–	–	–	–	–	–	–	24,7	143	2,9	3200	0,25	1,5	6,8	26,4	124	3,8	2400	0,27	7,1	4,7
P. barbatus (Grube)	21	20	–	–	–	–	–	–	–	18,0	85	1,7	2000	0,12	0,7	3,0	14,3	35	1,1	700	0,05	1,3	2,7
Tubifex ignotus (Stolč)	7	16	–	–	–	–	–	–	–	14,3	38	0,8	1200	0,02	0,1	0,15	2,2	x	–	–	–	–	–
(Ilyodrilus) templetoni (South.)	1	4	–	–	–	–	–	–	–	2,9	6	0,1	500	0,00	0,0	0,1	4,4	3	0,1	100	0,00	0,0	0,01
Rhynchelmis limosella Hoffm.	–	2	–	–	–	–	–	–	–	2,0	x	–	–	–	–	–	4,4	6	0,2	50	0,1	2,6	0,8
Criodrilus lacuum Hoffm.	8	13	–	–	–	–	–	–	–	6,7	5	0,1	100	1,8	11,1	50,5	2,2	1	0,0	100	0,03	0,8	1,2
Dero digitata (Müll.)	17	51	–	–	–	–	–	–	–	17,1	73	2,5	4100	–	–	–	23,7	187	53,4	2300	–	–	–
D. dorsalis Ferron.	–	5	–	–	–	–	–	–	–	1,0	x	–	–	–	–	–	2,2	x	–	–	–	–	–
Aulophorus furcatus (Müll.)	1	6	–	–	–	–	–	–	–	2,9	x	–	–	–	–	–	1,1	x	–	–	–	–	–
Haemonais waldvogeli Bretsch.	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1,1	x	–	–	–	–	–
Aulodrilus limnobius Bretsch.	4	8	–	–	–	–	–	–	–	2,9	2	0,1	50	–	–	–	7,7	32	9,2	500	–	–	–
A. pluriseta (Pig.)	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3,3	94	26,9	1100	–	–	–
Limnodrilus udekemianus Clap.	25	34	–	–	–	–	–	–	–	25,7	95	2,0	2400	0,36	2,2	5,4	11,0	13	0,4	500	0,05	1,3	1,8
L. hoffmeisteri Clap.	55	91	6,0	–	–	–	–	–	–	28,5	220	4,5	23800	0,26	1,6	25,8	75,0	2088	73,4	4800	1,54	42,1	4,8
L. claparedeanus Ratz.	7	4	–	–	–	–	–	–	–	4,8	29	0,6	2000	0,28	1,7	5,5	6,6	84	2,8	2800	0,14	3,6	5,5
Euilyodrilus hammoniensis (Mich.)	45	96	–	–	–	–	–	–	–	10,5	16	0,3	23700	0,02	0,1	24,3	79,2	1225	37,7	8000	1,44	37,2	11,3
E. heuscheri (Bretsch.)	1	14	–	–	–	–	–	–	–	1,0	5	0,1	1200	0,00	0,0	0,5	25,3	16	0,5	1200	0,00	0,1	0,5
Tubifex tubifex (Müll.)	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3,3	x	–	–	–	–	–
Peloscolex ferox (Eisen)	6	14	–	–	–	–	–	–	–	7,6	17	0,4	300	0,09	0,6	0,2	7,7	20	0,6	400	0,04	1,0	0,6
Peloscolex velutinus (Grube)	–	14	–	–	–	–	–	–	–	1,9	2	0,0	100	0,00	0,0	0,4	3,3	1	0,0	300	0,00	0,1	1,2
Haplotaxis gordioides (Hart.)	3	4	–	–	–	–	–	–	–	1,0	x	–	–	–	–	–	6,6	x	–	–	–	–	–
Lumbriculus variegatus (Müll.)	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,2	x	–	–	–	–	–

Примечание. * – количество обработанных проб; x – встречены в качественных пробах

Rheophilous species

The rheophilous species are those which flourish under conditions typical of flowing bodies of water, i.e. when the body of water contains biotopes of a river type (rheobiotopes). These include biotopes belonging to the bodies of water in a river system, where the influence of river flow is manifested by the presence of a current (either constant or temporary, due to spring flooding) and of compact, primarily sandy bottoms, as well as by definite quantitative limits to oxygen content, pH, organic matter (both total and readily hydrolyzable) etc. 95

River biotopes are extremely varied, depending on the degree to which they are influenced by the river flow (different current velocities, the extent of silting of sands etc.). A number of transitional types (from river to stagnant water ones) can be distinguished among them, differentiated by specific features of the oligochaete population. These should be distinguished from conditions of the stagnant water type, i.e. limnobiotopes, which are characterized by silty bottoms, absence of current, a lower oxygen content than that found in rheobiotopes and other specific features of the physico-chemical and gas regime (as in the case of rheobiotopes there are characteristic quantitative limits to the factors indicated). Rheophilous species are hardly ever encountered under limnobiotopic conditions even in bodies of water belonging to a river system.

According to the records of research in the Dnieper, approximately 16 species were found to be associated with river-type biotopes (Table 1). The composition of the Dnieper rheophilous species corresponds in the main to the grouping of species with a river ecology described in literature (Table 2).

The species classified as rheophilous do not form an ecologically homogeneous group but include, in their turn, groups of species which differ in their attitude to the through flow of the biotopes. Poly-rheophilous and meso-rheophilous (α - meso-rheophilous and β - meso-rheophilous) species can be distinguished in the rheophilous group (Table 1).

Poly-rheophilous live under conditions in which the influence of river factors is most sharply expressed (current at bottom not less than 0.3 - 0.5 m/sec, clean washed sands). In the Dnieper biotopes of this type occupy most of the area along the median line of the main channel and some well washed arms in the upper and middle reaches. Here the frequency and quantitative development of poly-rheophilous species have the greatest values by comparison with other types of river biotope; at the same time other rheophilous groups are suppressed under similar conditions (Fig. 1, 1). The decline in current velocity and the silting of the sandy bottom have an adverse effect on the development of poly-rheophilous species: some such as Rheomorpha neiswestnovae and Potamodrilus stephensoni[1] disappear at the first signs of silting-up; while
Propappus volki and Chaetogaster krasnopolskie can tolerate only 97
a very small degree of silting; their frequency and abundance decline noticeably in the current by comparison with those recorded in pure sands (Table 1). The most widely distributed and abundant rheophilous species is Propappus volki; Potamodrilus stephensoni and Chaetogaster krasnopolskiae are also fairly common, while the other species were encountered only in isolated samples.

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[1]These species can evidently be described either as rheobionts, in Thienemann's definition (1924), or in Lastochkin's definition (1927), as specific species.

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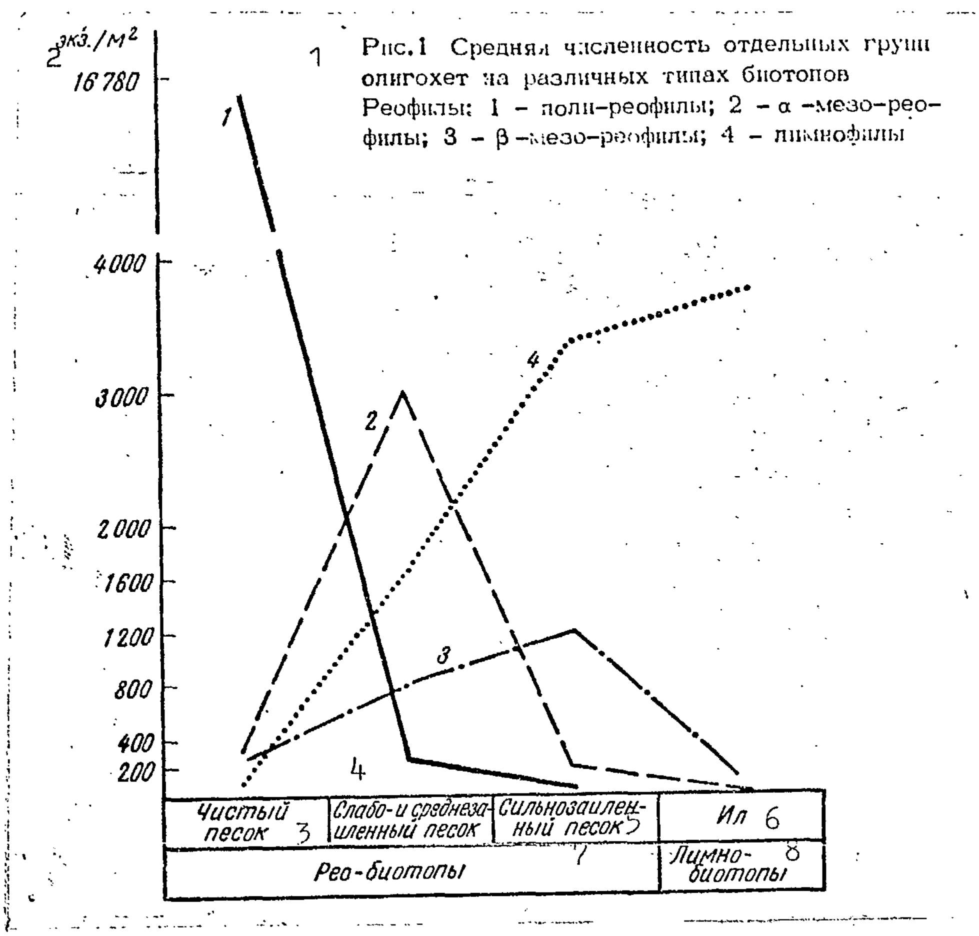
1 Таблица 2

2 Данные о видовом составе речных олигохет

3 Вид	4 Гримайловская-Морозова, 1929	5 Ласточкин, 1935, 1936, 1944	6 Малевич, 1956, 1957	7 Чекановская, 1962	8 Тимм, 1963, 1967
Rheomorpha neiswestnovae (Last.)		+	+		
Potamodrilus stephensoni (Last.)		+	+		
Vejdovskyella intermedia (Bretsch.)		+			
Nais pseudobtusa Pig.		+			
N.behningi Mich.	+	+	+	+	
N.bretscheri Mich.	+	+			+
Piguetiella blanci (Vejd.)	+	+	+		
Ophidonais serpentina (Müll.)		+			
Uncinais uncinata (Oerst.)		+			
Amphichaeta leydigi Tauber		+			
Chaetogaster krasnopolskiae Last.		+	+		
Ch. setosus Svetl.		+			
Aulodrilus pigueti Kowal.					+
Isochaetides michaelseni (Last.)		+	+	+	
I. newaensis (Mich.)	+	+	+	+	+
Limnodrilus udekemianus Clap.		+			
Euilyodrilus moldaviensis (Vejd. et Mraz.)	+	+	+	+	+
Ilyodrilus templetoni (South.)					+
Psammoryctides barbatus (Grube)		+			
P. moravicus Hrabě					+
Propappus volki Mich.	+	+	+	+	+
Criodrilus lacuum Hoffm.				?	

Key to Table 2. 1. Table 2 2. Data on the species composition of river oligochaetes 3. Species 4. Grimailovskaya and Morozov, 1929 5. Lastochkin, 1935, 1936, 1944 6. Malevich, 1956, 1957 7. Chekanovskaya, 1962 8. Timm, 1963, 1967



Key to Fig.1. 1. Fig. 1. Average abundance of separate oligochaete groups in different types of biotopes Rheophilous: 1) poly-rheophilous; 2) α-meso-rheophilous; 3) β-meso-rheophilous; 4) limnophilous 2. Specimens/m^2 3. Pure sand 4. slightly and moderately silted sand 5. Strongly silted sand 6. silt 7. Rheo-biotopes 8. Limnobiotopes

The mose-rheophilous group includes species which prefer river biotopes with lower through flow, a maximum current velocity of 0.3 m/sec and bottom material represented by sands silted-up to varying degrees. In their turn the meso-rheophilous species divide into two groups which are different in relation to the degree of through flow and to the intensity of silting of the sandy bottom. It was found that the body size and mode of life of the worms were different in these two meso-rheophilous groups. The more rheophilous of these groups (α-meso-rheophilous species) consists mainly of mesobenthic species inhabiting the surface of the bottom material (epifauna), while the other group (β-meso-rheophilous species) contains macrobenthic species capable of burying themselves in the bottom material (infauna).

α-meso-rheophilous species are more sensitive to the silting 98
of sand than meso-rheophilous species. They develop best on slightly silted sands (silt layer not exceeding 0.5 cm), their abundance decreases noticeably on moderately silted sands (silt layer 1 - 1.5 cm) and declines even more sharply on strongly silted sands (silt with some sand) (Figs. 1 and 2). Thus the optimum development conditions for α-meso-rheophilous species can be found in biotopes with slightly silted sandy bottoms; their development is reduced as pure washed sands are moved aside and as further silting takes place after the slightly silted stage.

β-meso-rheophilous species are found in variously silted sands from slightly to strongly silted), but their optimum development zone is located in sands which are more heavily silted-up than those inhabited by α-meso-rheophilous species. The highest figures of abundance and biomass for this group were recorded in moderately silted sands (Figs.1 and 3). A fairly high biomass was recorded in a number of cases in strongly silted sands and river ooze (silt with some sand), but the species listed are never found in the unredeposited deep silt (limnobiotopes) of stagnant bodies of water on the flood plain. The level of rheophily in individual species(which we assess from the character of the biotopes preferred) also varies within each meso-rheophilous group. Vejdovskyella intermedia, Nais pardalis and Aulodrilus pigueti are the α-meso-rheophilous species most tolerant of silting:

the tolerance of β-meso-rheophilous species increases in the following sequence: *Isochaetides newaensis*, *I. michaelseni* and *Euilyodrilus moldaviensis*.

Limnophilous species.

Typically limnophilous species are common in stagnant bodies of water, whether self-contained or connected with a river system, and in rivers. Conditions characteristic of the existence of limnophilous species are found in stagnant bodies of water (limnobiotopes); it is in these biotopes that limnophilous species are found most frequently and form the most persistent mass concentrations (Table 1). In rivers limnophilous species are found in limnobiotopes and in some types of river biotopes, mainly under conditions of weak through flow (moderately and strongly silted sands).

Species occupying a sort of intermediate position between the above-mentioned typical rheo- and limnophilous groups are also regarded as limnophilous. Their distribution is linked to rivers: they are encountered in the main channel, in bodies of water on the flood plain and in others not of a river origin but connected with rivers (lakes into which rivers discharge). The basic difference between these species, which we call "conditionally river species" or "limno-rheophilous species", and typical rheophilous species, is that in bodies of water belonging to a river system they are not encountered under typical river conditions in a strong current, but are confined mainly to biotopes of the stagnant type found in rivers and bodies of water on the flood plain (absence of current, deep silt, presence of weed beds). In river biotopes they are found under conditions of moderate and weak through flow (slightly
moderately silted sand). It is possible that, in addition to species 99

listed in Table 1, the limno-rheophilous group should also include *Nais pseudobtusa* and *N. barbata*.

In bodies of water belonging to the river system the habitats of limno-rheophilous species are similar to those of typical limnophilous species. The ecological differences between the two groups lie in the fact that limnophilous species inhabit not only bodies of water connected to a river system but also stagnant and isolated ones, while the distribution of the limno-rheophilous is seen to be confined to bodies of water of the first type only.

The existence of the ecological groups considered above shows that, thanks to the presence of biotopes with different through flow, the composition of Oligochaeta in bodies of water belonging to a river system manifests wide ecological differentiation and this results in the saturation of such biotopes by oligochaetes. Each type of biotope (classified by the degree of through flow) has a definite group of species which is most characteristic of it and is most developed in it (Fig.1). This can be seen clearly from the following diagram:

Reduction of through flow →

	Rheobiotopes		Limnobiotopes
Pure sand, bottom current velocity not less than 0.3 m/sec	Slightly or moderately silted sand	Strongly silted sand	Silt, no current
	Rheophilous species		Limnophilous species
Poly-rheophilous		Meso-rheophilous	
	α-meso-rheophilous	β-meso-rheophilous	

Decline in rheophily →

The four curves in Fig.1 depict the abundance of individual ecological groups whose maxima fall in different types of biotopes and it can be seen that biotopes with a lower through flow correspond to species with a lower rheophily. It must, however, be said that together with the characteristic species, members of contiguous ecological groups develop in each biotope (there is a special communication on the composition of the Oligochaeta in the different types of biotopes).

In addition to dividing oligochaetes into groups differing in their reaction to the current and to the combination of related factors, certain other ecological groups of species can also be distinguished. As regards their relationship to the nature of the substrate all aquatic oligochaetes can be divided into two groups: a) those inhabiting the bottom of the body of water (benthophilous) and b) those primarily forming part of the foulings on various objects submerged in the water (periphytophilous).

Benthophilous species inhabit the bottom surface and bury themselves in the bottom material. They include most aquatic oligochaetes - all the rheophilous species and most of the limnophilous ones. The connection between benthophilous species and the type of bottom material (sand, ooze) depends on their relationship to the current: all rheophilous inhabit bottom material which necessarily includes some particles of the sand size category
(poly-rheophilous species inhabit pure sands, meso-rheophilous 100
species inhabit various silted sands); limnophilous species prefer bottoms with silt deposits (deep ooze and silted sand).

Species with different relationships to the nature of the organic matter contained in the bottom material can be distinguished among the benthophilous species. The organic matter in a body of water may derive from the organisms which previously inhabited it (bacteria, algae, higher aquatic flora, fauna) and from allochthonous materials in the form of soil humus and artificial pollutants. The nature of organic matter in the bottom material and its chemical composition must undoubtedly be of direct primary importance to bottom-dwelling forms of Oligochaeta thanks to the bacteria developing there. In this connection it is natural to suppose that the detritus-feeders among oligochaetes include some ecological groups specialized in the processing of organic matter of particular types. Simultaneous investigations of the organic material in bottom deposits should enable us reliably to distinguish such groups. In spite of the present lack of information on this question certain observations can be made here.

A group of species - the detritophilous species - stands out among benthic oligochaetes because it is quite clearly associated with bottom material enriched by vegetable detritus, accumulated through the death of higher water plants (Table 3). They occur mostly in the weed bed zone, where they inhabit the bottom between the plants, with some of them (mesobenthic species) keeping more to the surface of the bottom material (Aulophorus furcatus and Dero digitata), while others (macrobenthic species) have the ability to bury themselves in the bottom material and form mass concentrations, especially around the root system. The frequency and quantitative development of detritophilous species in vegetation-free open areas of a body of water are much lower than in weed beds. The majority of the limno-rheophilous species and some limnophilous ones are detritophilous, and no members of this group have been recorded among the rheophilous species. Detritophilous species are found on silted sandy and silty bottoms (Fig.2).

Some oligochaetes are found to be associated with bottom material containing organic matter of a different nature. Thus, Euilyodrilus hammoniensis is most associated with the median line of bodies of water in which organic matter of planktonogenic origin predominates on the bottom. *Tubifex tubifex* and *Limnodrilus claparedeanus* are more common where there are artificial accumulations of organic matter (pollution by domestic sewage, waste from industrial and food enterprises etc.)

The periphytophilous species form a group whose most typical habitat is the foulings on various solid substrates found in the water: higher vegetation, wooden objects, stone and iron structures etc. (Table 4). Many of the species classified as periphytophilous are also encountered on the surface of bottom material, but their frequency and quantitative development are generally lower here than in the foulings (Fig.3). Periphytophilous species achieve the greatest variety and quantitative development 104
in foulings on higher water plants (Fomenko, 1964). It should be noted that most periphytophilous species are found in foulings belonging to a great variety of substrates and only some show a greater preference for the foulings on live plants (*Chaetogaster crystallinus*).

2 Встречаемость и численность детритофилов в медиали и рипали

1 Таблица 3

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Олигохеты 7	3 Медиаль (91)*					4 Рипаль: 5 грунт в зоне зарослей (105)*					под корнями растений (22)* 6	
	встречаемость, % 10	численность, экз/м² 8: средняя 11	численность, экз/м² 8: максимальная 12	биомасса, г/м² 9: средняя 11	биомасса, г/м² 9: максимальная 12	встречаемость, % 10	численность, экз/м² 8: средняя 11	численность, экз/м² 8: максимальная 12	биомасса, г/м² 9: средняя 11	биомасса, г/м² 9: максимальная 12	встречаемость, % 10	максимальное число экз. в пробе 13
Dero digitata (Müll.)	19,8	29	300	–	–	25,4	231	4100	–	–	13,6	–
D. dorsalis Ferron.	1,1	x	–	–	–	2,8	3	100	–	–	–	–
Aulophorus furcatus (Müll.)	1,1	–	–	–	–	2,8	2	100	–	–	4,5	–
Haemonais waldvogeli Bretsch.	–	–	–	–	–	0,9	x	–	–	–	–	–
Aulodrilus limnobius Bretsch.	1,1	x	–	–	–	8,5	33	500	–	–	–	–
A. pluriseta (Pig.)	–	–	–	–	–	2,8	93	700	–	–	–	–
Rhyacodrilus coccineus (Vejd.)	–	–	–	–	–	1,9	1	100	0,00	0,01	50,0	13
Limnodrilus udekemianus Clap.	7,7	4	200	0,1	1,1	28,2	104	2400	0,4	5,4	81,7	112
Psammoryctides albicola (Mich.)	22,0	54	2400	0,12	3,3	28,2	214	3200	0,4	6,8	77,2	101
P. barbatus (Grube)	18,7	18	650	0,02	2,7	14,1	102	2000	0,14	3,0	50,0	37
Tubifex ignotus (Stolč)	5,5	20	700	0,1	0,15	11,3	18	1200	0,1	0,12	36,3	13
Peloscolex ferox (Eisen)	7,7	13	300	0,01	0,2	7,6	24	400	0,04	0,6	31,8	173
P. velutinus (Grube)	1,1	1	300	0,00	1,2	3,8	2	100	0,00	0,8	18,2	35
Haplotaxis gordioides (Hart.)	–	–	–	–	–	0,9	x	–	–	–	31,8	75
Criodrilus lacuum Hoffm.	2,2	1	50	0,05	0,5	6,6	5	100	1,7	50,5	54,5	9
Enchytraeidae g. sp. juv.	4,4	2	100	0,00	0,01	14,1	12	260	0,01	0,1	59,0	52

* количество обработанных проб; x – встречены в качественных пробах.
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Key to Table 3 1. Table 3 2. Frequency and abundance of detritophilous species along the median line and in the bank zone 3. Median line (91)* 4. Bank zone 5. Bottom material in weed-bed zone (105)* 6. Under the roots of plants (22)* 7. Oligochaeta 8. Abundancem specimens/m^2 9. Biomass, g/m^2 10. Frequency, % 11. Average 12. Maximum 13. Maximum number of specimens in sample 14. * - number of samples processed; x - found in qualitative samples. 101

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1 Таблица 4

2 Встречаемость и численность некоторых видов олигохет в обрастаниях и на дне

3 Олигохеты	4 Дно								5 Обрастания				
	заиленный песок (105)* 6				ил (92)* 7				высшая водная растительность (101)* 8				Прочие предметы (12)* 9
	встречаемость, % 11	численность, экз/м² 10: средняя 12	% к общей средней 13	максимальная 14	встречаемость, % 11	численность, экз/м² 10: средняя 12	% к общей средней 13	максимальная 14	встречаемость, % 11	численность, экз/кг 10: средняя 12	% к общей средней 13	максимальная 14	встречаемость, % 11
Aeolosoma hemprichi Ehrenb.	15,2	118	4,1	7500	1,1	x	–	–	36,0	795	4,6	7160	33,3
A. variegatum Vejd.	1,9	–	–	–	1,1	x	–	–	5,0	x	–	–	–
Stylaria lacustris (L.)	20,9	210	7,2	9400	9,9	24	6,9	10700	62,0	1524	8,9	11830	50,0x
Ripistes parasita (Schmidt)	–	–	–	–	–	–	–	–	7,0	x	–	–	8,3
Slavina appendiculata (d'Udek.)	–	–	–	–	–	–	–	–	12,0	21	0,1	350	16,7
Nais pseudobtusa Pig.	6,7	2	0,1	100	3,3	x	–	–	66,6	7364	42,8	67340	41,5
N. barbata Müll.	6,7	2	0,1	100	1,1	x	–	–	39,0	2631	15,3	2557	66,7x
N. variabilis Pig.	6,7	x	–	–	5,5	x	–	–	47,0	995	5,8	9450	41,5x
Ophidonais serpentina (Müll.)	8,6	10	0,3	400	4,4	4	1,1	100	4,0	x	–	–	8,3
Chaetogaster diastrophus (Gruith.)	14,3	287	9,9	20500	1,1	x	–	–	48,0	1504	8,7	10450	25,0
Ch. diaphanus (Gruith.)	4,8	7	0,2	200	–	–	–	–	14,0	32	0,2	300	–
Ch. crystallinus Vejd.	1,0	x	–	–	1,1	x	–	–	22,0	173	1,0	800	–
Pristina longiseta Ehrenb.	2,9	2	0,1	50	3,3	1	0,3	50	32,0	182	1,1	2100	33,3
P. aequiseta Bourne	4,8	5	0,2	300	2,2	x	–	–	35,0	292	1,7	2080	33,3x
N. bretscheri Mich.	2,9	x	–	–	–	–	–	–	–	–	–	–	41,5
Dero digitata (Müll.)	17,1	73	2,5	4100	29,7	187	53,4	2300	39,0	1277	7,4	18650	8,3
D. obtusa d'Udekem	20,0	35	1,2	1450	13,2	4	1,1	100	18,0	x	–	5400	25,0
Nais simplex Pig.	4,8	7	0,7	300	–	–	–	–	8,0	x	–	–	–
N. communis Pig.	2,9	x	–	–	–	–	–	–	13,0	21	0,1	333	16,7
Nais elinguis Müll.	1,0	x	–	–	–	–	–	–	2,0	x	–	–	–
N. pardalis Pig.	25,7	116	4,0	5900	–	–	–	–	25,0	360	2,1	5000	41,5x
Chaetogaster langi Bretsch.	5,7	1	0,0	300	2,2	x	–	–	21,0	x	–	–	16,7
Ch. limnaei Baer	–	–	–	–	1,1	x	–	–	14,0	3	0,0	50	–

16 * количество обработанных проб; x – виды, встреченные в отдельных пробах в массовом количестве

Key to Table 4 1. Table 4 2. Frequency and abundance of some oligochaete species in foulings and on the bottom 3. Oligochaeta 4. Bottom 5. Foulings 6. Silted sand (105)* 7. Ooze (92)* 8. Higher water plants (101)* 9. Other objects (12)* 10. Abundance, specimens/m² 11. Frequency, % 12. Average 13. As percentage of total average 14. Maximum 15. * – number of samples processed; x – species found in mass quantities in separate samples. 102 and 103

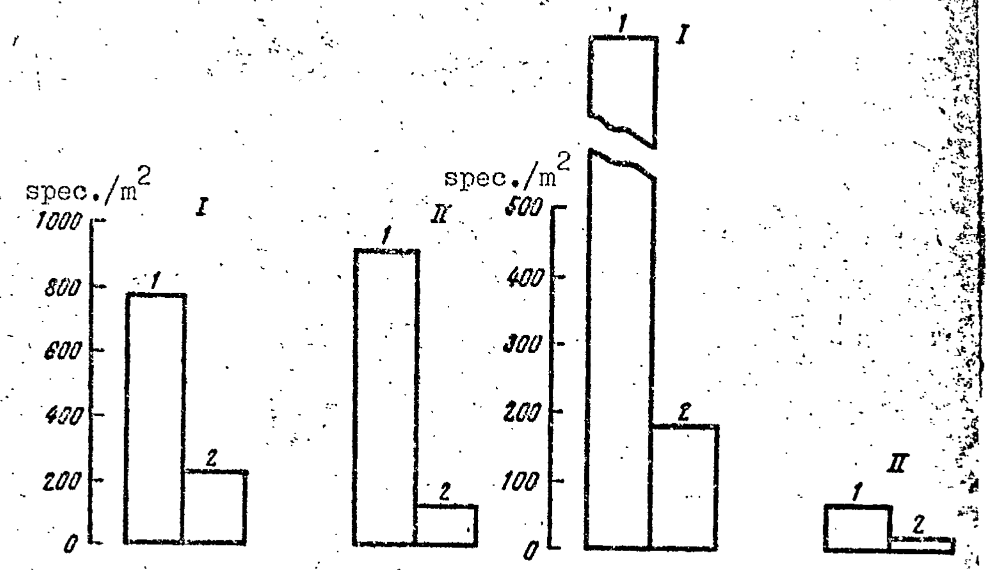

Рис. 2. Численность детритофилов в различных зонах водоема на различных грунтах I – заиленный песрк; II – ил; 1 – рипаль, 2 медиаль

Рис. 3. Численность перифитофилов на различных грунтах в различных зонах водоема
Условные обозначения те же, что на рис. 2.

Fig.2. The abundance of detritophilous species in different zones of a body of water on different bottom materials: I - silted sand II - ooze; 1. Bank zone 2. Median line.
Keyed on Figure:
Fig. 3. The abundance of periphytophilous species on different bottom materials in different zones of a body of water. Key as in Fig.2.

On the bottom periphytophilous species are mostly encountered on compact bottom materials (sand) at slight depths and in light currents; only isolated individuals are found on silts (Fig.3). The presence of periphytophilous species in foulings and on a compact bottom is evidently explained by the similarity of living conditions. Such similarity may be found in the hard base of the substrate and the resulting physical and chemical features of the biotopes under comparison, as well as in the microbenthic coenoses (bacteria, algae and invertebrates) found here, which provide similar feeding conditions. Lastochkin (1936) has noted the importance of epiphytic algae in the distribution of inhabitants of the periphyton. The typical periphytophilous species are invariably accompanied in the foulings by other species ecologically not confined to a single biotope (Table 4, heading "Other...").

Periphytophilous and detritophilous species are two groups of species ecologically associated with weed beds and differing in the nature of their adaptation to such beds. The periphytophilous species inhabit the surface of plants, using the vegetation only
as a base and a support, and feed on precipitated detritus and 105
organisms from biocoenoses of the periphyton. Detritophilous species inhabit bottom material in weed beds, feeding on the dying-off parts of the plant tissue. Higher water plants were evidently an important factor in the historical formation of different groups of species adapted to existence in weed beds and occupying different ecological niches. The presence of aquatic vegetation determines the distribution of the above mentioned oligochaete groups in the present bodies of water.

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ECOLOGICAL GROUPS OF OLIGOCHAETA IN THE DNIEPER

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Summary.

The current and associated factors (type of bottom material, physical and chemical regime) divide the Oligochaeta into rheophile and limnophile groups. The first group can be divided into poly-rheophiles and meso-rheophiles (α-meso- and β-meso-rheophiles). Benthophiles and periphytophiles (inhabitants of overgrowths) differ in the type of substrate they inhabit. The detritophilic group particularly stands out among the benthophiles, preferring bottom material enriched by vegetable detritus. The most typical representatives of different ecological groups can serve as indicators of certain typological features belonging to bodies of water.

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CULTURE METHODS FOR AQUATIC OLIGOCHAETA

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There are three problems in the breeding of oligochaetes: 1) how to keep live oligochaetes in the laboratory; 2) how to produce permanent cultures, i.e. artificial micropopulations, in the laboratory; 3) industrial cultivation in fish plants. The 107
species with the highest potential productivity are the most suitable for the latter purpose. The discovery of such species and determination of the optimum conditions for their cultivation is one of the practical tasks of the Vyrts"yarv limnological station.

Survey of published information

Bottom material, plants and natural water are used when keeping small Naididae and Aeolosomatidae in aquaria. The water has to be aerated and this is usually done mechanically by blowing air through it. This is a complicated system and in laboratory cultures favourable oxygen conditions in aquaria are usually achieved by the frequent changing of the water or by natural aeration, which is sufficient when the layer of water is thin. In this case only food is added. Szarski (1936a) bred various Naididae in small aquaria or in Petri dishes on detritus removed from aquaria containing fishes. Stolte (1921, 1922) fed *Nais variabilis* and *N. elinguis* with a suspension of bacteria obtained from an infusion of lettuce leaves. The author points out that old infusions loose their food value because the Infusoria developing in them destroy the bacteria.

Hyman (1941) developed a method for the cultivation of small aquatic animals (including Dero, Aulophorus and Nais species) on lettuce leaves brought to the boil in water and kept in a refrigerator after cooling. The depth of the water in the aquarium must not exceed 2.5 cm; the water is changed twice a week. At first only a few leaves are placed in the aquarium; as the population grows the entire bottom is covered with them. This is the culture recommended for the feeding of fingerlings of aquarium fishes. A bacterial culture for the feeding of Aeolosomatidae and Naididae can be obtained from an infusion of wheat grains or rice agar in a certain solution of mineral salts (Nuttycombe, 1937; Brandwein, 1937). Aelosoma hemprichi and A.variegatum have been successfully bred by Herlant-Meewis (1950, 1951) in Petri dishes containing an infusion of hay, in which the worms fed on bacteria and infusorians (Paramecium)

Pasquali (1938) bred A.hemprichi and A.headleyi and evidently also some species of Naididae on a culture of the algae Oocystis in Beneke's mineral salt solution. Szarski (1936a), however, established that though niadids ingest a large quantity of live algae they do not digest them.

Simm (1913) established that the predatory naidids Chaetogaster diaphanus and Ch.diastrophus can be fed not only on small animals but also on wheat flour, starch, egg white and even soap solution! Algae and bacteria pass through the intestine of these worms undigested. Szarski (1936a) used non-live foods for Ch.diastrophus and Ch.limnaei. In the experiments of Poddubnaya (1965) Ch.diaphanus was fed on its natural food - cladocerans.

Bülow (1955, 1957) kept various marine tubificids and enchytraeids in Petri dishes on a natural substrate at a low temperature in order to bring them to sexual maturity. Natural bottom material from a body of water was also used by Gavrilov (1931, 1935) in his *Limnodrilus* self-fertilization experiments. In their experiments on intraspecific relationships, Brinkhurst and Kennedy used an imitation of a natural substrate (bottom material and plants).

Cultures of cyst-forming oligochaetes can be obtained by watering portions of bottom material from dried-up ephemeral bodies of water. Such oligochaetes include many *Aeolosoma* species (Kenk, 1941, 1949; Stout, 1952) and the lumbriculids *Lamprodrilus mrazeki* and *Lumbriculus variegatus* (Mrázek, 1913; Hrabě, 1929)

Lumbriculus variegatus and tubificids can also live in aquaria in ooze to which nothing is added (Klunzinger, 1906; Poddubnaya, 1961a, 1961b, 1962a, 1962b, 1963). *Tubifex tubifex* here behaves normally even without aeration. *T.tubifex* and *Limnodrilus hoffmeisteri* can live and reproduce even in a medium temporarily deprived of oxygen (Alsterberg, 1922; Eggleton, 1931).

Vejdovsky (1876) kept *Psammoryctides barbatus* in aquaria containing sand without supplementary feeding, while Kennedy (1966a, 1966c) kept *Limnodrilus* species under these same conditions. Lehman (1941) proposed a method of cultivating *Tubifex tubifex* in crystallizing dishes with sand, providing supplementary feeding by dropping pieces of yeast onto the sand. As long as the water above the sand was changed regularly it remained clear. It was easy to find the coiled-up worms and their cocoons when the sand was stirred. Poddubnaya (1958) kept tubificids on ooze or on Canadian pondweed, also providing yeast as supplementary food. La Rue (1937) recommends that if tubificids are cultivated on ooze, additional food should be provided in the form of horse manure, potato, cabbage, bread etc.

Laboratory cultures of Enchytraeidae are usually formed in earth (Blount, 1937; Loosanoff, 1937; Le Ray and Ford, 1937). In some cases the substrate has been cottonwool with sewage and algae (Reynoldson, 1943) and nutrient agar (Dougherty and Solberg, 1961). Microbiologically sterile cultures have been produced of certain enchytraeids (Dougherty and Solberg, 1961), naidids and tubificids (Barysheva, 1940). Those who keep aquarium fishes as a hobby,breed two enchytraeid species as fish food: *Enchytraeus albidus* (Rose, 1957; Horn, 1960 et al.) and the smaller *E.buchholzi* (Klar, 1957; Breinl, 1961), in earth-filled boxes or jars. Soviet and some foreign fish plants breed *E.albidus* only, also using boxes containing earth, and an extensive literature is devoted to this species (Protasov, 1949; L'vov, 1948, 1949, 1951; Petrenko, 1951; Konstantinova, 1954, 1956; Ivlev and Ivleva, 1949; Ivleva, 1953a, 1953b, 1953c, 1955, 1957, 1960, 1961; Malikova, 1953; Askerov, 1962, 1963; Marchenko, 1966 et al.).

Cultivation method for aquatic Oligochaeta used at the 109
Vyrts"yarv limnological station.

Tubificidae have been the main object of cultivation since 1962. They are relatively undemanding: ooze can be used as a substrate and it is easy to extract the worms from it by washing. The operation could be mechanized (in fish plants enchytraeids are extracted from the earth manually).

Crystallizing dishes 10 cm in diameter and 8 cm deep (occasionally larger, up to 33 cm across) are used as aquaria for laboratory cultures. About 300 ml of ooze is poured into such a standard aquarium, which is then filled to the brim with tapwater. As the water evaporates the dishes are topped up.

Standard ooze obtained from Lake Vyrts"yarv at an approximate depth of 2 m with Borutskii's grab is used as the substrate and the basic food. The ooze is washed twice through a silk sieve (14 meshes per cm^2) to remove extraneous animals and coarse detritus: once, immediately after the ooze is obtained and again two months later so as to give the smallest Chironomidae and Oligochaeta which pass through the mesh time to grow. A stock of washed ooze is kept in the laboratory. The ooze is of a grey colour and rich in lime; there are approximately 10 billion bacteria per g of the raw material (Lokk et al., 1968).

Other methods of eliminating the mesofauna from ooze (strong heating, drying, prolonged storage under oxygen-free conditions) turned out to be unsuitable: either the development of worms in ooze processed in this way was worse or the worms died.

Experiments, usually of long duration, are continued until the natural death of the worms. A definite number of worms (usually 10) are placed in an aquarium. The aquaria are inspected 3 to 4 times a year, some more frequently. During inspection the entire contents of the aquarium are washed: the ooze passes through, while the worms and their cocoons remain in the sieve. They are counted and sometimes weighed _in vivo_. Instead of measuring live worms, which is both laborious and inaccurate, we simply divide them by appearance into four size groups: large, average, small and minute (newborn). The number of embryos in the cocoons is also counted. The parents are returned to an aquarium with new standard ooze and the progeny are removed. The older generation of oligochaetes differs from the progeny not only in size and in the possession of a developed reproductive system but also in the darker colour of the chloragogen tissue of the intestine; this has been previously described in naidids (Stolte, 1924).

Enamel dishes measuring 40 x 40 x 4 cm (for 4 litres of ooze), arranged in batteries on the same principle as a Konstantinov's apparatus, were used at the limnological station for experiments on the semi-commercial cultivation of aquatic oligochaetes. Wooden box-tanks measuring 40 x 40 x 12 cm lined with polyethylene film were used in the open air. Additional food for the oligochaetes is provided by compressed or fodder yeast, or an algal culture. The worms are recorded by live weight.

Some results 110

We present the most important data on the life cycles and productivity of oligochaetes obtained by us by 1967.

Tubifex tubifex. Cultivated since 1963. An excellent subject for laboratory cultivation. The maximum life span exceeds 3 years; approximately half the individuals die before they are 2½ years old. There are 1 - 8 (most commonly 3) embryos in each cocoon; development takes 15 - 18 days at room temperature. Sexual maturity is reached within 2 - 3 months. Each breeding worm reproduces about 4 times a year and produces an average brood of 30 on each occasion (i.e. 120 a year). The potential productivity of four generations of the progeny of one specimen exceeds 8 million! However, when the population is too dense reproduction is inhibited. For example, 3 breeding worms in an aquarium 10 cm in diameter produced an average of 41 young each in an experiment, while 10 in the same aquarium each produced 35 young and 30 produced only 4 (Timm, 1966). If 100 adult worms are kept in such an aquarium their reproductive system does not develop and they are distinguished by their small size and dark, often almost black colour (a sign of ageing). A simple experiment was formulated to clarify the reasons for this phenomenon (lack of food or the accumulation of the worms' own excretions?) (Table 1). In the first variant of this experiment the water above the ooze was changed every week, the second variant served as a control and in the third one the worms were given compressed yeast as a supplementary food. It became clear that reproduction was controlled by the concentration of food. The frequent changing of the water even had an adverse effect (because of impoverishment of the microflora?).

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1 Таблица 1

2 Продуктивность и выживание Tubifex tubifex в различных условиях питания*

3 Вариант опыта	Среднее число потомства 1 особи 4			Процент производителей, сохранившихся до 24.III1967 г. 5
	16.IV-10. VIII 1966 г.	10.VIII-12. XII 1966 г.	12.XII 1966 г. - 24.III 1967 г.	
6 Ил, смена воды	20	10	10	37
7 Ил (контроль)	32	39	31	100
8 Ил, дрожжи	90	54	72	73

9 * В каждом опыте было 3 стандартных аквариума с 10 червями.

Key to Table 1. 1. Table 1 2. The productivity and viability of Tubifex tubifex under different feeding conditions* 3. Variant of experiment 4. Average quantity of progeny produced by 1 individual 5. Percentage of breeders surviving until March 24, 1967 6. Ooze, change of water 7. Ooze (control) 8. Ooze, yeast 9. * 3 standard aquaria with 10 worms were used in each experiment.

The inhibition in the reproduction of tubificids when
population density is increased was not taken into account by
Brinkhurst and Kennedy (Brinkhurst and Kennedy, 1965; Kennedy,
1966a, 1966b). Since juveniles predominated in the natural
populations which they investigated and since reproduction of the
worms was not repeated during 10 - 13 months in the laboratory,
these authors maintain that Tubifex tubifex, Limnodrilus udekemianus
and also in most cases L.hoffmeisteri and other tubificids mature 111
when two years old. In actual fact the worms in Kennedy's
experiments did not mature because of the lack of food; the micro-
population had reached the limit of its abundance.

The productivity of T.tubifex is strongly affected by temperature as well as by food. According to the data of Matsumoto and Yamamoto (1966) T.tubifex laid cocoons in Japan at temperatures between 8 - 10° and 23 - 25°C. Under natural conditions reproduction took place between March and October with a break in the hottest month - August. The same authors inform us that T.tubifex produced an average of 456 progeny between March and July; the life span of the worms reached 4 to 6 years. Korotun (1959) considers that 2.5° and 38°C are the lethal temperatures for T.tubifex and that 11°C is the lower temperature limit of their reproduction. At 3 - 11°C the reproductive system of the worms was observed to develop incompletely. Under natural conditions the species reproduced from May till September, with a break in July (26°C). We tried to keep T.tubifex in a refrigerator at 1 - 4°C. The worms matured at 6 - 10 months and laid cocoons: the average number of progeny was between 6 and 9 times less than at room temperature.

T.tubifex is a suitable subject for commercial development.

In order to achieve its maximum productivity it is necessary to keep it at the optimum temperature conditions (probably 20 - 25°C) and to provide supplementary food. Our limnological station has commenced experiments in order to determine the optimum feeding conditions for this species under semi-commercial cultivation conditions.

Limnodrilus hoffmeisteri. Cultivated since 1965; the older individuals were still alive in their second year. Reproduction commences at 2 - 3 months and takes place at least four times a year. During the year the worm produces 150 - 300 offspring, i.e. more than *T.tubifex*. The cocoons, covered by a layer of ooze, contain between 1 and 3 embryos. Reproduction is inhibited by overpopulation and stimulated by supplementary feeding. At 1 - 4°C *L.hoffmeisteri* reached maturity when 6 months old and produced an average progeny of 12. This highly productive species is a promising subject for commercial raising. It is difficult to count and weigh worms belonging to this species in laboratory experiments since particles of silt become attached to the mucus-covered surface of their bodies and the worms twist themselves into large bundles from which it is difficult to isolate them. The similar bundles of *T.tubifex* fall apart easily when shaken.

Limnodrilus udekemianus. In aquaria since 1958. Only individuals brought from the body of water as adults reproduce; each of them lays one large cocoon containing two eggs. Repeated reproduction was not observed in the aquaria, even though the reproductive system of these worms is sometimes regenerated. Reproductive organs (without clitellum) appear in the young at an age of 1 year. The oldest individual of this species in our culture is more than 8 years old. It emerged from the cocoon in February

1959 but has never reproduced, in spite of the data of Gavrilov (1931, 1935) to the effect that the species is even capable of autocopulation. It seems that L.udekemianus is not able to reproduce normally under these conditions.

Euilyodrilus hammoniensis. In aquaria since 1962. Age 112
of oldest individuals - 2 years. Worms obtained from the lake reproduce in the aquaria; the cocoon contains up to 9 embryos; one individual produces up to 24 offspring per season. A reproductive system, including the clitellum, may appear among the worms emerging from cocoons in the aquaria when they are a year old, but reproduction is rarely observed. The species is not adapted to life in small aquaria. Even under natural conditions it is not encountered in small puddles or ditches; it may be sensitive to sharp, daily temperature variations. When we left aquaria in the open air in September the worms died on the following day.

The results of experiments on the productivity of four tubificid species under laboratory conditions are set out in Table 2.

1 Таблица 2

2 Продуктивность и выживание некоторых видов Tubificidae в лабораторных условиях (с октября 1965 г. по март 1967 г.)

Вид и число подопытных особей 3	Среднее число потомков 1 особи за весь период 4	Процент особей, сохранившихся до марта 1967 г. 5
T. tubifex *	145	83
L. hoffmeisteri*	127	87
L. udekemianus **	0	33
E. hammoniensis*	4	13

6 * В опыте были 3 стандартных аквариума по одному червю в каждом.
7 ** В опытах были 3 стандартных аквариума с 10 червями в каждом.

Key to Table 2 on typescript page 176.......

Key to Table 2: 1. Table 2 2. The productivity and viability of some Tubificidae under laboratory conditions (from October 1965 through March 1967 inclusive) 3. Species and number of individuals in experiment 4. Average number of progeny produced by one individual over the entire period. 5. Percentage of individuals surviving in March 1967 6. * 3 standard aquaria each containing one worm were used in the experiment 7. ** 3 standard aquaria each containing 10 worms were used in the experiments.

Psammoryctides barbatus. Cultivated since 1966. Reaches sexual maturity within a year and reproduces only in the spring. The cocoons contain 1 - 10 (more commonly 5 - 8) embryos and each individual produces an average of 17 - 22 offspring per season. Growth is accelerated by supplementary feeding on yeast.

Peloscolex ferox. In aquaria since 1966. During the two years the worms did not reproduce in spite of the development of a reproductive system.

Lumbriculus variegatus. Cultivated since 1966. Reproduces throughout the year by architomy. Rates of growth and reproduction are accelerated by supplementary feeding on yeast. May be suitable for commercial raising.

Nais communis. Cultivated since 1965. Reproduces by paratomy, which is accelerated by a small amount of supplementary feeding; large amounts of yeast lead to mortality among the worms. If *N.communis* is accidentally placed in aquaria with *T.tubifex* it may inhibit the reproduction of the latter. In spite of its high abundance, the biomass of *N.communis* in an aquarium always remains insignificant.

Aeolosoma hemprichi. Accidentally created culture of low
abundance in existence since 1966. In the winter found almost 113
exclusively as cysts.

Criodrilus lacuum. Transferred in spring 1965 from the

Daugava River, the species grows in aquaria but does not reach maturity.

Aquaria containing ooze have been inhabited since 1967 by Nais elinguis and Stylaria lacustris (both species have laid cocoons), Rhyacodrilus coccineus, Isochaetides newaensis, I. michaelseni, Stylodrilus heringianus, Rhynchelmis limosella and R. tetratheca. We were unsuccessful in establishing cultures of Chaetogaster diastrophus, Amphichaeta leydigi, Nais barbata and Eiseniella tetraedra (the worms perished rapidly).

Conclusions.

The method developed at the Vyrts"yarv limnological station can be used for the laboratory cultivation of many aquatic oligochaetes. At the same time some species which are widely distributed in natural bodies of water adapt badly to life in aquaria (e.g. Euilyodrilus hammoniensis). Of the species investigated, Tubifex tubifex and Limnodrilus hoffmeisteri were the most productive and offered the best prospects for commercial raising. We agree with the hypothesis of Brinkhurst and Kennedy (1965) that these species dominate polluted bodies of water thanks to their ability to reproduce rapidly and overtake other tubificids in the filling of biotopes temporarily vacated after winter kills and other local catastrophies. In balanced biocoenoses they retreat into the background. When cultivated they are able to realise their entire reproductive potential only if there is strict elimination to prevent overpopulation.

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CULTURE METHODS FOR AQUATIC OLIGOCHAETA

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Summary.

The article presents a survey of published information on methods of keeping and breeding aquatic Oligochaeta. A description is given of the method used by the author at the Vyrts"yarv limnological station: the worms are kept in small 188 crystallizing dishes (diameter 10 cm) on washed silt (300 ml per vessel). The dishes are filled to the brim with tap water. The silt is changed 3 - 4 times a year. Tubifex tubifex, Limnodrilus hoffmeisteri and possibly Lumbriculus variegatus are suitable for mass cultivation as food for fishes: these species reproduce in a culture independently of the time of year.

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THE ROLE OF TUBIFICIDS IN THE OXYGEN BALANCE OF BODIES OF WATER 118

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Because of the immediacy of the problem of protecting bodies of water against pollution, research is now being carried out in various fields: hydrology, chemical hydrology, limnology and sanitary engineering. In the field of sanitary engineering research is mainly directed toward the development of methods for the calculation of the oxygen regime, this being the most common and widespread way of establishing the limiting load of sewage on a body of water. Existing methods do not take into account all the components of the oxygen balance. As a rule they are based on the calculation of oxygen absorbed by dissolved pollutants, while the oxygen consumption from undissolved pollutants is not taken into account. And yet it is known that bodies of water polluted by sewage often accumulate beds of silt deposits which consume up to 80% of the oxygen and are the cause of acute oxygen deficit. Therefore, the lack of attention paid to the problem of the role of bottom deposits in the life of bodies of water and especially to the significance of bottom deposits in the oxygen regime, can be explained only by the fact that there has been hardly any investigation of the conditions under which oxygen is absorbed by undissolved matter in a body of water. The problem of discovering the conditions governing the oxidation of undissolved matter in bodies of water can be solved only after the connection and interrelationship between all natural factors determining the course of these processes has been established. The activity of benthic animals, which develop abundantly where there are accumulations of silt, should be regarded as one of the principal factors influencing the rate and direction of biochemical oxidation of organic matter in the deposits.

The main object of the present study, which was carried out in conjunction with other sanitary engineering research in the Neva, its delta and the mouth-reaches of the main tributaries by the Leningrad Civil Engineering Institute in the years 1964 - 1966, was therefore to find an answer to the question of the extent to which the activity of benthic animals may affect the biochemical oxidation of deposits and whether this ought to be taken into consideration when calculating the oxygen regime of bodies of water.

The earliest preliminary investigations confirmed the presence of silt deposits in areas of the discharge of sewage and showed that tubificids (Tubifex tubifex, Limnodrilus hoffmeisteri, Psammoryctides albicola, Limnodrilus claparedeanus, Peloscolex ferox, Limnodrilus udekemianus and Euilyodrilus sp.) develop on a large scale throughout the areas where such deposits exist.

We therefore included in the programme of general sanitary investigations of the bottom of bodies of water determination of the 119
abundance of tubificids in the areas under investigation, study of the conditions responsible for their mass development and experimental determination of the extent to which the vital activity of tubificids affects the oxygen demand of bottom deposits.

An investigation of the quantitative development of tubificids in bodies of water showed that this was determined by the level of pollution of the bottom material by readily decomposing organic matter. Statistical processing of all the data obtained yielded correlations between the number of tubificids and the pollution level of bottom deposits for separate chemical indices. Correlation analysis showed that the abundance of tubificids in the bottom material rises as the total amount of organic matter increases to 18 - 20%, but that any further increase in the amount of organic matter leads to a reduction. The abundance of tubificids in the bottom material was similarly affected by an increase in the content of oxygen-consuming organic matter, i.e. by the value of the chemical oxygen demand for oxygen (COD) in the bottom material. As the COD increased to 7.6 g per 100 g the abundance of tubificids increased, but above this limit their numbers declined (Fig. 1).

In order to find out what prevented the development of tubificids beyond the limits mentioned (the adverse effect of the decay products or the oxygen deficit in the water created under these conditions) it was necessary to turn to data relating to the Bol'shaya Neva River, in which the concentration of dissolved oxygen was never less than 7.5% during the investigation period. In the given case a direct correlation between these quantities was noted. Even when the COD reached 12 g/100 g, the tubificid abundance did not decline. It can therefore be assumed that the reduction in the numbers of tubificids in the first case was due primarily to the oxygen deficit created in small bodies of water when there are large concentrations of organic matter on the bottom.

Similar processing of the data did, indeed, show that when oxygen concentration falls below 4 mg/litre the development of tubificids is inhibited (Fig.2). Another factor inhibiting the development of oligochaetes is a concentration of petroleum products in the bottom material in excess of 600 mg per 100 mg (Fig.3).

The monthly abundance of Tubificidae increases from April until October (Fig.4) and, as it does so, the biomass falls. Thus, the abundance of tubificids in all the investigated bodies of water is determined by the pollution level in the bottom material, on the one hand, and by seasonal dynamics connected with the tubificid life cycle, on the other. The presence of readily decomposing organic matter, a minimum oxygen concentration in the water of 4.0 mg/litre and a maximum content of petroleum products in the bottom material of 600 mg/100 g are necessary conditions for the normal development of tubificids in these bodies of water. Bearing in mind that tubificids are forms most tolerant of pollution, the above-mentioned concentrations can be considered as limiting for all macrobenthic groups in the bodies of water under investigation.

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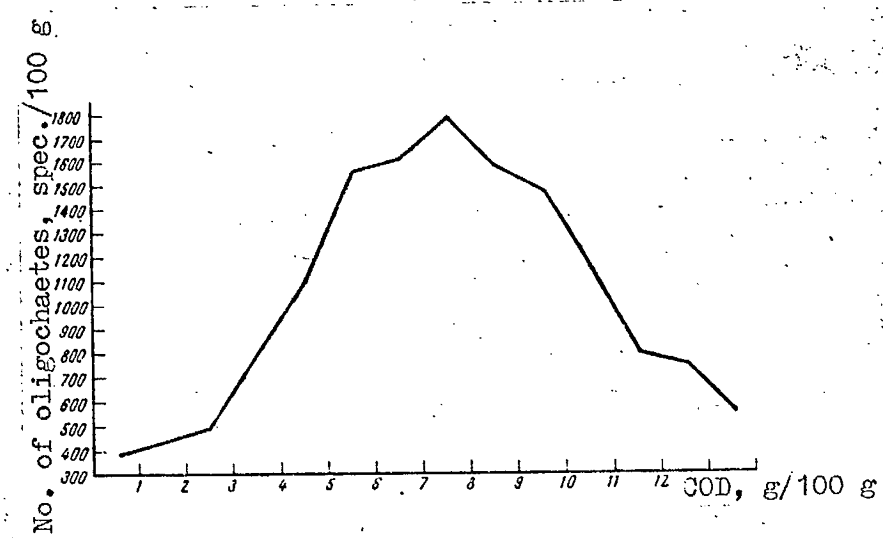


Рис.1. Изменение числа олигохет в зависимости от величины ХПК грунтов

Fig.1. Changes in the quantity of oligochaetes as a function of the COD of the bottom material.

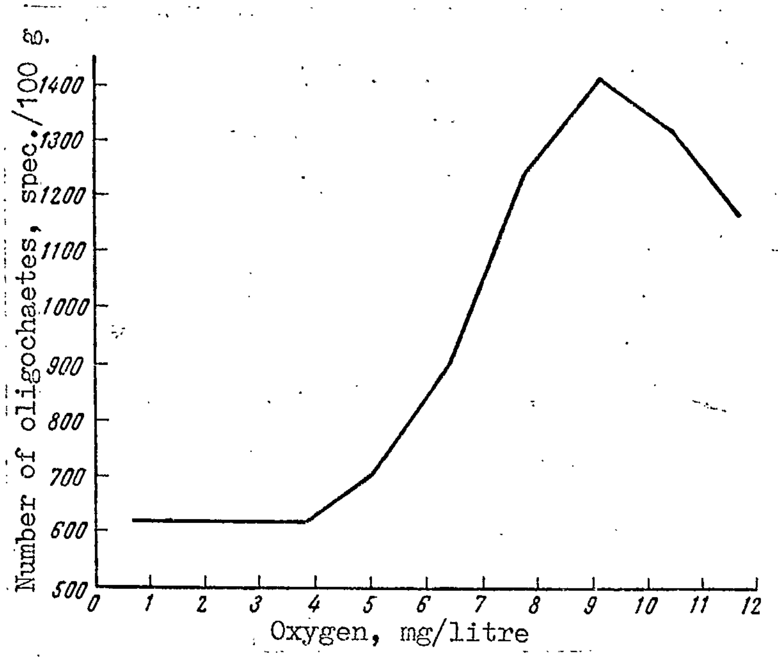
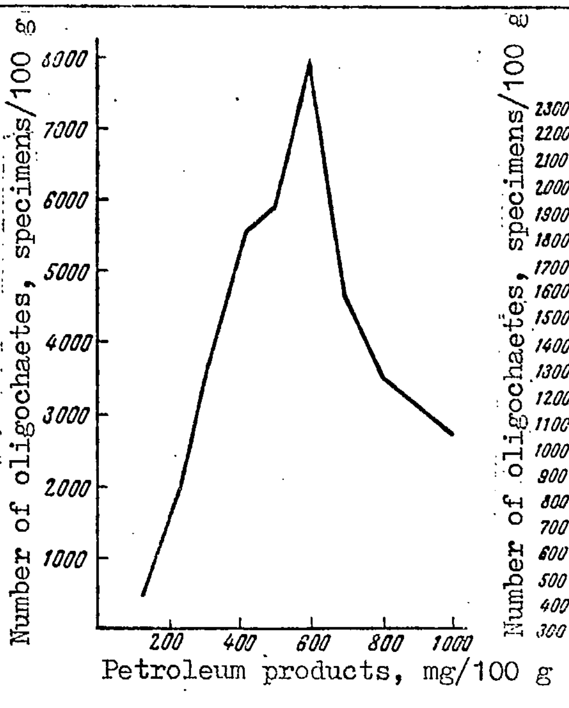


Рис.2. Изменение числа олигохет в зависимости от концентрации кислорода в воде

Fig.2. Changes in the quantity of oligochaetes as a function of the oxygen concentration in the water.



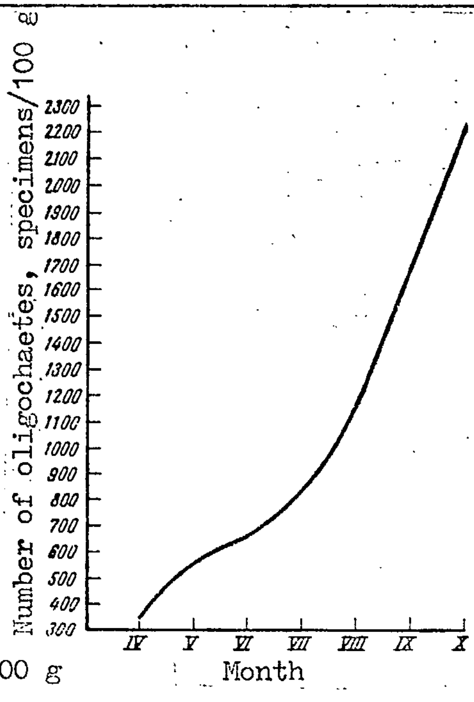


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Рис.3. Изменение числа олигохет в зависимости от содержания в грунтах нефтепродуктов

Fig.3. Changes in the quantity of oligochaetes as a function of the content of petroleum products in the bottom material.

Рис.4. Изменение количества олигохет по месяцам

Fig.4. Monthly variations in the quantity of oligochaetes.

We conducted 110 different experiments and selected and analyzed 850 samples of water and bottom material in the course of experimental determination of the effect of tubificids on the oxygen demand of bottom deposits. The experiments were carried out with two oligochaete species: Limnodrilus udekemianus and Tubifex tubifex.

The experiments showed that the daily oxygen demand of silts containing oligochaetes exceeded the oxygen demand of silts without oligochaetes by 3 - 4 times. The difference between these values (represented in the equation by "l") ranged between 4.9 and 12.3 mg when photosynthesis took place in the aquaria and between 16.6 and 26.2 mg when there was no photosynthesis.

It can be assumed that the quantity l is the sum of two components:

$$l = m + n,$$

where m is the daily oxygen demand of the tubificids for respiration, n is a variable characterizing the intensification of the biochemical oxidation of the silts as a result of the vital activity of the tubificids.

It is evident that a part of the organic matter becomes assimilated in the body of the animals and is not involved in the oxygen demand. But further experiments showed that this proportion was so small (1 - 3%) that it could be ignored.

Experimental determination of the oxygen demand for the respiration of oligochaetes revealed that the daily oxygen demand for respiration was a linear function of the oligochaete abundance (Fig.5), i.e. $m = ax$ where a is a linear coefficient dependent on temperature and x is the number of oligochaetes. 122

The value of m in different experiments varied between 51.7 and 58.8% of the value of l, while the value of n varied correspondingly between 41.1 and 48.3%, i.e. on average 55% of the value of l was accounted for by the expenditure of oxygen on the respiration of the oligochaetes, while 45% was accounted for by the more intensive oxygen demand of the ooze resulting from the vital activity of the worms. If we accept that in a rough approximation m = n, then the expression l = m + n will take the form l = 2ax. In this form the quantity l may, in principle, supplement certain formulas describing the aerobic oxidation processes in bottom deposits.

When changes in the content of organic matter in the silts processed by tubificids were determined it was found that an insignificant part of the organic matter (approx. 3%) was assimilated in the body of the worms and this is of no importance to the oxygen balance. However, the processing of organic matter in the intestine of the tubificids to readily oxidizable forms results in an increase of the COD in the excrement of the worms (by 44.6% a day on average) relative to that of the initial ooze.

Oligochaetes help to transfer oxygen-consuming organic matter from the bottom material into the water: in stagnant conditions the secretion of oxygen-consuming matter from silt into the water in aquaria containing oligochaetes is 50% higher per day than that in the control aquaria. At the same time the oxygen concentration in the experimental, as compared with the control aquaria, is reduced by 40%. When the aeration of the water was increased, the rate of release of decay products was twice as high in the aquaria containing oligochaetes as in the control aquaria. The accompanying decline in oxygen content was slight (not exceeding 10%). The experiments thus showed that when oligochaetes are present in bottom material at an abundance of 37 thousand specimens/m^2 (this corresponds to their average abundance in polluted areas of bodies of water) the oxygen demand of the benthic deposits is increased 3 to 4 times. This is due to the speeding up of biochemical oxidation processes in the silts, to the effect of tubificids on the quantity of benthic decay products discharged into the water and to the oxygen demand for the respiration of the oligochaetes.

Calculations of the oxygen balance of bodies of water polluted by undissolved substances must, therefore, take into account the presence of benthic organisms and the additional oxygen occasioned by their presence. The daily increase in oxygen demand due to the activity of oligochaetes at any given moment must not, however, be considered as only a negative factor of their effect on the oxygen regime.

It is evident that when the quantity of organic matter is constant (as it was in our experiments), an increase in the daily oxygen demand indicates an increase in the rate of oxidation and a decrease in the time needed for complete oxygen stabilization of the silt. This, indeed, was the case in our experiments:

1) the quantity n, representing variations in the daily BOD (biochemical oxygen demand) of silts due to the influence of 123
tubificids, increased by 1.5 - 2 times in 24 hr; 2) the amount of oxygen-consuming matter (COD) in the excrement of the worms increased by 44.6%, i.e. 1.5 times, in 24 hr as compared with the initial ooze; 3) the quantity of decay products released under normal water aeration conditions in the presence of oligochaetes was 112%, i.e. twice as great as that in the control aquaria.

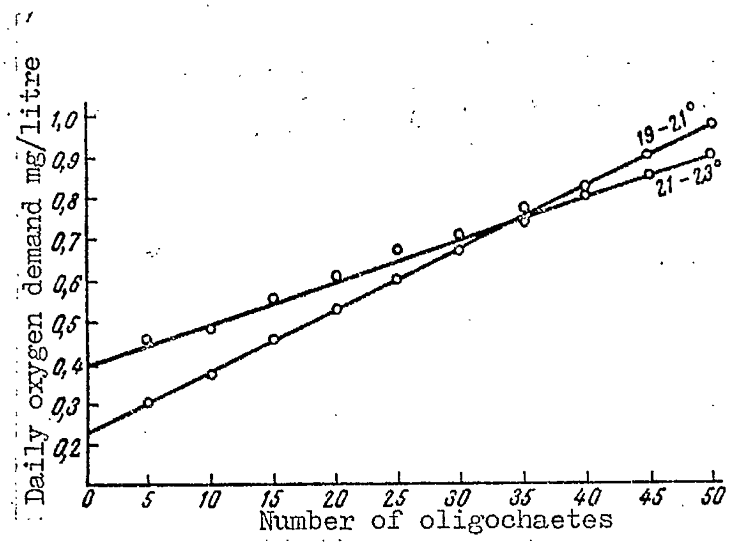

Рис.5. Суточное потребление олигохетами кислорода на дыхание

Fig.5. Daily oxygen demand of oligochaetes for respiration.

Since the condition of a constant initial quantity of organic matter is observed these data confirm that under experimental conditions the rate of biochemical oxidation of silts increases 1.5 - 2 times under the influence of tubificids.

The investigations carried out have shown that the effect of the vital activity of tubificids on the oxygen regime must depend on the hydrologic features of bodies of water (degree of through flow and water discharge). Experiments carried out in stagnant water and other experiments with a current and additional aeration have shown that in the first case oligochaetes encourage the more rapid development of an acute oxygen deficit (up to 80%), after which their activity slows down sharply. Under these conditions the presence of tubificids can hardly be considered a positive phenomenon since, by decreasing the oxygen content, they cause a deterioration in the mineralization conditions for organic matter. In the second case oligochaetes considerably accelerate the biochemical decomposition of silts. The accompanying decrease in oxygen concentration is, as a result of good reaeration, insignificant (not exceeding 10%). In this case the vital activity of tubificids is undoubtedly beneficial since it encourages the more intensive self-cleansing of bottom materials. The same sort of picture was observed in bodies of water in which water discharges were slight and heavy.

In small bodies of water the oxygen consumed cannot be replaced at the same rate and the conditions for self-cleansing deteriorate sharply. In order, therefore, to exclude the possibility of overloading such bodies of water when calculating the amount of
sewage effluent it is evidently necessary to allow for additional 124
oxygen consumption if hydrobionts are present. In bodies of water with heavy water discharge and sufficient reaeration, benthic hydrobionts aid the intensification of self-cleansing and permit some additional loading of the outfalls. This factor should also be taken into account for profitable exploitation.

Conclusion

The information obtained enables us to indicate the main lines of the research needed in order to work out ways of recording the vital activity of tubificids in the oxygen regime of bodies of water.

1. The influence of tubificids on the oxygen regime of bodies of water is undoubtedly determined by their abundance. In order to forecast the abundance of tubificids in bottom deposits, further investigation of abundance as a function of the ecological features of bodies of water and their seasonal variations is therefore necessary.

2. Since most methods for calculation of the oxygen balance of bodies of water incorporate the rate of the biochemical oxidation of organic matter as a constant, it is necessary to investigate the influence of tubificids on the rate of oxygen stabilization processes in silts and to obtain numerical values of the constants in this process (by direct methods) as a function of the abundance of tubificids and of temperature.

3. There is a need for further investigation of the rate of respiration as a function of temperature.

The data yielded by the above research may (if we have reliable methods of calculating the oxygen demand of silt deposits) enable us to make allowance in calculations of the oxygen balance of bodies of water for the vital activity of tubificids, the most widely distributed and abundant group of benthic organisms in organically polluted waters.

THE ROLE OF TUBIFICIDS IN THE OXYGEN BALANCE OF BODIES OF WATER

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Summary.

It is experimentally demonstrated that the daily oxygen uptake of silts rises 3 - 4 times in the presence of Tubificidae (Oligochaeta) at a population density of 37 000 specimens/m^2. The increase in the consumption of oxygen is due to the respiration of the worms and to intensified biochemical oxidation of the silts

resulting from their vital activity. The rate of oxidation of organic matter in the silts increased 1.5 - 2 times under experimental conditions when tubificids were present. The effect produced on the oxygen regime of a body of water by tubificids must be related to its hydrological conditions.

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OLIGOCHAETA IN THE WESTERN REGIONS OF THE UKRAINE AND THEIR ROLE IN THE DEVELOPMENT OF CERTAIN CESTODES IN FISHES

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Oligochaeta are a common, sometimes even dominant, component of the aquatic fauna in the western regions of the Ukraine. Their value as food for many benthophagic species of fishes therefore cannot be doubted. But while providing nourishment for food fishes, the Oligochaeta also play a negative role, serving as intermediate hosts for many species of the Caryophyllaeidae (Cestoda), the sexually mature stage of which parasitizes the intestines of cyprinids and, less frequently, of cobitids. 125

Tapeworms (Caryophyllaceae) are very common in fishes from natural bodies of water and pond fish farms. According to published information, these parasites are particularly pathogenic to young fishes in pond farms. Between 10 and 30 tapeworms in the intestine of a yearling can cause death and this has been observed frequently in the fish farms of the western regions of the Ukraine (Ivasik, 1952; Bauer, 1959; Kulakovskaya, 1962a, 1962b).

Information concerning the oligochaete fauna of this territory can be found in the works of the Polish scientists Kowalewski (1911, 1913) and Golanski (1911), but the investigations of these authors were confined to only a few bodies of water.

Our tasks were, therefore, as follows: to determine the species composition of the Oligochaeta over a wider area, to investigate their distribution in different types of bodies of water and to clarify their role in the development cycles of 126
tapeworms in such waters, to establish the dynamics of the infestation of oligochaetes by the procercoid stage of the tapeworms (Caryophyllaeidae) in different categories of fish farm ponds, and to establish the infestation of Oligochaeta by other parasite species.

Collections were therefore made in natural and man-made bodies of water in the Western Bug, Dniester and Danube basins between the years 1961 and 1967. The basins of these rivers contain bodies of water which differ in water temperature, current velocity, the amount of silting of the bottom, the amount of water plants and the invertebrate and vertebrate fauna. All these characteristics determine the qualitative and quantitative composition of the oligochaetes in the bodies of water and the nature of their infestation by caryophyllid procercoids, as well as their significance as intermediate hosts of these cestodes in different types of bodies of water.

Having regard to their similar and dissimilar features, the investigated bodies of water can be divided into the following groups: 1) mountain rivers and watercourses with low water temperature, fast current, stony and sandy bottoms with practically no vegetation and a poor species composition of invertebrates and vertebrates; 2) mountain lakes, small stagnant bodies of water on the flood plains of mountain rivers with silted sand as their bottom material, rich in invertebrate fauna but containing no fishes (or with a very poor fish fauna); 3) lowland rivers with a slow current, silted bottom, aquatic vegetation and a wide variety of species of invertebrates and fishes; 4) oxbows and backwaters characterized by lack of a current, strong silting up of the bottom, abundant vegetation, and an invertebrate and vertebrate fauna rich as regards both species composition and abundance; 5) the system of bodies of water in pond fish farms.

Bodies of water in the first group are characterized by an oligochaete fauna poor in species and abundance and which varies throughout the year. No oligochaetes are found in such bodies of water in the spring and autumn months, the high-water period. When the water level falls and the current decreases in the summer, an oligochaete fauna poor in abundance and species composition consisting primarily of tubificids, develops in the stretches with a gentle current which are then formed. Species of the family Naididae settle in the foulings on stones (algae and mosses) and in sand covered by algae.

The conditions obtaining in mountain rivers and the fewness of the species of fishes which are final hosts of tapeworms are responsible for the lack of infestation of Oligochaeta by the procercoids of these cestodes, which also minimizes the importance of oligochaetes as intermediate hosts of the Caryophyllidae under these conditions.

The second group of mountain bodies of water is, unlike the previous group, distinguished by a rich assortment of oligochaete species and by their abundance. _Peloscolex velutinus_ and _Stylodrilus heringianus_ are characteristic species, as are some naidids, which develop on aquatic vegetation.

The Oligochaeta of such bodies of water are occasionally infested by tapeworm species, but only by those which can reach sexual maturity in the worms' body cavity, i.e. progenetic tapeworms. Procercoids requiring the presence of their final hosts - fishes - were found only in bodies of water connected with fish ponds and located in large mountain valleys.

Oligochaetes are frequently a dominant component of the benthos in lowland rivers; species of the family Tubificidae attain particular abundance where a sandy bottom is covered by a layer of silt. Species of the family Naididae settle among the water plants and on their decaying remains.

Oligochaeta are of great importance as intermediate hosts for tapeworms in such bodies of water. The infestation of oligochaetes by the procercoids reaches 0.3 - 1.5%, and in some cases even 2.5 - 3.0%. Progenetic tapeworms are rarer.

Oxbows and river backwaters are most abundantly populated by species of the family Naididae. However, a very thick layer of silt often accumulates in them and members of the family Tubificidae are appreciably less numerous than in rivers with sandy bottoms covered by a thin layer of silt.

The various categories of fish farm ponds are distinctively populated by oligochaetes. Small hibernation ponds, which do not contain fish in the summer and whose beds are, in effect, moist throughout the summer, are inhabited by species of the family Tubificidae, while Naididae are rare.

Finishing and rearing ponds are large bodies of water, often containing an abundance of vegetation, and silt always accumulates in the fish collecting ditches and pools next to the outlet boxes. This creates favourable conditions for the development of the tubificids (Lumbriculus variegatus and Rhynchelmis tetratheca in the silt and among the roots, and naidid species among the aquatic vegetation.

When agricultural and improvement works are incorrectly carried out (incorrect drying out of the bed in hibernation ponds, the lengthy failure to take ponds out of use, their employment as hibernation ponds etc) the existence of large numbers of fishes in them, by comparison with the numbers in natural bodies of water results in the creation of conditions which greatly encourage the infestation of oligochaetes by tapeworm procercoids. Thus, in some hibernation ponds and in ponds used for hibernation at the "Rudniki", "Lisnevichi", "Komarno" and "Lyubin'-Velikii" fish farms in L'vov province the infestation of oligochaetes by cestodes in the years 1962 and 1963 was 20 - 35% and sometimes even 70%. The rate of infestation was between 1 and 18 larvae.

Near the fish feeding locations and around the outlet boxes in finishing and rearing ponds, 8 - 15% of Oligochaeta were infected by cestodes, while between the roots of plants they were either free of procercoids or 0.3 - 2% were infested.

In pond fish farms, therefore, the significance of oligochaetes as intermediate hosts of fish cestodes may far outweigh their value as food. Only the correct implementation of agricultural and improvement measures can lower the level of infestation of Oligochaeta by tapeworm larvae.

When the material collected from bodies of water in the 128
basins of the above-named rivers was identified it was found to contain the following aquatic oligochaetes:

Fam. Aeolosomatidae

Aeolosoma hemprichi Ehrenberg, 1828
A. variegatum Vejdovsky, 1884

Fam. Naididae

Subfamily Chaetogastrinae

Chaetogaster diaphanus (Cruithuisen, 1828)
Ch. crystallinus Vejdovsky, 1883
Ch. langi Bretscher, 1896
Ch. limnaei Baer, 1827

Subfamily Naidinae

Ophidonais serpentina (O. F. Müller, 1773)
Nais pseudobtusa Piguet, 1906
N. barbata Müller, 1773
N. communis Piguet, 1906
N. elinguis Müller, 1773
N. variabilis Piguet, 1906
N. pardalis Piguet, 1906
Slavina appendiculata (d'Udekem, 1855)
Stylaria lacustris (Linnaeus, 1767)
Dero obtusa d'Udekem, 1855
Aulophorus furcatus (Müller, 1773)

Subfamily Pristininae

Pristina foreli Piguet, 1906
P. longiseta Ehrenberg, 1828
P. bilobata (Bretscher, 1903)

Fam. Tubificidae

Subfamily Rhyacodrilinae

Rhyacodrilus sp.

Subfamily Tubificidae

Aulodrilus limnobius Bretscher, 1899
A. pluriseta (Piguet, 1906)
A. pigueti Kowalewski, 1914
Limnodrilus udekemianus Claparède, 1862
L. helveticus Piguet, 1913
L. hoffmeisteri Claparède, 1862
L. claparedeanus Ratzel, 1868
Euilyodrilus hammoniensis (Michaelsen, 1901)
E. moldaviensis (Vejdovsky et Mrázek, 1902)
Psammoryctides albicola (Michaelsen, 1901)
P. barbatus (Grube, 1861)
P. moravicus (Hrabě, 1934)
Tubifex ignotus (Štolc, 1886)
T. tubifex (O.F. Müller, 1773)
Ilyodrilus templetoni (Southern, 1909)
Peloscolex ferox (Eisen, 1879)
P. velutinus (Grube, 1879)

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Branchiura sowerbyi Beddard, 1892

Fam. Enchytraeidae

Enchytraeidae gen. sp. N 1
Enchytraeidae gen. sp. N 2

Fam. Haplotaxidae

Haplotaxis gordioides (Hartmann, 1821)

Fam. Lumbriculidae

Lumbriculus variegatus (O.F. Müller, 1773)
Stylodrilus heringianus Claparède, 1862
Rhynchelmis tetratheca Michaelsen, 1920

Fam. Lumbricidae

Eiseniella tetraedra (Savigny, 1826)

Nine species of the family Tubificidae from among all those listed above have been recorded by us as intermediate hosts of the Caryophyllaeidae: Limnodrilus udekemianus, L.helveticus, L.hoffmeisteri, L.claparedeanus, Euilyodrilus hammoniensis, E.moldaviensis, Psammoryctides albicola, P.barbatus, Tubifex tubifex.

There is published information on the possible development of procercoids of the Caryophyllaeidae in members of the fam. Naididae. D'Udekem (1885) found a tapeworm larva in the body cavity of N.proboscidea, and this was later identified by Nybelin as Caryophyllaeus. The same thing is also mentioned by Nybelin (1922), Wardle (Wardle and McLeod, 1952) and Yamaguti (1959). We have not found tapeworm larvae in members of families other than the Tubificidae. Our experiments on the infestation of species of the genus Chaetogaster, Stylaria lacustris, N.Barbata and N. pseudobtusa have so far not been successful.

The failure to find larvae of the Caryophyllaeidae in the body cavity of other species of the fam.Tubificidae does not argue that they cannot be intermediate hosts for these cestodes. The absence of procercoids from some tubificids can be explained in several ways. Peloscolex ferox, Tubifex ignotus, Rhyacodrilus sp. and similar species have been comparatively little investigated and it is not appropriate to assess their role in the development of tapeworms. The absence of procercoids from Audrilus species, on the other hand, can be explained by their small body size, which offers little scope for development of the comparatively large cestode procercoids. Peloscolex velutinus is found in bodies of water which do not contain the final hosts of cestodes - fishes - and in which only those tapeworms capable of reaching sexual maturity in the oligochaete body cavity are very occasionally to be found. Therefore, there is very little chance of tapeworm eggs finding their way into *P.velutinus*.

The tapeworm procercoids discovered by us in oligochaetes were mostly concentrated in the anterior part of the body and they reached the invasive, or sexually mature stage in the reproductive segments. In the case of multiple invasion very young procercoids were found in all the body segments, sometimes even in the caudal section. A large procercoid invasion rapidly results in the death of the worm due to the pressure of the growing cestodes on the body wall of the host and its consequent rupture.

The following tapeworm species were found in the body 130
cavities of the nine tubificid species listed above.

Subfamily Caryophyllaeinae (Nybelin, 1922)

1. *Caryophyllaeus laticeps* (Pallas, 1781). Tubificid species infested by the procercoids of this cestode were found in natural bodies of water in the basins of the Western Bug, the Dniester and the Danube. There are frequent instances of the infestation of tubeworms (Tubificidae) by *C.laticeps* procercoids in the water-supply ditches of fish farms.

The percentage of infested oligochaetes in these bodies of water is low: 0.3 - 1.5%. The invasion rate varies between 1 and 4 procercoids.

2. *Caryophyllaeus fimbriceps* Annenkowa, 1919. Tubificids containing the procercoids of *C.fimbriceps* in the body cavity have often been found in ponds of different categories belonging to fish farms in the L'vov, Ternopol' and Transcarpathian provinces.

The percentage of infestation, which is not the same in ponds of different categories, sometimes reaches 15 - 20%. The invasion rate is between 1 and 7 larvae in the body cavity per worm.

3. Caryophyllaeus brachycollis Janiszewska, 1951. A rare species. Found by us in L.hoffmeisteri and T.tubifex from the Dniester and a small tributary of the Western Bug.

4. Archigetes sieboldi Leucart, 1869. Tubificids infested by sexually mature and immature specimens of these tapeworms were found in the Dniester and its tributaries and in bodies of water in the basin of the Western Bug. 0.5 - 1.5% of the tubificids were infested; an infested worm contained 1 - 3 larvae.

5. Glaridacris brachyurus (Mrázek, 1908). The species is very rarely to be found in running water but the infestation of Tubificidae sometimes reaches 70% and the rate of invasion 1 - 3 cestodes in the bodies of water left on river flood plains by the spring floods. Just such a high level of infestation was observed in the autumn of 1967 on the flood plain of the Rata River - a tributary of the Western Bug. Tubificidae with G.brachyurus in the body cavity have been found both in natural bodies of water of the Western Bug, Dniester and Danube basins and in the ponds of fish farms.

6. Glaridacris limnodrili Yamaguti, 1935. This species is found very occasionally in the USSR as a parasite of the gudgeon (Kulakovskaya, 1926b). It is also capable of maturing in tubificids.

G.limnodrili was found by Yamaguti in 1964 parasitizing Limnodrilus sp. from the Japanese Kamo River.

In 1963 the author found a form with a strong resemblance to G.limnodrilus in a hibernation pond belonging to the "Rudniki" fish farm. Further material is needed before this identification can be confirmed.

7. Biacetalbum appendiculatum (Mrázek nec Ratzel, 1897; Janiszewska, 1950). The species has been found in different types of bodies of water (rivers, stagnant bodies of water, ponds). The greatest intensity and extent of oligochaete infestation by this cestode are, however, observed in quiet or stagnant bodies of water with a silted bottom and aquatic vegetation.

Subfamily Lytocestinae Hunter, 1927 131

8. Khavia sinensis Hsü, 1935. The species has been found in the USSR by Kulakovskaya and Krotas (1961) in fish from pond farms in the western regions of the Ukraine and Lithuania, where it is met in the intestines of Eastern carp and pond carp hybrids. It was brought into the Soviet Union with Eastern carp from Far Eastern bodies of water.

K.sinensis procercoids were discovered in tubificids from the "Lisnevichi", "Rudniki", "Lyubin'-velikii" and "Komarno" fish farms in L'vov Province.

The percentage of tubificids infested by procercoids of these tapeworms between 1961 and 1963 was 50 - 70%, and the maximum invasion rate was 20 procercoids. Instances of multiple invasions were recorded. We have never observed such extensive and intensive infestation of tubificids in fish farm ponds by the procercoids of other tapeworm species.

Our investigations show that the degree of infestation by the different tapeworm species is not the same in all tubificid species.

For example, there are only a few observed instances of the infestation of L.udekemianus by the tapeworms B.appendiculatum and K.sinensis. B.appendiculatum has been found in the body cavity of L.helveticus from a small body of water in the Danube river basin. The following species have been found in L.hoffmeisteri: A.sieboldi, G.brachyurus, B.appendiculatum, G.limnodrili and occasionally C.laticeps, C.fimbriceps, C.brachycollis and K.sinensis. A.sieboldi, B.appendiculatum and K.sinensis develop in the body cavity of L.claparedeanus. E.hammoniensis acts as the intermediate host for C.laticeps, C.fimbriceps and K.sinensis. In the Dniester basin E.moldaviensis has been recorded as an intermediate host of C.laticeps. C.fimbriceps and K.sinensis procercoids develop in the body of P.albicola in fish farm ponds. A case of infestation by a C.laticeps procercoid has been observed in P.barbatus from natural bodies of water associated with the Western Bug. In fish farm ponds this species is an intermediate host for C.fimbriceps and K.sinensis. The greatest number of tapeworm species has been recorded in T.tubifex. Thus, C.laticeps and C.brachycollis develop in it in natural bodies of water and C.fimbriceps and K.sinensis in fish ponds. Cases of infestation of T.tubifex by the progenetic B.appendiculatum and A.sieboldi are infrequent.

It is evident from what has been said that tapeworm species capable of reaching sexual maturity in the body of oligochaetes more often develop in species of the genus Limnodrilus. Less frequently these tubificids are intermediate hosts for C.fimbriceps and K.sinensis - parasites of cyprinids in pond fish farms. T.tubifex and species belonging to the genera Euilyodrilus and Psammoryctides are the principal intermediate hosts for C.laticeps, C.brachyurus, C.fimbriceps and K.sinensis. Progenetic species, however, develop in them only very rarely.

Thus the level of infestation of oligochaetes by tapeworm procercoids depends not only on the conditions in a given body of water but also on the species composition of the tubificids present in it.

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OLIGOCHAETA IN THE WESTERN REGIONS OF THE UKRAINE AND THEIR ROLE IN THE DEVELOPMENT OF CERTAIN CESTODES IN FISHES

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Summary.

The present article is based on collections of aquatic Oligochaeta from bodies of water in the basins of the Western Bug, the Dniester and the Danube.

We found 46 oligochaete species distributed by families as follows: Aeolosomatidae - 2, Naididae - 18, Tubificidae - 19, Enchytraeidae - 2, Haplotaxidae - 1, Lumbriculidae - 3 and Lumbricidae - 1. Nine species of the family Tubificidae among the 46 oligochaete species were recorded as intermediate hosts of 8 tapeworm species (Cestoda, Caryophyllaeidae) which are parasites of Cyprinidae and Cobitidae.

Species of the genera Euilyodrilus, Psammoryctides and Tubifex are the principal intermediate hosts of those tapeworms which reach sexual maturity in the intestines of fishes (Caryophyllaeus laticeps, C.fimbriceps, C.brachycollis, Khavia sinensis). The tapeworms which develop in the body cavity of species of the genus Limnodrilus are mainly those species which also reach sexual maturity in oligochaetes (Archigetes sieboldi, Glaridacris brachyurus, C.limnodrili and Biacetabulum appendiculatum).

The nature of oligochaete infestation by tapeworms in different types of bodies of water depends on the conditions

prevailing in them. The species composition of procercoids of Caryophyllaeidae depends on the species composition of the tubificids in such bodies of water.

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IV. OLIGOCHAETA IN RESERVOIRS UDC 595.771

THE FORMATION OF AN OLIGOCHAETE FAUNA AND OLIGOCHAETE DISTRIBUTION IN THE VOLGOGRAD RESERVOIR

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The filling of the southernmost reservoir in the Volga chain, the Volgograd reservoir, began in late October, 1958. By 1959 it had been filled to the planned level.

The reservoir's hydrologic and physiographic features divide it into three zones: an upper zone, between Balakov and Saratov; a central zone, from Saratov to Kamyshin and a lower zone, from Kamyshin to the Volgograd Hydroelectric Station dam.

In the upper zone, where the bottom, according to Belyavskaya (1965), is approximately 45% silt, through flow is observed, especially during spring floods. The central and lower zones are characterized by 70 to 80% silting of the bottom area; through flow is negligible in the central zone and practically absent in the lower zone. The silt here forms a thick layer on the sand and is not washed off even during the spring floods.

According to Sidenko (1965), the Volgograd reservoir is characterized by the near stability of its level throughout the year. Therefore, there are no annually inundated areas in the central and lower zones except that small overflows onto the flood plain are to be observed in an arm of the Eruslan River. The flood plain is extensively inundated only in the upper area (near the town of Balakovo).

Many authors (Sidenko, 1965; Yakovleva, 1965 et al.) consider that to maintain a constant level in the reservoir has an adverse effect on the development of meadow vegetation in the bank zone, as a result of which the reservoir has fewer sources of supply of the organic matter essential to the development of planktonic and benthic organisms, including oligochaetes.

There is no published information on the formation of the oligochaete fauna and on oligochaete distribution in the Volgograd reservoir, with the exception of a small amount of information given by Lyakhov (1961b), Ekaterininskaya (1962) and Belyavskaya (1960, 1962, 1965) in their descriptions of the benthic fauna of this reservoir.

The author has processed oligochaete collections from the Kuibyshev biological station of the USSR Academy of Sciences made between 1959 and 1964. The material was collected along profiles throughout the reservoir.

Michaelsen (1923) and Bening (1924) quote 24 oligochaete species for the biocoenoses of the Lower Volga and the system of water bodies connected with it. The most characteristic of these are Nais behningi, 135
Stylaria lacustris, Isochaetides newaensis and Propappus volki, all of which, with the exception of Stylaria lacustris, are typically potamophilous species.

On the basis of 200 samples processed by O. V. Chekanovskaya, Dremkova (1954) lists 9 oligochaete species discovered in the area where the Volgograd Hydroelectric Station was constructed. Propappus volki and I. newaensis were the most frequently encountered.

Lyakhov (1961a) also notes the predominance of the psammorheophilous species Propappus volki and I. newaensis and of the naidids Nais behningi and Stylaria lacustris.

In the material we processed (approximately 400 samples) 29 species of Oligochaeta were discovered, not counting the juvenile forms of Limnodrilus species and other tubificids.

In the years immediately after the filling of the reservoir (1959 - 1960) the oligochaete fauna was primarily characterized by naidids, since Naididae were the dominant forms in both the flooded area and the river bed area. Stylaria lacustris (42.8%) and Uncinais uncinata (28.5%) were the most frequently encountered in the flooded area. The only tubificid encountered in the flooded area with any frequency was Tubifex tubifex (28.5%)

Isolated specimens of the indigenous fluvial species N. behningi, I. newaensis, Isochaetides michaelseni and Propappus volki were found on the inundated flood plain after filling. An abundance of juvenile tubificids had, however, already appeared here.

Terrestrial Enchytraeidae and Lumbricidae were rare on the inundated flood plain, contrary to the case of the Kuibyshev (Izosimov, 1960; Ekaterininskaya, 1960, 1964), Cherepovets (Poddubnaya, 1966) and some other reservoirs. Evidently the land flooded here had been steppe or even semi-desert terrain with little water (Lyakhov, 1961a).

In terms of frequency of occurrence and of abundance, the dominant forms on the old river bed were Propappus volki (48.1%), Stylaria lacustris (33.3%), and I. newaensis (28.2%), i.e. species characteristic of Lower Volga biocoenoses even before inundation.

The following members of a typical river fauna were discovered: Homochaeta naidina, Piguetiella blanci, Specaria josinae, Ripistes parasita, Nais pseudobtusa, Nais behningi and Psammoryctides barbatus. The first four species have not been recorded previously in the biocoenoses of the Lower Volga.

These psammo-, litho- and pelorheophilous forms were still able to find fully favourable conditions in the reservoir, thanks to its light silting, its high water-exchange coefficient and, consequently, its greater through flow.

The presence of the following pelophilous species, which are the first of a progressive silting-up and of a decline in the flow rate, should be noted: *Euilyodrilus hammoniensis*, *E. moldaviensis*, *Limnodrilus claparedeanus*, *L. hoffmeisteri*, *Dero* sp. etc. These, however, still occurred rarely and in small numbers.

In the years which followed the picture changed drastically. The variety of oligochaete species decreased year by year. Whereas in the years 1959 - 1960 approximately 30 oligochaete species could be found in 136
the reservoir, there were only 16 by 1961 - 1962 and the number had fallen to 10 by 1963 - 1964, and only five of these were at all significant in frequency of occurrence and abundance. These were mostly pelophilous and in part pelorheophilous tubificids: *I. newaensis*, *L. hoffmeisteri*, *E. moldaviensis*, *E. hammoniensis* and *Tubifex tubifex*. The leading species in this tubificid association were *I. newaensis* (72.7%), *E. moldaviensis* (54.2%) and *L. hoffmeisteri* (52.2%). *E. hammoniensis* and *Tubifex tubifex* (18.2%) were much rarer.

All these dominant oligochaete forms are most abundant on silt-sand bottoms, and these are precisely the materials found on the greatest areas of the bottom, especially in the central zone.

Poddubnaya (1965) considers that oligochaetes show a preference for such bottom material because of the abundance of readily available organic matter and also, evidently, because they are better able to penetrate into such bottom materials than into compact oozes, which are which are accessible only to worms with a very powerful musculature, such as I. newaensis.

With the exception of I. newaensis, indigenous Volga fluvial species disappear from this reservoir very quickly. For example, the frequency of occurrence of Propappus volki fell from 48.1% in 1959 to 20.2%, while its abundance fell from 19 500 specimens/m^2 to 500, and the species could only be found in the upper and central zones. By 1961 its frequency incidence was only 1.02% and its abundance 100-130 specimens/m^2, and it could be found only in the upper zone. Since 1962 Propappus volki has been completely absent from the oligochaete fauna of the Volgograd reservoir. The same applies to Nais behningi.

This rapid elimination of potamophilous species from the oligochaete fauna is connected with the fact that the Volgograd reservoir was filled with water over a very short period (one year) and a constant level regime was established immediately. Thus there was an immediate change in conditions for potamophilous forms.

Because the Rybinsk reservoir took seven years to fill, the rise in the water level was negligible and the river bed sections retained a high through flow. As a result the potamophilous forms were preserved here longer (Poddubnaya, 1965).

Naidids are also disappearing from the reservoir, since most of them are phytophilous and the Volgograd reservoir does not provide suitable conditions for the development of macrophytes because of the strong wave action on the banks and their destruction; in addition the inundated vegetation has gradually decomposed.

An evaluation of the distribution of the above-mentioned species in the reservoir shows that Isochaetides newaensis, E. moldaviensis and L. hoffmeisteri are spreading widely throughout the reservoir, while E. hammoniensis and Tubifex tubifex find conditions most favourable in the central and especially in the lower zone.

It should also be noted that, by comparison with, for example, the 137
Kuibyshev reservoir, T. tubifex and E. hammoniensis are less common and abundant in the Volgograd reservoir. In this respect it is similar to the Rybinsk reservoir where, according to Poddubnaya's data (1965), E. hammoniensis is also the least abundant species of the tubificid association.

From a comparison of the oligochaete fauna in the three zones of the reservoir it can be seen that in all years the greatest variety of oligochaete species was observed in the central zone, which is more silted and has weaker through flow, rather than in the relatively less silted upper zone, which has more through flow and where, on the contrary, the annual decrease in the variety of oligochaete species was most noticeable (see the Table).

These factors are not, of course, conducive to the development of planktonic and benthic organisms, including Oligochaeta.

It is true that some oligochaete species which are meso- and poly-saprobionts, such as L. hoffmeisteri and T. tubifex, stand up to pollution well and are frequently even found in large numbers near main sewage pipes, but they (especially T. tubifex) are evidently less resistant to oil pollution. This, perhaps, explains why this species is less widely distributed, occurs less frequently and is less abundant in the Volgograd reservoir than in some others.

The oil pollution is less pronounced in the central zone.

Though the variety of oligochaete species in the reservoir is not great at present, their abundance and biomass rise every year. Thus, between 1960 and 1964 the biomass of oligochaetes increased from 0.15 to 1.34 g/m^2 in the central zone and from 0.23 to 2 g/m^2 in the lower, while the abundance of I. newaensis increased from 9 to 126 specimens per m^2 (Belyavskaya, 1965). Over the same years the frequency of occurrence of I. newaensis increased from 26.2 to 72.7%.

The biomass of oligochaetes in the Volgograd reservoir is, nevertheless, far lower than in the Kuibyshev reservoir where, according to the data of Aristovskaya and Egereva (at press), it was 4.64 g/m^2 in 1964 and 5.44 g/m^2 in 1965, and also than in the Rybinsk reservoir where it reaches 6-7 g/m^2 in many areas and as much as 18 g/m^2 on the old river bed (Poddubnaya, 1965).

In spite of all this the Oligochaeta still occupy one of the leading positions among the benthos of the Volgograd reservoir. Their significance as food for benthophagic fishes is consequently increased, especially when considered in relation to the reduction in the overall benthic biomass and, in particular, of the main food items - Chironomidae, whose biomass in the reservoir is very low.

The formation of an oligochaete fauna in the Volgograd reservoir has, therefore, progressed along approximately the same lines as that in the Kuibyshev (Izosimov, 1960; Ekaterininskaya, 1960, 1964), Rybinsk (Poddubnaya, 1965; Lastochkin 1936, 1947), Dnieper and other large reservoirs (Lastochkin, 1949).

In these reservoirs, however, E. moldaviensis took over as the dominant species in the pelophilous association formed after the destruction of the potamophilous association, while in the Volgograd reservoir this role belongs to I. newaensis.

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Key to Table on p. 138. 1. Oligochaeta in the Volgograd reservoir (by year and zone) 2. Species 3. Zone 4. Upper 5. Central 6. Lower

1 Видовой состав олигохет Волгоградского водохранилища (по годам и зонам)

2 Вид	1959–1960 гг.			1961–1962 гг.			1963–1964 гг.		
	3 Зона								
	4 верхняя	5 средняя	6 нижняя	4 верхняя	5 средняя	6 нижняя	4 верхняя	5 средняя	6 нижняя
Uncinais uncinata (Oersted)		+	+						
Vejdovskyella intermedia (Bretsch.)		+							
Ophidonais serpentina (Müll.)			+		+				
Homochaeta naidina Bretsch.		+							
Dero digitata (Müll.)	+	+	+						
Ripistes parasita (O. Schm.)	+								
Dero obtusa d'Udekem	+	+	+						
Dero sp.	+	+	+	+					
Specaria josinae (Vejd.)	+								
Chaetogaster diaphanus (Gruith.)	+	+							
Piguetiella blanci (Piguet)	+								
Nais pseudobtusa Piguet		+							
N. behningi Michaelsen		+							
Stylaria lacustris (Linneus)	+	+	+		+				
Paranais sp.	+								
Naididae gen. sp.	+	+							
Euilyodrilus hammoniensis (Mich.)			+	+	+	+		+	+
E. moldaviensis (Vejd. et Mraz.)		+	+	+	+	+	+	+	+
Tubifex tubifex (Müller)		+	+	+	+	+	+	+	+
Psammoryctides barbatus (Grube)		+						+	
Peloscolex ferox (Eisen)		+			+			+	+
Tubificidae gen. sp. juv.		+			+				
Isochaetides michaelseni (Last.)	+	+	+		+	+	+	+	+
Isochaetides newaensis (Mich.)	+	+	+	+	+	+	+	+	+
I. newaensis (Mich.) juv.	+	+	+		+			+	+
Limnodrilus hoffmeisteri Clap.	+	+	+	+	+	+	+	+	+
L. hoffmeisteri f.parva South.	+	+	+	+	+	+			
L. udekemianus Clap.		+	+		+	+		+	+
L. helveticus Piguet					+				
L. claparedeanus Ratz.		+		+	+	+			
Limnodrilus sp.	+	+	+		+	+	+	+	
Limnodrilus sp. juv.	+	+	+	+	+	+	+	+	+
Propappus volki Michaelsen	+	+							
Lumbriculus variegatus (Müller)	+	+		+					
Rhynchelmis limosella Hoffmeist.		+	+						

Some Naididae (Dero digitata, Dero sp., Uncinais uncinata) are still fairly frequently encountered in the Kuibyshev reservoir, though they have changed their habitat - descending from the inshore zone to greater depths. They have disappeared almost completely from the Volgograd reservoir.

Certain members of the pelophilous tubificid association - L. hoffmeisteri f. parva, T. tubifex, E. hammoniensis, L. undekemianus, I. michaelseni and L. helveticus, are rarer and less numerous in the Volgograd reservoir. The spectrum of oligochaete species is narrower here than, for example, in the Kuibyshev reservoir, where 16 - 17 oligochaete species can be found, or in the Rybinsk reservoir, which has 18 known species (Poddubnaya, 1965).

This is evidently explained not only by the low food value of the bottom material, but also by the lack of bodies of water on the flood plain around the reservoir, since the pelophilous oligochaetes of such bodies of water are the main source of the oligochaete fauna of newly created reservoirs.

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THE FORMATION OF AN OLIGOCHAETE FAUNA AND OLIGOCHAETE DISTRIBUTION IN THE VOLGOGRAD RESERVOIR

By N. C. Ekaterininskaya

Summary.

The formation of the oligochaete fauna of the Volgograd reservoir has been affected by the specific conditions of the reservoir - the stability of its water table, the lack of macrophytes in the littoral zone and topographic features (steppe and semi-desert). The number of species is very small. Only 5 species are widely distributed: *Isochaetides newaensis* (Mich.), *Euilyodrilus hammoniensis* (Mich.), *E. moldaviensis* (Vejd. et Mraz.), *Limnodrilus hoffmeisteri* (Clap.) and *Tubifex tubifex* (Müller).

Potamophilous forms are frequently eliminated. Naididae, especially phytophilous forms, are almost absent. The pelophilous tubificid complex is dominated by *I. newaensis* and not by *E. moldaviensis*, the dominant species of many other reservoirs during the first years after filling.

Bibliography: 21 titles.

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SEASONAL POPULATION DYNAMICS OF OLIGOCHAETA IN THE BIOLOGICAL FOULINGS OF HYDRAULIC ENGINEERING INSTALLATIONS IN THE DNIEPER RESERVOIR

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During investigations of biological foulings on hydraulic engineering installations in the Dnieper reservoir it became evident that the fouling organisms included large numbers of oligochaetes. It was subsequently established by calculation and analysis that they constituted from 60 to 86.5% of the total abundance of organisms discovered, depending on the substrate. 141

Beling (1931, 1939) and Berestov (1941) noted that the fauna on the rocks of the Dnieper rapids contained hardly any oligochaetes before the filling of the reservoir, but that after their abundance increased as a result of the improved ecological conditions.

Consideration is given in the present paper to changes in the species composition and total abundance of oligochaetes as functions of the substrate, to the seasonal dynamics of oligochaete abundance in biological foulings and to the succession of dominant species in the course of the year.

The paper is based on collections made by the authors in the years 1964 - 1966 from the walls of water pipes and chambers and from panels of wood. In all, 125 quantitative and qualitative samples were collected and processed during the investigations. The collected material was processed in the laboratory of the Hydrobiological Research Institute at Dnepropetrovsk University.

The following oligochaete species were found among the foulings: *Stylaria lacustris* (L.), *Aulophorus furcatus* (Müller), *Nais pseudobtusa* Piguet, *N. barbata* Müller, *N. communis* Piguet, *Uncinais uncinata* (Oersted.), *Chaetogaster* sp., *Limnodrilus hoffmeisteri* f. *typica* Claparede, *L. hoffmeisteri* f. *parva* Southern and species of the family Enchytraeidae. Over the three years in which foulings were investigated the main species were: *S. lacustris* (15208 specimens/m^2), *N. barbata* (6532 specimens/m^2) and the less common *N. pseudobtusa* (2481 specimens/m^2) and *N. communis* (270 specimens/m^2). *Limnodrilus udekemianus* Claparède, *L. hoffmeisteri* Claparède, *L. claparedeanus* Ratzel, *Euilyodrilus hammoniensis* (Michaelsen) and *Tubifex tubifex* (Müller) predominate on silts in the reservoir (Lubyanov, 1952, 1955, 1962), while *Isochaetides michaelseni* (Lastočkin) and *I. newaensis* (Michaelsen) predominate where silting is moderate. 142

Members of the family Naididae have been recorded in the benthic macrofauna of the Dnepropetrovsk reservoir (Lubyanov, 1952) and large numbers have been found in trawl samples during investigation of the microzoobenthos of its different biotopes (Buzakova, 1967).

The Table below sets out the annual dynamics of the abundance of oligochaetes in the foulings in the upper zone of the reservoir (the authors' summer investigations) and the benthic macrofauna (from the data of I. P. Lubyanov and Yu. K. Gaidash) (oligochaetes/m^2 in numerator, their biomass g/m^2, in denominator).

	1964	1965	1966
Staryi Kodak - Lyubimovka (benthic macrofauna)	$\frac{4600}{3.84}$	$\frac{2560}{10.4}$	$\frac{260}{0.4}$
Dnieper regional power station (biological foulings)	$\frac{10482}{1.57}$	$\frac{10384}{2.18}$	$\frac{9543}{0.65}$

The data obtained revealed that there were between 2 and 36 times more oligochaetes in the fouling biocoenoses than in the benthic macrofauna.

According to the investigations in the summer of 1966, the qualitative composition of Oligochaeta on various substrates in the fouling biocoenoses was as follows: four species on granite (S. lacustris, N. barbata, N. pseudobtusa, Chaetogaster sp.), two on wood (S. lacustris and N. barbata) and the same two on iron. The abundance (specimens/m^2) and biomass (g/m^2) recorded on the different substrates in the summer of 1966 was as follows:

	Quantity	Biomass
Crystalline granite	130 000	8.2
Wood	10 314	2.2
Iron	4 857	0.8

A comparison of the density of Oligochaeta on the above-mentioned substrates shows that granite surfaces are the most densely populated, with wood and iron in second and third place.

The seasonal dynamics of oligochaete abundance and biomass in the macrofauna of foulings on hydraulic engineering installations is set out below (oligochaetes/m^2 in numerator, biomass, g/m^2, in denominator).

	October 1964	February 1965	May 1965	August 1965
Oligochaeta	$\frac{289\ 575}{43.44}$	$\frac{732}{1.24}$	$\frac{500}{0.30}$	$\frac{24\ 427}{3.15}$

In analyzing the data obtained it should be noted that the abundance and biomass of oligochaetes increase from the spring to the autumn and decrease sharply in the winter. The same seasonal distribution was observed on wooden panels submerged to a depth of 5 m below the surface of the water (1964, 1966). 143

The seasonal species composition of Oligochaeta changed as follows: 2 species (S. lacustris and N. barbata) with an abundance of between 300 and 6412 specimens/m^2 and a biomass of 0.04 - 0.42 g/m^2, were found in the foulings on the wooden panels in the spring; in the summer the number of species increased to four (S. lacustris, N. barbata, N. pseudobtusa, N. communis) and the total abundance to between 1489 and 12 265 specimens/m^2 with a biomass of 1.57 - 3.03 g/m^2. There was hardly any difference in species composition between the autumn and the summer, but abundance and biomass reached their maximum values of 144 865 - 36 685 specimens/m^2 and 21.72 - 9.16 g/m^2 respectively in the autumn. In the winter the foulings contained only N. barbata and N. pseudobtusa, with an abundance of 365 - 590 specimens/m^2 and a biomass of 0.73 - 0.59 g/m^2.

Our monthly observations of changes in the qualitative composition, abundance and biomass of foulings carried out in 1964 and 1966 clearly identified the months in which the dominant oligochaete species (Stylaria lacustris and Nais barbata) reach their maximum abundance and the months in which abundance falls to a minimum.

S. lacustris is found in the spring (May), the summer (June - August) and in isolated cases in the autumn (September only); maximum development is observed at the beginning of summer (June, water temperature 24.5 - 25.2°C), when the species accounts for 49.2 - 92.3% of the total abundance of oligochaetes. N. barbata, which is encountered throughout the year, becomes the dominant species in the autumn during the period when oligochaetes attain their maximum development (September, water temperature 18.2 - 16.4°C), when it constitutes 76 - 86.1% of the total abundance.

The mass development of the oligochaete species named is evidently encouraged by the following ecological factors: current velocity (0.25 m/sec), a constant influx of nutrients and a favourable gas regime (June CO_2 level was 2.33 ml/litre and oxygen level was 8.89 ml/litre at 101.4% saturation; September CO_2 level was 12.58 ml/litre and oxygen level was 10.49 ml/litre at 107.2% saturation).

We have therefore established that biological foulings on hydraulic engineering installations in the Dnieper reservoir include 10 oligochaete species and forms, dominated by _Stylaria lacustris_, _Nais barbata_, _N. pseudobtusa_ and _N. communis_; the highest concentration of oligochaetes is found in foulings on a granite surface. The abundance and biomass of the oligochaetes increase from the spring to the autumn. Because oligochaetes are one of the least important components of the total biomass of the foulings, they cause no real harm to the hydraulic engineering installations, but they do have a role to play in the reservoir as a biological element of the food resources for fishes.

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SEASONAL POPULATION DYNAMICS OF OLIGOCHAETA IN THE BIOLOGICAL FOULINGS OF HYDRAULIC ENGINEERING INSTALLATIONS IN THE DNIEPER RESERVOIR

By A. K. Dyga and I. P. Lubyanov

Summary.

Ten oligochaete species and forms were found on the hydraulic engineering installations in the reservoir. The following species predominate: Stylaria lacustris (L.), Nais barbata Müll., N. pseudobtusa Pig. and N. communis Pig. The seasonal dynamics of oligochaete abundance and biomass (organisms and grammes per m^2) are expressed by the following figures: winter - 732 and 1.24, spring - 500 and 0.30, summer - 24427 and 3.15, autumn - 289575 and 43.44 (data obtained in the years 1964 - 1966).

Bibliography: 7 titles

UDC 595.771

THE ROLE OF OLIGOCHAETA IN THE BENTHIC FAUNA OF FISH PONDS AND OTHER WATERS IN THE UKRAINIAN STEPPE

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The importance of Oligochaeta in different types of bodies of water, in particular as food for fishes, is indicated by published information (Borutskii, 1935; Borutskii, Klyuchareva and Nikol'skii, 1952; Derzhavina, 1913; Ioffe, 1948; Chekanovskaya, 1962 et al.).

Investigations covering a period of three years have shown that 145
fish farm ponds in the zone of large and small reservoirs are a sort of intermediate stage between reservoirs (in the catchment region) and ponds, with the characteristics of the latter predominating.

According to T. N. Kovtun, the gas and salt regimes of bodies of water on fish farms have the following specific features:

1. A considerable increase in the oxidizability of the water, which reaches 40 mg O_2/litre, whereas in the reservoirs in whose zone the ponds are located it does not exceed 20 mg O_2/litre; in ponds constructed in dry ravines and small rivers oxidizability reaches 34 mg O_2/litre.

2. Sharp fluctuations of oxygen content in the water in the range 6 - 15 mg/litre; this is not observed in ordinary ponds and reservoirs.

3. A more alkaline pH of the water. Whereas the pH of the reservoir in whose zone a fish farm was constructed equalled 7.0 - 7.7., it was as high as 8.8 - 9.2 in the fish ponds. The pH of ponds

constructed on small rivers and dry ravines ranged between 7.1 and 8.3.

4. The presence of up to 13 mg/litre of free carbon dioxide in some bodies of water; in adjoining reservoirs there is either none at all or very little; the amount of free carbon dioxide in natural ponds rarely exceeds 10 mg/litre.

5. An increase in the content of dissolved salts, which sometimes reaches 1850 mg/litre; in collective farm ponds it ranges between 600 and 800 mg/litre, while in reservoirs it seldom exceeds 400 mg/litre in the zone of the water intake for fish farms.

6. Slightly higher saturation of the water by biogenous substances.

That the above combination of hydrochemical conditions promotes the development of oligochaetes is confirmed by the data of Timm(1964) and Grigyalis (1963), to the effect that the majority of oligochaete species inhabit bodies of water with different levels of mineralization and with a more alkaline pH.

Cherevko (1967), who investigated the phytoplankton of the Tarom fish farm, built in the zone of the Dnieper reservoir, noted the curious fact that this phytoplankton was richer than that of the reservoir in the intake zone or that of ponds built in some ravines and small rivers. It is well known that phytoplankton plays an important role in the replenishment of organic matter in reservoirs. According to Kuznetsova (1952) and to Pototskaya and Tsyba (1965) phytoplankton is very rapidly mineralized after its death (to the extent of 50 - 90%); this happens while it is still suspended in the water and only an insignificant proportion of non-decomposed matter is precipitated to the bottom.

Higher water plants from the inshore zone are a great source of detritus in bodies of water. All this contributes to the favourable development conditions for oligochaetes.

According to G. B. Mel'nikov, the same characteristic is to be seen in the formation of zooplankton in bodies of water on fish farms, which is far more varied and abundant than the plankton from the initial body of water - i.e. from reservoirs and ponds.

The benthic fauna of fish farms is as varied as that of the reservoirs (we have in mind the water intake zone), and is represented by chironomid, dragon-fly and may-fly larvae, oligochaetes and molluscs. The biomass of benthic organisms in fish farms is somewhat greater (between 146
0.1 and 64.3 g/m^2, excluding molluscs) than in reservoirs (0.44 - 11.76 g/m^2, excluding molluscs) and ponds (0.1 - 60 g/m^2). Oligochaetes account for between 0.03 and 12.6 g/m^2.

The following tubificids from the group of species inhabiting the bottom material were discovered in the ponds of the Tarom fish farm: *Limnodrilus hoffmeisteri* (Clap.), *L. udekemianus* Clap., *L. claparedeanus* Ratz., *Isochaetides michaelseni* (Last.) and *Tubifex tubifex* (Müll.). Naidid species, which inhabit the inshore zone of bodies of water and especially the macrophyte bed zone, were here represented by: *Nais barbata* Müll., *Stylaria lacustris* (L.) and *Uncinais uncinata* (Oersted). *Limnodrilus hoffmeisteri*, *L. undekemianus* and *Tubifex tubifex* were the most widely distributed. In 1965 their abundance was between 40 and 5830 specimens/m^2 and their weight between 0.076 and 12.192 g/m^2. The maximum development of oligochaetes was observed in the summer (June - August) when their biomass reached 90% of total biomass. In the summer of 1966 the biomass of Oligochaeta ranged between 7 and 60% of the total biomass (mainly *L. hoffmeisteri*) in the finishing pond, was 22% of the total biomass in the spawning ponds and 2% in rearing ponds. Oligochaete abundance was between 80 and 3320 specimens/m^2 in the finishing pond, with a biomass of between 0.2 and 5 g/m^2, 120 specimens/m^2 with a biomass of 0.2 g/m^2 in the rearing pond and 40 specimens/m^2 with a biomass of 3.912 g/m^2 in spawning ponds.

The reservoirs on the Krivoi Rog fish farm were found to contain the tubificids L. hoffmeisteri, L. udekemianus, L. claparedeanus and T. tubifex and the naidids S. lacustris and N. barbata. In Yuzhnoe reservoir, which is characterized by a high bacterial content in the summer period, the abundance of adult oligochaetes near the shore was 400 specimens/m^2, with a biomass of 14.32 g/m^2, which was 97% of the total biomass. 280 - 3520 specimens/m^2 with a biomass of between 0.25 and 5.39 g/m^2 were found in the Karachun reservoir during the same period. The abundance and biomass of Oligochaeta in the KRES reservoir were 1240 specimens/m^2 and 4.336 g/m^2 respectively. Oligochaete biomass in the Yuzhnyi reservoir declined considerably in the autumn to become 0.4 g/m^2 (4.8% of the total), with an abundance of 320 specimens/m^2.

Only two tubificid species, T. tubifex and L. hoffmeisteri, were found on the Nikopol' fish farm. In Sholokhov reservoir, which is rich in stony bottom biocoenoses, oligochaete abundance is low (40 - 120 specimens/m^2), while their biomass (0.01 - 0.048 g/m^2) does not exceed 6% of the total biomass of the benthic organisms. In the Nikolaev reservoir, which is characterized by the predominance of silted bottom biocoenoses, the abundance and biomass of oligochaetes are considerably higher, respectively 2680 specimens/m^2 and 2.66 g/m^2, i.e. 9% of the total biomass of the benthic fauna.

For the sake of greater clarity we give in Table 1 the abundance and biomass of benthic invertebrates in different bodies of water belonging to fish farms in the zone of large and small reservoirs. It is evident from the Table that oligochaetes attain maximum development in the summer in such bodies of water as the Yuzhnoe, KRES and Nikolaev reservoirs and the finishing pond of the Tarom fish farm. The Karachun reservoir is an exception, since in it oligochaete abundance and biomass reach their maximum values (5960 specimens/m^2 and 63.912 g/m^2) in the autumn. This 147
is due to the intensive microbiological processes, connected mainly with saprophytic bacteria, which take place in it during this period.

1 **Таблица 1**

2 Численность (экз/м^2) и биомасса (г/м^2) олигохет по сезонам в водоемах рыбхозов степной зоны Украины

	Водоем	Весна 4	Лето 5	6 Осень
3				
7	Водохранилище			
8	Южное	1420 / 4,84	400 / 14,32	720 / 0,8
9	Карачуновское	7040 / 4,8	3520 / 5,392	5960 / 63,912
10	Макортовское		1240 / 0,2	320 / 0,28
11	Николаевское		2680 / 2,66	1120 / 1,4
12	Шолоховское		40 / 0,01	200 / 0,62
13	Крэсовское		1240 / 4,336	
14	Пруды Таромского рыбхоза			
15	нагульный	1120 / 5,544	5880 / 12,192	
16	выростной		120 / 0,2	
17	нерестовый		40 / 3,912	

18 **Примечание.** В числителе – численность олигохет, в знаменателе – биомасса

Key to Table 1 1. Table 1 2. Seasonal abundance (specimens/m^2) and biomass (g/m^2) of oligochaetes in bodies of water belonging to fish farms in the steppe zone of the Ukraine. 3. Body of water 4. Spring 5. Summer 6. Autumn 7. Reservoir 8. Yuzhnoe 9. Karachun 10 Makortov 11. Nikolaev 12. Sholokhov 13. KRES 14. Tarom fish farm ponds 15. Finishing 16. Rearing 17. Spawning 18. Note. Numerator - oligochaete abundance; denominator - biomass

In reservoirs of the Makortov and Sholokov type, where microbiological processes are weak, oligochaete biomass and abundance are low. The presence of a food supply and a favourable hydrochemical regime are, therefore, the major determining factors in the development of oligochaetes in bodies of water in the Ukrainian steppe zone.

According to Grigyalis (1963), there is intensive laying of cocoons and young appear in May and June. Abundance is highest between June and August. The decline in biomass and the simultaneous rise in 148
abundance are due to the dying-off of mature individuals after reproduction. Most oligochaetes in these bodies of water are detritophages which feed on vegetable and animal detritus contained in the bottom material. Bacteria apparently play a not unimportant role in their nutrition (Rodina, 1958; Barysheva, 1940). The mass reproduction of oligochaetes is favoured by the abundance of bacterial decay products.

According to A. S. Arkhipov, the microbiological processes which take place in bodies of water on the Tarom fish farm in spring are characterized by a lower development of bacteria than in the summer and autumn. The quantity of saprophytic bacteria in the Yuzhnoe and Karachun reservoirs, for example, ranges between 155 and 180 cells per ml of water; the bacteria which decompose proteins to hydrogen sulphide are either absent or present in negligible quantites (3 cells per ml of water); each ml of water contains between 9 and 23 denitrifiers which reduce nitrates to nitrites. The quantity of saprophytic cells is high in the summer (between 800 and 12 000 cells/ml) in all fish farm reservoirs except the Makortov and Sholokhov reservoirs; there are from 65 to 288 cells/ml which decompose protein into hydrogen sulphide, between 94 and 238 denitrifiers/ml which reduce nitrates to nitrites and between 18 and 96 which reduce nitrates to nitrogen. It is during this period that mass development of oligochaetes is to be observed.

Oligochaetes play an important role in nursery ponds. According to our data (Chaplina, 1953) the rich biomass of the benthic fauna reaches 68 g/m^2 in some ponds (Table2), where predominance of chironomid larvae, oligochaetes and certain insects is observed among the pond fauna.

An investigation of the food of carp in these ponds showed that the stomach contents (especially in 40-day old fingerlings) consisted mainly of oligochaetes and chironomid larvae. Large copepods and cladocerans were recorded as secondary components in spite of their predominance in the plankton (more than 1 million specimens per cubic metre of water). When carp young were provided with their main food in the form of chironomid larvae and oligochaetes, fast growth and normal development were encouraged. Borutskii (1935) has established that only benthic organisms inhabiting the first 10 cm of the bottom are accessible to benthophagic fishes. According to Grigyalis (1963), the surface layer of silt to a depth of 3 cm contains 68.5% of the total quantity of oligochaetes.

Two-week old well nourished carp fingerlings weighing 1 - 2 kg transferred from spawning ponds to an experimental pond at the Sofievka hatchery reached a weight of 120 - 130 g when 40 days old, while in another experimental pond they weighed 22 - 25 g and in the control pond only 12 - 16 g. Two-week old prepared carp underyearlings also grew intensively in finishing ponds, reaching 400-600 and even 800 g in weight, and this was in no small measure due to the oligochaetes, which are eaten in large quantities by carp more than 2 weeks old. The results of the investigations have been set out in detail in a number of publications: Mel'nikov and Chaplina (1954), Chaplina (1953, 1965). Taken as a whole the benthic fauna of nursery ponds contained the following oligochaetes: Limnodrilus hoffmeisteri f. typica Clap., L. hoffmeisteri f. parva (South.), L. claparedeanus Ratz., L. udekemianus Clap., L. helveticus Piguet, Tubifex tubifex (Müll.), Tubifex sp., Euilyodrilus hammoniensis (Mich.), Lumbricullus sp. and Enchytraeus sp. (total: nine species). 149

1 Таблица 2

2 Динамика развития зообентоса мальковых прудов Софиевского рыбопитомника

3 Организмы	4 Даты 20.VI	24.VI	26.VI	30.VI	10.VII	15.VIII
5 Пруд опытный						
Олигохеты 6	300 / 2,5	1000 / 6,0	–	100 / 0,8	–	–
Жуки и их личинки 7	–	180 / 0,2	400 / 3,0	200 / 7,5	100 / 0,4	300 / 4,0
Личинки хирономид 8	20000 / 50,0	27000 / 48,0	15000 / 18,0	3400 / 10,0	300 / 2,1	800 / 6,5
Другие насекомые 9	10000 / 15,4	150 / 2,0	1700 / 3,0	800 / 2,0	500 / 11,2	–
Всего 10	30300 / 67,9	28330 / 56,2	17100 / 24,0	4500 / 20,3	900 / 13,7	1100 / 10,5

11 Пруд контрольный						
Олигохеты 6	400 / 4,0	400 / 3,6	–	200 / 2,0	300 / 1,8	–
Жуки и их 7 личинки	100 / 0,09	–	–	–	–	–
Личинки хи- 8 рономид	1800 / 7,10	900 / 8,0	–	1200 / 5,0	600 / 1,0	–
Другие на- 9 секомые	500 / 0,6	1000 / 2,1	–	100 / 2,1	300 / 0,2	–
Всего 10	2800 / 11,79	2300 / 13,7	–	1500 / 9,1	1200 / 3,0	–

12 Примечание. В числителе – численность организмов (экз/м^2), в знаменателе – биомасса (г/м^2).

Key to Table 2 1. Table 2 2. Developmental dynamics of the zoobenthos in fingerling ponds on the Sofievka fish farm 3. Organisms 4. Dates 5. Experimental pond 6. Oligochaetes 7. Beetles and their larvae 8. Chironomid larvae 9. Other insects 10. Total 11. Control pond 12. Note. Numerator: Abundance of organisms (specimens/m^2); denominator: biomass (g/m^2)

According to Lubyanov and Fed'ko (1953), nine oligochaete species were discovered in the finishing and rearing ponds of collective farms: *Nais communis* Piguet, *Uncinais uncinata* (Oersted), *Ophidonais serpentina* (Müll.), *Stylaria lacustris* (L.), *Limnodrilus hoffmeisteri* Clap. (*L. h.* f. *typica* and *L. h.* f. *parva*), *L. udekemianus* Clap., *Euilyodrilus hammoniensis* (Mich.), *Tubifex tubifex* (Müll.) and *Criodrilus* sp.

As we have already stated, 10 oligochaete species were discovered in bodies of water on fish farms: *Limnodrilus hoffmeisteri*, *L. udekemianus*, *L. claparedeanus*, *Isochaetides michaelseni*, *Euilyodrilus hammoniensis*, *Tubifex tubifex*, *Uncinais uncinata*, *Nais barbata*, *Stylaria lacustris* and

Lumbricus terrestris Linn. Their abundance and biomass are somewhat higher than in ponds and reservoirs in the same zone as the fish farms. Altogether 18 species and forms of Oligochaeta have been discovered in the bodies of water on fish farms, in reservoirs in the water intake zone and in collective farm ponds in the Ukrainian steppe zone. These included 11 pelophilous species and forms: Limnodrilus hoffmeisteri f. typica, L. hoffmeisteri f. parva, L. helveticus, L. udekemianus, L. claparedeanus, Isochaetides michaelseni, Euilyodrilus hammoniensis, Tubifex tubifex, Criodrilus sp., Enchytraeus sp. and others; 4 phytophilous species: Nais barbata, N. communis, Uncinais uncinata and Ophidonais serpentina; 1 lithophilous species: Lumbricillus sp.

In conclusion it may be said that the Oligochaeta play an important role in bodies of water in the steppe zone of the Ukraine and especially in those on fish farms. Differences in the species composition and the considerable fluctuations in the abundance and biomass of oligochaetes in bodies of water of different types appear to be due to differences in ecological and bioecological conditions; these will be studied in the next stage of our investigation.

THE ROLE OF OLIGOCHAETA IN THE BENTHIC FAUNA OF FISH PONDS AND OTHER WATERS IN THE UKRAINIAN STEPPE

By N. I. Zagubizhenko and A. M. Chaplina

Summary.

Information is given about the species composition (18 species) and seasonal dynamics of the oligochaete biomass in the Ukrainian steppe zone. The article contains material on the feeding of carp on oligochaetes.

Bibliography: 16 titles.*

* Translator's note. Bibliography not included in Russian original, despite this statement.

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THE EFFECT OF THE REGULATED DISCHARGE OF THE DNIEPER ON THE POPULATION DYNAMICS OF OLIGOCHAETA IN THE DNIEPER RESERVOIR (LAKE LENIN)

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Many rivers have been converted into chains of reservoirs 151 as a result of hydraulic engineering. Five reservoirs already exist on the Dnieper: the Dnieper reservoir, or Lake Lenin (built in 1933 and reconstructed in 1947) and the Kakhovka (1955), Kremenchug (1959), Dneprodzerzhinsk (1963) and Kiev reservoirs. A study of the changes in the hydrobiological regime of the Dnieper and its chain of reservoirs and of their effect on each other is of some scientific and practical importance in relation to further development of the theory of the biological productivity of bodies of water. It therefore seems useful to examine the population dynamics of oligochaetes in the first artificial body of water on the Dnieper - the Dnieper reservoir, especially since the construction of the Kremenchug, Dneprodzerzhinsk and Kiev reservoirs in its upper reaches. The above three new reservoirs have a colossal influence on all aspects of life in Lake Lenin. Problems concerned with the formation of a benthic fauna in Lake Lenin and detailed descriptions of the qualitative composition and quantitative development of oligochaetes before the regulation of the middle reaches of the Dnieper by hydraulic engineering works have been discussed in the literature (Lubyanov, 1953, 1955, 1962).

The present Lake Lenin is still characterized by the heterogeneous conditions found along its long axis and it can, as before, be divided into an upper, middle and lower part. As a result of the formation of the chain of reservoirs there has been some increase in the transparency and colour of the water in Lake Lenin. Considerable changes have also been noted in the temperature regime: the spring warming up of the water commences later (by 15 - 17 days), as does the subsequent cooling of the water. The content of dissolved solids in the water is lower than that recorded during the river period.

As a result of the great depths in Lake Lenin, considerable oxygen stratification is observed in the summer period. In 1964, for example, near the village of Fedorovka (depth 30 - 31 m) there were 12.6 mg/litre of oxygen at the surface and 0.43 mg/litre at the bottom, while in the Vol'nyi and Vil'nyanka bays oxygen content was 15.31 mg/litre at the surface and 0.95 mg/litre at the bottom. Stratification is observed not only in the oxygen regime, but also in other chemical characteristics. The quantity of organic matter in the water decreases between the surface and the bottom; this can be seen from the decline in water oxidation indices near Fedorovka village in 1964 from 18.8 to 12.8 mg O_2/litre. On the other hand, there are increases at the bottom in the amounts of ammonia (0.380 - 0.904 mg/litre in 1965 near Fedorovka village), nitrites (same location, 0.015 - 0.047 mg/litre), phosphorus (0.036 - 0.086 mg/ 152
litre in 1966 near Petrovo-Svistunovo village), bicarbonates and especially free carbon dioxide (same location, 0.88 - 6.60 mg/litre).

The sedimentation of suspended matter and the deposition of bottom deposits and detritus carried along by the river current takes place in the upper Dnieper reservoirs. For example, there was 14.08 mg/litre of suspended matter in the central reach of Lake Lenin in 1959 and 4.9 - 6.1 mg/litre in 1965. The nature of accumulation of benthic deposits has changed. Whereas in the past they were mostly of allochthonous origin, they are now mainly autochthonous and come in particular from the intensive settling of the plankton as it dies, especially Cyanophyceae. The thickness of the uncompacted phytoplankton deposited on the bottom in the autumn has reached 40 - 50 cm. The abundance of algae in the reservoir increases on moving downstream (i.e. between Dnepropetrovsk and Zaporozh'e).

The substantial changes in the composition of the benthic fauna, expressed both in the variety of its species and in the quantitative development of certain species, forms, groups and entire associations, which can be observed in the Dnieper are due to the general and particular changes in the hydrobiological regime of Lake Lenin caused by the formation of the chain of reservoirs.

According to data for the years 1964 - 1967 the coenoses of benthic fauna in the Dnieper reservoir are qualitatively less varied than those which existed in the reservoir after its reconstruction. Ever since the Dnieper has been sealed by the dam of the Dneprodzerzhinsk Hydroelectric Power Station, the sand (psammorheophilous) coenoses have been of little significance in Lake Lenin and oligochaetes have been poorly represented in both quantity and quality by Isochaetides michaelseni (Last.) and I. newaensis (Michlsn). As a result of the decline in the current velocity in Lake Lenin the sandy bottom materials are becoming silted. The benthic fauna is represented in the silted areas of the reservoir by different groups of organisms including leeches, molluscs and chironomid, may-fly and dragon-fly larvae, but oligochaetes constitute 75 - 80% of the total macrozoobenthos [*Limnodrilus hoffmeisteri* Clap., *L. udekemianus* Clap., *L. claparedeanus* Ratz. and *Tubifex tubifex* (Müll.)]. The benthic fauna of the silt biocoenoses in the reservoir's profundal zone (depth 9 - 45m) consists mainly of the oligochaetes *L. hoffmeisteri*, *T. tubifex* and *Euilyodrilus hammoniensis* (Michlsn), which account for 97 - 98% of the entire macrozoobenthos. In phyto(rheo)philous biocoenoses oligochaetes are far less important (7 - 10% of the total abundance of phytophilous organisms) and are represented by *Stylaria lacustris* (L.), *Nais barbata* (Müll.), *N. simplex* Piguet, *N. communis* Piguet and *Uncinais uncinata* (Oersted).

According to data for the years 1964 - 1967, there are now fewer oligochaete species in Lake Lenin than during reconstruction of the reservoir, 14 species as against 49; 5 of these 14 species are widely distributed and abundant: the phytophilous *S. lacustris* and the pelophilous *Limnodrilus hoffmeisteri*, *L. udekemianus*, *L. claparedeanus* and *Tubifex tubifex*.

The abundance and biomass dynamics of Oligochaeta before 153
and after regulation of the upper reaches of the Dnieper have been systematically investigated in the central and lower parts of the reservoir's profundal zone and are set out in Tables 1 and 2.

It was established that tubificids were most abundant in the profundal zone in the middle area of the Dnieper reservoir on silt at a depth of 22m, where the density was 22000 specimens/m^2 in July

1 Таблица 1

2 Динамика численности (экз/м^2) и биомассы (г/м^2) олигохет в профундали Днепровского водохранилища (озеро Ленина)

3 Район исследования	Глубина, м 4	5 Год 1954	1959	1964	1967
У села Любимовки 6	8,0	2360 31,52	3140 4,96	4660 3,84	11200 15,22
Против залива Вороного 7	13,5	3360 32,45	2540 3,4	12080 24,096	2920 6,92
Против залива Плоско-Осокоровки 8	22,0	7200 29,18	1480 2,0	22000 43,608	9600 17,92
У села Федоровки 9	30,0	1100 1,003	4800 8,48	17120 39,432	4760 8,64
Выше залива Вольного 10	33,0	1100 2,37	7200 16,592	10240 24,126	2320 4,4
Кичкас (около плотины) 11	45,0–50,0	3760 13,56	360 0,248	8660 9,736	5840 9,68

12 Примечание. В числителе – количество животных, в знаменателе – их биомасса.

Key to Table 1: 1. Table 1 2. Abundance (specimens/m^2) and biomass (g/m^2) dynamics of oligochaetes in the profundal zone of the Dnieper reservoir (Lake Lenin) 3. Area of investigations 4. Depth, m 5. Year 6. Near Lyubimovka village 7. Opposite Voronyi Bay 8. Opposite Plosko-Osokorovka Bay 9. Near Fedorovka village 10. Above Vol'nyi Bay 11. Kichkas (near dam) 12. Note. Numerator - number of animals, denominator - biomass.

1964, 7800 in 1965, 5820 in 1966 and 9600 in 1967. The lowest abundance in the same area was recorded in the autumn (October, 1965) and was 580 specimens/m^2. The species composition of the oligochaetes has become more uniform (Limnodrilus hoffmeisteri, L. udekemianus, T. tubifex, Euilyodrilus hammoniensis). The abundance of these oligochaete species at a depth of 45 - 50 m was 11160 specimens/m^2 in the spring of 1966 and 5840 specimens/m^2 in the summer of 1967. The abundance of Oligochaeta in this area was low in the autumn.

Areas of the reservoir where the bottom is of loess have a very uniform oligochaete fauna with a low abundance - 20 to 40 specimens/m^2.

The biomass dynamics of tubificids is slightly different from the population dynamics. The oligochaete biomass was greatest in the profundal zone of the middle and lower parts of the reservoir at a depth of 33 m in the spring of 1964 (36.912 g/m^2) and at a depth of 13.5 m in the spring of 1965 (40.0 g/m^2), since the oligochaete biomass is increased at the very beginning of reproduction as a result of the growth of maturing individuals. At the depth of 45 - 50 m, relatively inaccessible to fishes, the oligochaete biomass was, like the abundance, high in the spring of 1965 (14.0 g/m^2) and 1966 (22.16 g/m^2).

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1 Таблица 2

2 Динамика численности (экз/м^2) и биомассы (г/м^2) олигохет в профундали Днепровского водохранилища после зарегулирования стока Днепра в верхнем бьефе (по данным 1964–1967 гг.)

	Район исследования	1964 г.			1965 г.			1966 г.		1967 г.		
3		весна	лето	осень	весна	лето	осень	весна	лето	весна	лето	осень
7	У села Любимовки	8600 / 34,40	4600 / 3,840	680 / 1,548	500 / 6,0	2560 / 10,4	1720 / 2,84	680 / 8,7	260 / 0,4	2880 / 5,36	11200 / 15,22	480 / 0,68
8	Против залива Вороного	11000 / 29,632	12080 / 24,096	8160 / 31,512	4000 / 40,0	2420 / 20,0	4140 / 19,78	900 / 1,3	4800 / 13,2	15760 / 40,68	2920 / 6,92	3080 / 7,2
9	Против залива Плоско-Осокоровки	13340 / 22,858	22000 / 43,608	10060 / 26,608	1120 / 5,2	7800 / 28,0	580 / 2,34	10760 / 18,36	5820 / 10,2	–	9600 / 17,92	10000 / 24,48
10	У села Федоровки	–	17120 / 39,432	880 / 1,912	1760 / 8,0	4280 / 15,4	1640 / 9,34	4200 / 7,84	2140 / 3,2	–	4760 / 8,64	2420 / 3,6
11	Выше залива Вольного	11660 / 36,912	10240 / 24,120	5620 / 6,236	1600 / 10,0	820 / 6,6	2040 / 9,84	4640 / 15,08	7560 / 22,0	–	2320 / 4,4	1440 / 4,16
12	Кичкас (около плотины)	–	8660 / 9,736	–	2820 / 14,0	2440 / 9,2	1640 / 6,96	11160 / 22,16	3000 / 5,2	–	5840 / 9,68	320 / 0,72

13 Примечание. Прочерки – пробы в указанные сроки не брались

Key to Table 2: 1. Table 2 2. Dynamics of oligochaete abundance 154
(specimens/m^2) and biomass (g/m^2) in the profundal zone of the Dnieper reservoir after regulation of the upper reach of the Dnieper (according to data for the years 1964 - 1967) 3. Area of investigations 4. Spring 5. Summer 6. Autumn 7. Near Lyubimovka village 8. Opposite Voronyi Bay 9. Opposite Plosko-Osokorovka Bay 10. Near Fedorovka village 11. Above Vol'nyi Bay 12. Kichkas (near dam) 13. Note. Dashes indicate no samples taken at the stated times..

As abundance increases a decline is to be observed in the 155
biomass due to the dying-off of mature individuals after reproduction. The lowest oligochaete biomass was thus recorded in the summer of 1966 (in the central part of the reservoir) - 0.4 to 10.2 g/m^2.

Oligochaetes are firmly established constituent elements of the psammorheophilous, pelophilous, phytophilous and lithophilous biocoenoses of the reservoir. They constitute 90 - 97% of the total abundance of the macrozoobenthos in pelophilous biocoenoses.

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THE EFFECT OF THE REGULATED DISCHARGE OF THE DNIEPER ON THE POPULATION DYNAMICS OF OLIGOCHAETA IN THE DNIEPER RESERVOIR (LAKE LENIN)

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Summary

Changes in the oligochaete fauna of the reservoir since the construction of the Kremenchug, Dneprodzerzhinsk and Kiev hydroelectric stations are discussed. The species composition has been impoverished (14 species as against 49). The benthic fauna of the profundal zone is represented by pelophilous tubificids; abundance and biomass indices (expressed in organisms and grammes per m^2) have the following values: 22000 and 43.61 in 1964, 7800 and 28.00 in 1965, 10760 and 18.36 in 1966 and 9600 and 17.92 in 1967.

Bibliography: 5 titles.

UDC 595.771

OLIGOCHAETA IN THE CENTRAL REACH OF THE KUIBYSHEV RESERVOIR

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The object of the present work is to establish the species composition of Oligochaeta in the central reach of the Kuibyshev reservoir and the seasonal variations in their abundance and biomass. Observations were carried out in different biotopes of this section, located between the mouth of the Kama and the confluence of the Bol'shoi Cheremshan. The configuration of its banks, its depths and its bottom materials vary. Our observations were carried out in two areas: around the Bannye Islands in 1963 and in the Main Bay area in 1964. The material at our disposal (3348 worms) came from 100 samples taken by Petersen grab (bite area $1/40m^2$). Samples in each area were taken at four stations whose ecological features, location (distance from the bank) and depths corresponded. Stations 1, 2, 3 and 4 in the Bannye Islands area thus correspond to stations 1^a, 2^a, 3^a and 4^a in the Main Bay area (Fig. 1).[1]

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[1] I wish to express my deep gratitude to Professor V. V. Izosimov and to I. V. Egereva, the head of the Laboratory of Hydrobiology, Tatar Department, State Research Institute for Lake and River Fisheries, for their help.

Station 1 (26 samples) and st. 1^a (8 samples) were located in the winding inlets which cut deep into the left bank of the reservoir and are well protected from currents and breakers. The bottom material at st. 1 was a fairly thick layer of dark-grey, sometimes black silt with an admixture of sand. St. 1^a was located in Main Bay, whose area is not greater than 4000 hectares. The bottom materials are less silted at this station; plant remains and submerged meadows are found. The maximum depth at st. 1 and 1^a did not exceed 5 m.

St. 2 (11 samples) and st. 2^a (9 samples) were located on the inundated flood plain, 500 - 600 m from the islands and the left bank of the reservoir, at a maximum depth of 6.5 m. A very low level of silting was a feature of the station in the Bannye Islands area; the surface layer of the bottom material often consisted of compacted soil containing some sand. Somewhat heavier silting was observed in the Main Bay area. The areas in which the stations were located are affected by winds and when the depth is slight the silt deposits are frequently stirred up (Lukin, 1961; Lyakhov, 1963).

St. 3 (12 samples) and 3^a (11 samples) were located in the centre 157
of the flooded area on the left bank, at a maximum depth of 13 m. By comparison with stations 2 and 2^a, these stations were more influenced by winds and the stirring up of silt deposits was considerable. In the area of Main Bay the silting is greater than that observed in the Bannye Islands area; silt accumulations (maximum thickness 15 cm) are found in small depressions on the bottom.

St. 4 (13 samples) and 4^a (11 samples) were located in the centre of the former bed of the Volga at a maximum depth of 33 m. These stations are characterized by large accumulations of silt deposits. The silt is soft on top and has much denser lower layers.

The samples were thus collected from four ecologically different areas: bays, the flood plain along the bank (maximum depth 6.5 m), the centre of the flood plain (maximum depth 13 m) and the former river bed.

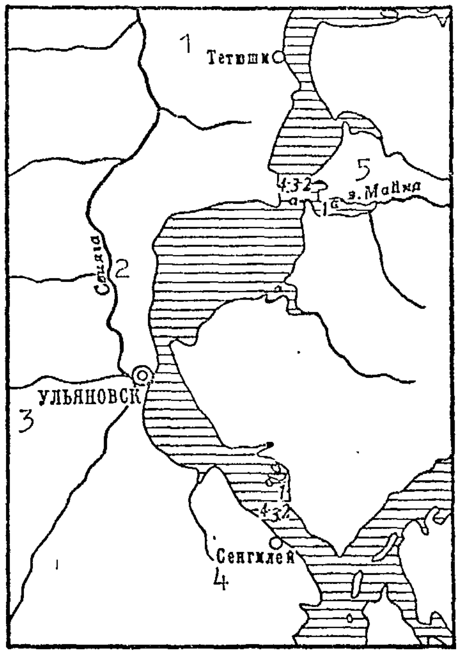

Рис.1. Схема среднего участка Центрального плёса Куйбышевского водохранилища
Объяснения ко всем рисункам в тексте

Fig. 1 Diagram of the central section of the middle reach of Kuibyshev reservoir. All illustrations explained in the text. Keyed on Figure: 1. Tetyushi 2. Sviyaga 3. Ul'yanovsk 4. Sengilei 5. Main Bay

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It emerges from the processing of the material that the abundance (specimens/m^2) of oligochaetes varies with the bottom material, the depth and the time. Figs. 2 and 3 show the abundance of oligochaetes in the different areas. The abundance of oligochaetes was, on average, much greater (almost three times greater) in the area of the Bannye Islands in 1963 than in the Main Bay area in 1964. Biomass changes less sharply. In 1963 the oligochaete biomass increased by 0.10 - 16.07 g/m^2 on average in the Bannye Islands area, on moving from the bays on the left bank in the direction of the river bed, i.e. toward the right bank of the reservoir; the corresponding increase in the Main Bay area in 1964 was 0.20 - 10.68 g/m^2.

In 1963 the samples from the area of the Bannye Islands contained many juvenile oligochaetes, which sharply increased abundance but had less 158 effect on the biomass statistics. It seems very likely that the appearance of considerable numbers of juvenile oligochaetes in 1963 was related to the temperature conditions. 1963 was distinguished from subsequent years by high temperatures (Goncharenko, 1967).

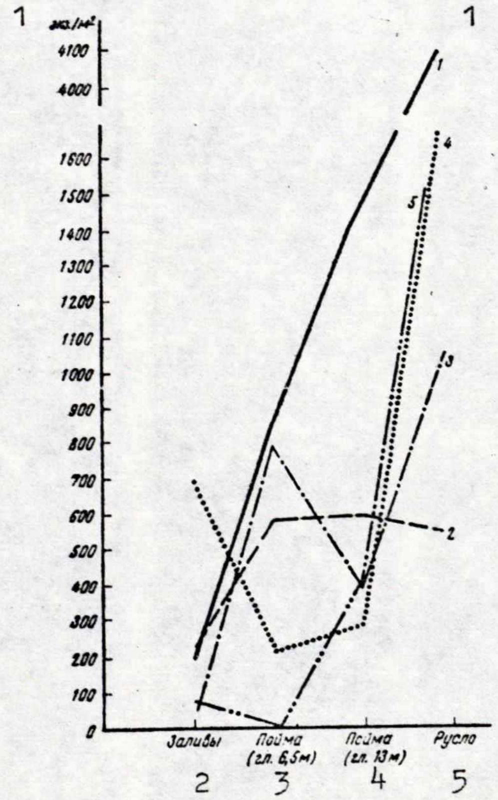

Рис.2. Численность олигохет в районе Банных островов в 1963 г. 1 – май; 2 – июнь; 3 – июль; 4 – август; 5 – сентябрь

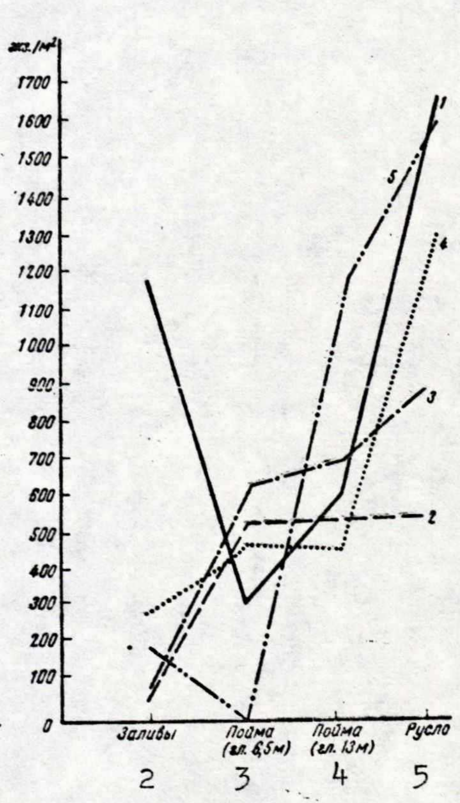

Рис.3. Численность олигохет в районе залива Майна в 1964 г. 1 – май; 2 – июнь; 3 – июль; 4 – август; 5 – сентябрь

Fig. 2. Oligochaete abundance in the area of the Bannye Islands in 1963. 1) May, 2) June, 3) July, 4) August, 5) September. Keyed on Figure: 1. Specimens/m^2 2. Bays 3. Flood plain (depth 6.5 m) 4. Flood plain (depth 13 m) 5. River bed.

Fig. 3. Oligochaete abundance in the Main Bay area in 1964. 1) May, 2) June, 3) July, 4) August, 5) September. Keyed on Figure: 1. Specimens/m^2 2. Bays 3. Flood plain (depth 6.5 m) 4. Flood plain (depth 13 m) 5. River bed

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Oligochaete abundance and biomass thus increased between the left bank and the river bed during the entire investigation period.

Oligochaete abundance falls sharply in the bays and in the centre of the flood plain in July, throughout the flood plain in August and in the bays and at the flood plain stations located nearer the left bank of the reservoir in September. The flood plain in the Main Bay area also has minimum abundance and biomass (0.70 g/m^2) in May and September. The smaller quantity of oligochaetes on the flood plain areas can be partially explained by the waves, which are more frequent and larger here than in the deeper areas and which cause frequent stirring up and washing through 160 of the silt and the fauna which it contains.

It is difficult to give a precise indication of the reasons for such changes in the abundance and biomass of oligochaetes in different areas of the Central reach. It can, however, be assumed that the dying-off of sexually mature oligochaetes after reproduction is of some importance here /a number of authors have described the death of sexually mature Oligochaeta after the deposition of cocoons (Stolte, 1940; Chekanovskaya, 1962; Poddubnaya, 1962)/. This feature is clearly reflected in the oligochaete biomass.

Oligochaete abundance and biomass are undoubtedly affected by the sizeable numbers (up to 640 specimens/m^2) of predatory chironomid larvae (Procladius). Karataevskaya (1964) notes that Procladius is a dominant form in Main Bay, especially in the autumn. It is known (Luferov, 1958,

1961) that Procladius larvae consume oligochaetes. The role of the benthophagic fishes in the flood plain areas, which consume oligochaetes as part of their food, is a factor which certainly must not be ignored. July and August (and also September, if the weather is warm) are the months in which the fishes feed most intensively.

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1 Количество (экз/м^2) и частота встречаемости (в %) олигохет в разных участках района залива Майна (I) и района Банных островов (II)

2 Вид	3 Средня численность, % встречаемости															
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Stylaria lacustris (L.)	20	20	12	4	-	-	-	-	-	-	-	-	-	-	-	-
Dero digitata (Müller)	-	-	-	-	-	-	-	-	-	20	-	8	-	-	-	-
Dero sp.	-	-	-	-	-	-	-	-	-	40	-	8	-	-	-	-
Nais sp.	-	20	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Nais barbata Müller	-	-	-	-	-	-	-	-	-	-	-	-	-	160	-	8
Chaetogaster diastrophus (Gruithuisen)	-	40	-	4	-	-	-	-	-	40	-	8	-	-	-	-
Naididae gen. sp.	27	-	38	-	40	-	9	-	-	-	-	-	20	-	9	-
Isochaetides michaelseni (Lastočkin)	20	20	12	4	60	-	11	-	40	-	10	-	-	-	-	-
I.newaensis (Michaelsen)	-	40	-	4	-	-	-	-	-	-	-	-	228	205	45	100
Limnodrilus hoffmeisteri (Claparède)	-	-	-	-	-	-	-	-	-	40	-	8	-	60	-	8
Limnodrilus sp. (juv.)	120	47	12	23	135	115	44	36	90	77	55	50	186	513	64	92
Euilyodrilus hammoniensis (Michaelsen)	-	-	-	-	240	-	11	-	-	-	-	-	67	100	27	15
E.moldaviensis (Vejd. et Mrazek)	40	-	12	-	223	100	78	27	262	174	82	58	511	150	100	61
Euilyodrilus sp. (juv.)	153	80	38	23	207	60	33	18	130	108	18	42	403	120	64	38
Psammoryctides barbatus (Grube)	-	-	-	-	40	-	11	-	-	-	-	-	-	-	-	-
Tubifex tubifex (Müller)	576	212	62	85	187	218	33	91	358	549	99	75	150	1132	36	100
Tubifex sp.	140	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-
Peloscolex ferox (Eisen)	-	80	-	12	-	20	-	9	-	20	-	8	-	-	-	-
Tubificidae gen.sp.(juv.)	128	53	63	31	130	143	67	73	127	127	73	67	167	133	82	84
Lumbriculus variegatus (Müller)	30	-	10	-	-	-	-	-	-	-	-	-	100	85	9	30

Key to Table on Page 159: 1. Abundance (specimens/m^2) and frequency (in %) of oligochaetes in different areas of Main Bay region (I) and the Bannye Island region (II) 2. Species 3. Mean abundance, percentage frequency of occurrence

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We found 13 oligochaete species in the Central reach (see Table). The highest frequency and the greatest abundance in samples from all biotopes were recorded for Tubifex tubifex. Izosimov (1960) notes that this species inhabits wide areas of the entire reservoir bed and is the second most frequent species in the Kuibyshev reservoir. Certain naidids are also important in this respect in the bays. Euilyodrilus moldaviensis is an abundant form on the flood plain.[1]

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[1] Izosimov (1960) considers that this species should be accorded third place as regards frequency.

In addition to the species mentioned above, Isochaetides newaensis is the most frequent abundant species (up to 540 specimens/m^2) on the former river bed, where the silting is heaviest.

The basic nucleus of the oligochaete fauna is provided by E. moldaviensis, T. tubifex and Peloscolex ferox[2] on the inundated flood plain and by Isochaetides newaensis, E. moldaviensis, E. hammoniensis and T. tubifex on the former river bed.

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[2] Aristovskaya (1958) notes this species as a dominant in flood plain bodies of water.

In conclusion it can be stated that the oligochaete fauna of the Central reach of Kuibyshev reservoir is distinguished by high abundance and biomass and by the variety of species. Seasonal observations show that oligochaete abundance and biomass vary with the month and in different areas of the reservoir. This is a result of the influence of currents and breakers, of changes in temperature conditions which affect the reproduction and development of different oligochaete species and of a number of factors of a biotic nature (consumption of oligochaetes by fishes and predatory invertebrates).

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OLIGOCHAETA IN THE CENTRAL REACH OF THE KUIBYSHEV RESERVOIR

By. A. A. Noskova

Summary.

Information is given on the species composition (20 species), abundance and biomass of Oligochaeta. The maximum abundance (4800 specimens/m^2) and biomass (16 g/m^2) were recorded in May 1963.

Bibliography: 11 titles

FRESHWATER OLIGOCHAETA AND THEIR IMPORTANCE AS FOOD FOR FISHES

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Freshwater oligochaetes are one of the most widely distributed and numerous groups of benthic hydrobionts. They are of great importance as food of high calorific value for fishes. Merely in the bodies of water of the Dniester Basin 92 forms of oligochaetes have been discovered, mainly naidids (35) and tubificids (32). Twenty six of the forms from the Dniester, or 29% of the total composition, are found in the bodies of water of all basins, from the Danube to the Amur inclusive. We may mention Stylaria lacustris, Ripistes parasita, Nais pseudobtusa, Chaetogaster diaphanus, Aulodrilus limnobius, Limnodrilus hoffmeisteri, Tubifex tubifex, Eisenia rosea and other species. In addition to them, approximately 15 oligochaete species from the Dniester occur in inland bodies of water in almost all the continents. Some of them, such as Propappus volki, have ranges confined to the Eurasian mainland, while others, for example Paranais friči, are at present known only in Europe and are found comparatively infrequently.

The well known species Isochaetides michaelseni, Euilyodrilus bedoti. E. vejdovskyi, E. moldaviensis, Psammoryctides albicola. Tubifex ignotus and some others have ranges confined to Europe. Of them, Euilyodrilus caspicus, Psammoryctides albicola and P. barbatus, which tolerate slightly saline water (such as is found in the Sea of

Azov), are of particular interest.

The ecological spectrum of freshwater oligochaetes is also extremely wide. They are to be found under the most varied abiotic and biotic conditions of the aquatic environment and on the most varied substrates.

Freshwater oligochaetes are components of lithorheophilous, psammorheophilous, pelorheophilous, pelophilous and phytophilous ecological associations. Each of them is typified by its own, numerically dominant composition of oligochaetes. According to our observations, the pelophilous and pelorheophilous oligochaete associations were taxonomically the most varied.

Not only pelophilous species such as Euilyodrilus moldaviensis and Psammoryctides barbatus, but even the psammorheophilous species Aulodrilus limnobius have been incorporated in the pelophilous association inhabiting the predominantly mineral oozes of the Dubossary reservoir and the oxbow of the Dniester.

Only euroxybionts - Dero, Limnodrilus hoffmeisteri, L. 163
udekemianus, L. claparedeanus, Euilyodrilus hammoniensis - retain a dominant position in the bodies of water of floodplains, ponds and small reservoirs where there is appreciably more organic matter in the oozes and the gas and salt regime is considerably more strained; certain naidids make a limited contribution to the coenosis.

We include in the pelorheophilous association oligochaetes inhabiting variously silted sandy bottoms. The species which are equally at home here include many algophages - epibionts of the benthic fauna, the naidids Vejdovskyella comata and V. intermedia, almost all the Dero species discovered by us. several Nais species, *Ophidonais serpentina* and others. The small predators *Chaetogaster diastrophus* and *Ch. diaphanus* and the parasitic oligochaete *Ch. limnaei* are common. The tubificid detritus feeders *Isochaetides michaelseni*, *L. udekemianus*, *L. claparedeanus*, *Euilyodrilus hammoniensis* and *E. moldaviensis* are abundantly represented. Moreover, certain psammorheophilous species (*Aulodrilus limnobius*) and sometimes even such generally recognized psammorheophilous species as *Isochaetides newaensis* and *Propappus volki* are found even among the dominants of the pelorheophilous association.

The psammorheophilous oligochaete association is far less rich than the pelorheophilous one. The only dominant psammorheophilous species were found to be *Aulodrilus limnobius*, *Isochaetides newaensis*, *Propappus volki* and *Euilyodrilus bedoti*. In this case most of the dominants of the psammorheophilous association are represented by such pelorheophilous species as *Isochaetides michaelseni*, *Euilyodrilus moldaviensis* and *Psammoryctides barbatus*; the pelophilous species *Limnodrilus hoffmeisteri* and *L. claparedeanus* were also found to be fairly common in it.

Such ecologically indistinct limits to the psammorheophilous oligochaete association are to be explained in this case firstly by the unstable hydrologic regime in the Dniester and in the reservoir, which is conducive to frequent change not only of the components of the coenosis, but also of the sandy substrate inhabited by them and, secondly, the appreciable and almost continuous turbidity of the water, which makes it impossible for the sand to be washed completely clean either in the river or in the swassh zone of the reservoir.

For quite obvious reasons the lithorheophilous ecological association of oligochaetes was found to be the sparsest. Numerically it is defined solely by Nais pardalis, Limnodrilus hoffmeisteri, L. claparedeanus and Euilyodrilus hammoniensis.

The phytophilous association also has certain distinguishing features. It is appreciably richer than the lithorheophilous association, but poorer than the pelorheophilous and pelophilous associations. It has been found to contain a total of only 30 forms of oligochaetes, mainly naidids and aelosomatids; only 9 forms are numerically predominant - Aeolosoma hemprichi, Stylaria lacustris, Dero obtusa, Nais simplex, N. variabilis, Ophidonais serpentina, Chaetogaster diastrophus, Ch. diaphanus, Aulodrilus limnobius.

This completes our general ecological description of freshwater oligochaetes in bodies of water in the Dniester Basin.

We also consider it appropriate to deal with some aspects 164
of the quantitative development of oligochaetes, at least in the main types of bodies of water investigated, since this may be of assistance in reaching an understanding of their importance in hydrobiological processes.

It is evident from Table 1 that oligochaetes make a fairly appreciable contribution to the total abundance and biomass of the benthic fauna in bodies of water of almost all types. Even on the sand and shingle-sand bottoms of the reach of the Dniester subsequently covered by the reservoir, which were not very suited to oligochaetes, they constituted 40% of the total benthic fauna in terms of abundance and 30% in terms of biomass, with the exception of the Kamenka and Dubossary stations on the Dniester, where oligochaetes are 25% of the total benthic fauna in terms of abundance but only 2% in terms of biomass.

The absolute and relative abundance of oligochaetes in unit area is far higher in the flooded Kuchurgan lagoon than in the Dniester: the relatively small percentage contribution of their biomass to the total biomass of the benthic fauna is to be explained by the profuse development here of molluscs (Dreissena polymorpha).

With regard to reservoirs and ponds, oligochaetes play a decisive role in them both with respect to abundance and in their contribution to the biomass of the benthic fauna.

In Dubossary reservoir, for example, the quantity of oligochaetes ranges on average from 5153 specimens/m^2 in the winter, with a biomass of 18.0 g/m^2, to 8062 specimens/m^2 in the summer, with a biomass of 11.0 g/m^2. At certain stations the mean long-term abundance of oligochaetes reaches 12790 specimens/m^2, with a biomass of 30 g/m^2, while in some instances they are concentrated to above 373480 specimens/m^2, with a biomass of 166 g/m^2.

Along the longitudinal profile of the reservoir the mean abundance of oligochaetes alters from 12720 specimens/m^2 at Poyany station to 3590 specimens/m^2 at Kuchiera station near the dam and 2804 specimens/m^2 in the Yagorlyk oxbow in the lower part of the reservoir. However, the ratio of the abundance of oligochaetes to the total abundance of the benthic fauna alters little throughout the reservoir. It was 89% at Poyany station and had fallen to a level of 63% at Kuchiera station. Even in the Yagorlyk oxbow the abundance of oligochaetes was 54% of the total abundance of the benthic fauna.

It follows that oligochaetes play a fairly appreciable role in formation of the benthic fauna of bodies of water. Hence it may be concluded that their role in the biological processes of bodies of water is not without importance.

Insufficient attention has hitherto been paid in the literature to the feeding of fishes on oligochaetes. The reason is evidently the difficulty of identifying them in the food bolus of fishes. Because they do not possess skeletal formations, oligochaetes are rapidly macerated in the intestines of fishes (4 - 5 hr). Their setae are retained for slightly longer, but irrespective of this they are a poor taxonomic character of oligochaetes and are in general unsuitable for determination of their quantity. Therefore, if we are to establish the importance of oligochaetes in the nutrition of fishes, the fishes must be caught in the feeding grounds and the intestines preserved immediately.

1 Таблица 1

2 Сравнительные показатели численности и биомассы олигохет и процентное отношение их к общей численности и биомассе донной фауны на 1 $м^2$

3 Водоем	4 Численность		5 Биомасса	
	6 $экз/м^2$	%	7 $г/м^2$	%
8 Днестр (среднее по двум станциям — Каменка и Дубоссары)	362	25	0,32	2
9 Участок Днестра на месте образования Дубоссарского водохранилища	742	40	0,84	30
10 Пойменный водоем (Кучурганский лиман)	2660	63	3,64	5
11 Дубоссарское водохранилище	7013	77	15,31	40
12 Малые водохранилища	3379	65	4,66	35
13 Пруды	3060	70	9,76	80

Key to Table 1: 1. Table 1 2. Comparative indicators of the abundance and biomass of oligochaetes and their percentage contribution to the total abundance and biomass of the benthic fauna in 1 m^2 3. Body of water 4. Abundance 5. Biomass 6. Specimens/m^2 7. g/m^2 8. Dniester (mean for two stations - Kamenka and Dubossary) 9. The reach of the Dniester where the Dubossary reservoir has been formed 10. Floodplain body of water (Kuchurgan lagoon) 11. Dubossary reservoir 12. Small reservoirs 13. Ponds

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The food value of oligochaetes is indisputable. Attention was drawn to this long ago by Klust (1935) and Yablonskaya (1935), and it has been confirmed in recent years by many investigators. Attention should be paid to the research of Birger (1957), Grigyalis (1963) and Timm (1964), who have demonstrated that, far from being inferior to other fodder hydrobionts with respect to the percentage content of certain nutrients and to digestibility, oligochaetes take first place. The content of dry matter in the tubificid body is 15 - 26%, of which only approximately 7% is ash, while the rest consists mainly of protein (46 - 58%), carbohydrates (15 - 24%) and lipids (11 - 15%).

Analyses of the contents of 1615 food boluses of 20 species of fishes were obtained by processing a large amount of factual material on the feeding of fishes. We give below the frequency of occurrence and proportionate contribution of oligochaetes in the intestines of fishes of the Dniester Basin:

Fish	Number of Food Boluses Investigated	Percentage Frequency of Oligochaetes	Mean Percentage Ratio of Oligochaetes to the Weight of the Food Bolus
Sterlet	159	31	9

Fish	Number of Food Boluses Investigated	Percentage Frequency of Oligochaetes	Mean Percentage Ratio of Oligochaetes to the Weight of the Food Bolus
Sevryuga	1	-	-
Whitefish	81	81	16
Pike	7	14	-
Roach	88	5	1
Chub	62	21	18
Asp	80	5	7
Undermouth (*Chondrostoma nasus*	66	3	-
Gudgeon	52	23	19
Barbel	9	66	-
Bream	95	31	8
White-eyed Bream	104	31	36
Vimba	350	21	13
Pond Carp	20	50	24
Wild Carp	26	10	-
Crucian Carp	171	59	-
Catfish	5	20	-
Pike-Perch	55	9	3
Perch	100	3	0.2
Ruffe	78	9	8

The frequency of oligochaetes varied in the range between 14 and 100% in the food boluses of most of the fishes investigated. It may be noted in passing that the percentage frequency is dependent not so much on the selectivity of a benthos-feeding fish as on the presence of oligochaetes in the feeding grounds of the fishes.

The mean relative contribution of oligochaetes to the food boluses of these fishes ranged from 1 to 36% of the weight of the bolus. In some instances, however, the food bolus consisted entirely of oligochaetes, for example, the maximum weight of oligochaetes was 83% in the bolus of the gudgeon, 95% for the bream, 99% for the vimba, 99.8% for the sterlet, 100% for the asp and 100%

for the chub. The absolute weight of oligochaetes in food boluses sometimes reaches 26.7 g, as was found in the sterlet. It is not so uncommon for them to constitute 3 - 4 g of the food bolus (for example in the chub, the asp, the vimba and the pond carp).

It is evident from the foregoing data that freshwater oligochaetes are of considerable practical interest to the fish industry as well as of scientific interest and that therefore a detailed study of them merits the most serious attention.

In conclusion we consider it not inappropriate to stress once again the exceptionally important role of oligochaetes in the biological productivity of bodies of water, especially ponds and reservoirs. In these bodies of water, which have the highest fish productivity, 40 - 80% of the biomass of the benthos on which fishes feed is constituted by oligochaetes. Even in rivers and in bodies of water on the flood plains, where molluscs, amphipods and secondarily aquatic hydrobionts predominate in the benthic fauna, oligochaetes account for as much as 2 - 5% of the biomass.

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FRESHWATER OLIGOCHAETA AND THEIR IMPORTANCE AS FOOD FOR FISHES

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Summary

Information is given concerning the quantity and biomass of oligochaetes in bodies of water in the Dniester Basin (Kuchurgan lagoon, Dubossary reservoir, ponds and other small bodies of water). The information given concerning the feeding of fishes on oligochaetes is based on investigation of the contents of 1615 stomachs from different species of fishes. More than 20 species of fishes feed on oligochaetes, which constitute between 14 and 100% of their stomach contents.

Bibliography: 5 titles.

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PROCEDURE FOR THE ESTIMATION OF OLIGOCHAETA IN FISH INTESTINES

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At the present stage in the development of the trophology 167
of fishes the quantitative-gravimetric method of processing gastro-
intestinal tracts is the most objective of the existing methods.
However, like every method, it is not without its defects and an
element of subjectivity in quantitative evaluation of the food of
fishes (Shorygin, 1952). It is essential to work out and employ 168
methods for the quantitative recording of food organisms which
will permit of more precise estimation.

The method of recording Oligochaeta in the gastro-intestinal tract remains one of the weak links in investigations of the food of fishes, especially benthophages.

Oligochaetes are frequently a considerable part of the benthic biomass in bodies of freshwater, especially bodies of a new type, i.e. reservoirs. For example, oligochaetes consitute 22.7% of the total quantity of macrozoobenthos in the river bed sector of the upper river part of the Dnieper, 42.7% in river arms and 55.1% in bodies of water on the flood plain (Fomenko, 1963). Oligochaetes also play a large role in foulings in beds of higher water plants. According to the data of Fomenko (1964), oligochaetes constituted 56 - 93% of the total quantity of macrophyte foulings in the lower reaches of the Dnieper. They are of great importance in the biological fouling biocoenosis of the Dnieper reservoir (Lake Lenin) and are a biological constituent of the food resources of fishes (Dyga and Lubyanov, 1967). Oligochaetes account for 75 - 80% of all zoobenthos in the same reservoir (Lubyanov and Gaidash, 1967). We know that the food value of oligochaetes is very high (Birger, 1961; Grigyalis, 1966; Timm, 1962) and that they are highly assimilable.

Oligochaetes undoubtedly play a not insignificant role in the food of fishes, but the existing means for recording them in food boluses have been inadequately worked out and are no longer capable of satisfying the demands of investigators. Many authors, while noting the importance of oligochaetes in the food of fishes, recognize that the quantitative methods for their recording are imperfect.

Underestimation of the role of oligochaetes in the food of fishes has been due to the extreme difficulty of detecting them in the intestines, where the body of aquatic oligochaetes is very rapidly destroyed (Timm, 1964). Klust (1935) notes that when carp in an aquarium are fed solely on oligochaetes nothing is to be found in the intestine five hours after the ingestion of food apart from a formless food gruel. When oligochaetes are consumed along with other organisms it is only occasionally that they are to be found in the food bolus. Carp underyearlings digest such oligochaetes as <u>Tubifex tubifex</u> (Müll) and <u>Enchytraeus albidus</u> (Henle) in 1.5 hr (Grigyalis, 1967).

Hitherto oligochaetes have been detected and recorded in the food bolus mainly on the basis of whole organisms newly ingested by the fish or fragments in the initial stage of digestion. These identifiable food components may as a rule be detected only in the anterior division of the intestine. In this case organisms may be counted without particular effort and their weight may be determined. but it is not always possible under natural conditions to obtain material at the precise moment when a fish begins to feed.

The development of a procedure for determination of the species to which oligochaetes belong on the basis of the presence of their setae in the food bolus is a very important point in the history of the study of this question (Poddubnaya, 1962). Attempts have been made to use setae to determine the number of oligochaetes ingested. Essentially the method is one of counting the number 169
of setae and dividing this number by the mean number of setae of one oligochaete to obtain the number of organisms consumed.

Employing the various techniques referred to above, many authors have attempted to elucidate the considerable importance of Oligochaeta in the food of fishes: sturgeons (Mel'nichuk, 1958), bream, wild carp, white bream (Aristovskaya, 1954; Egereva, 1960; Zhiteneva, 1958; Zaitseva, 1962; Kogan, 1958; Yaroshenko et al, 1960, 1967) and young pike and perch (Makkoveeva, 1952).

Without detracting from the importance of the methcd of recording oligochaetes on the basis of their setae, we have to recognize that it is vastly inaccurate and limited. As has been noted by Chekanovskaya (1962), setae are formations with a short life which rapidly become worn and drop off; in addition, setae of all types (especially hair-setae) frequently break off. Therefore there are grounds for the assertion that oligochaete setae may be ingested by fishes along with ooze as remains of the corpses of oligochaetes. This is also confirmed by our experiments.

Following the confirmation in trophological research of the most objective quantitative and gravimetric method the defects of the method of recording oligochaetes on the basis of setae are particularly apparent. It is not without reason that many authors confine themselves in their works on nutrition to recording oligochaetes in the food bolus under the heading "frequency of occurrence". The high percentage error in the quantitative recording of oligochaetes on the basis of setae is further explained by the fact that the number of setae in a bundle and the number of segments in each specimen vary greatly in different species and in different stages (from 2 to 25 setae and from 3 - 5 segments to several hundred).

We conducted a series of experiments on young carp in the years 1963 - 1966 to determine the degree of digestion and the possibility of recording oligochaetes in the intestines of fishes.

Juvenile carp of length (l) 78 - 110 mm and weight 11.8 - 30.8 g were kept in aquaria with a capacity of 15 litres. Water temperature in them did not exceed 20.5°C (range from 18.4 to 20.5°C) and oxygen content was maintained at a level of 4.69 mg/litre (range from 3.68 to 6.64 mg/litre) with a mean percentage saturation of 49.18%.

The carp used in the experiments were fed on the oligochaetes *Limnodrilus hoffmeisteri* Clap., *L. udekemianus* Clap. and *Tubifex tubifex* (Müll.). The fish were dissected at various intervals after feeding: every 30 min for 6 hours. The experiment was repeated three times, in two variants (with the most limited feeding and with abundant feeding). When processing the intestines attention was paid to the position of the food bolus in the intestine, to the extent of its digestion etc. The contents of the intestines were examined under MBR-1 and MBS-2 microscopes.

The analysis of the food was preceded by preliminary processing of the contents of the intestine. There is usually much mucus in the food bolus, especially when the intestine is only slightly filled. In order to facilitate examination of the food bolus, we employed 5% alkali solution (KOH) as recommended by Zhiteneva (1958). The mucus was broken down into small particles under the influence of the alkali and this considerably facilitated examination of the contents.

Analysis of the contents of the food bolus in the fishes 170
investigated revealed that oligochaetes of the species referred to above were semi-disintegrated after 30 minutes spent in the intestines of the juvenile carp and had acquired the consistency of liquid gruel within an hour.

After preliminary processing and careful examination of this gruel under the microscope we succeeded in detecting the transparent "integumental membranes" of the oligochaetes with bundles of setae. After oligochaetes have been in the intestine for an hour they acquire the appearance of a transparent cord, scarcely to be seen even under the microscope, and only the presence of setae enables them to be detected. Such "integumental membranes" are fairly durable and may be extracted with comparative ease from the food gruel with a dissecting needle. We succeeded in detecting "integumental membranes" with setae in the fore, middle (Fig. 1) and hind divisions of the intestine, and also in excrement (Fig. 2) without great difficulty. This indicates that oligochaetes and their setae are not completely digested in the intestines of fishes and may be recorded when studying their food.

We used stains to make it easier to count the "integumental membranes": fuchsin, alkaline methylene blue and carbol-gentian violet. Only weak solutions of dilute stains may be suitable for this purpose, since the "integumental membranes" become brittle under the influence of more concentrated solutions. The use of these stains appreciably improves the detection of oligochaetes in fish intestines.

Staining the contents of the intestines enabled us to detect a considerable quantity of "integumental membranes" of Oligochaeta in the bream (Figs. 3 and 4) and the white bream (yearlings and older) from the middle reaches of the Dnieper (1961 - 1963) and the Dneprodzerzhinsk reservoir (1964 - 1966).

It is possible by isolating the "integumental membranes" of oligochaetes from the total mass of the food bolus of fishes and by measuring their length and thickness to arrive at a more accurate estimate of oligochaetes in the food of fishes. One essential condition here is the availability of data on the qualitative composition and abundance of oligochaetes in the body of water concerned and also on the average size and weight of a single individual of the various species.

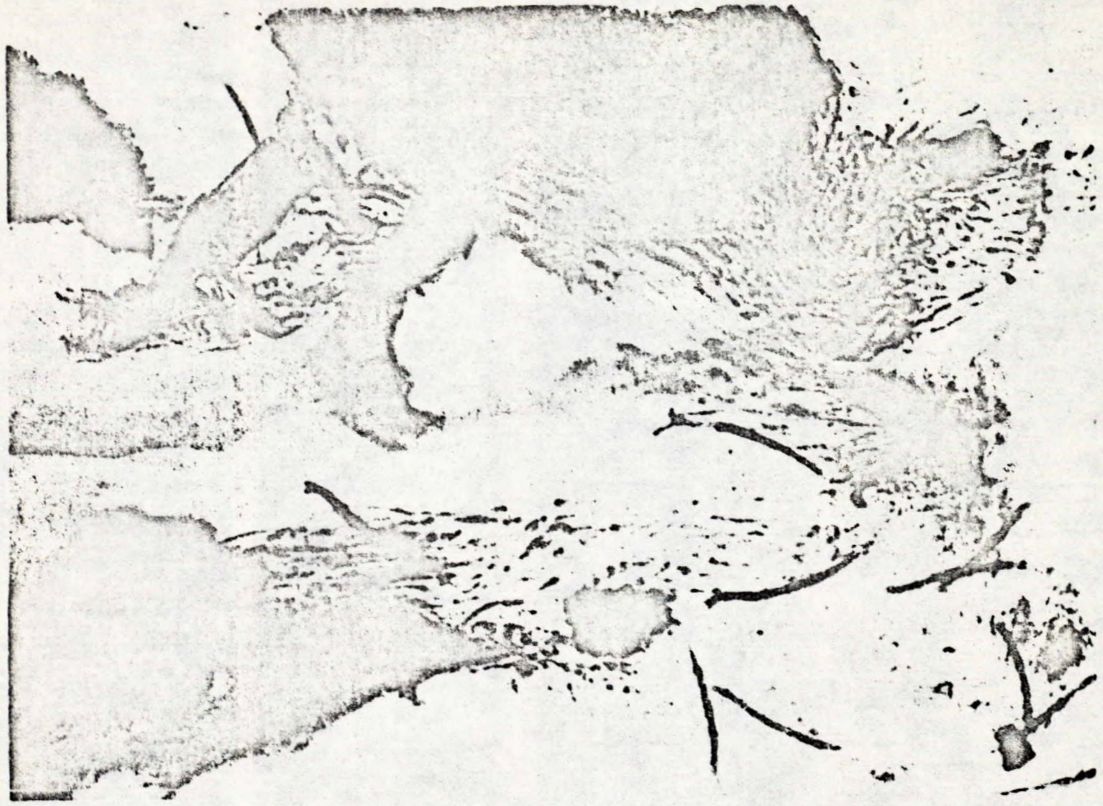

Рис.1. "Покровные оболочки" олигохет из среднего отдела кишечника молоди карпа, окрашенные фуксином.
Время пребывания в кишечнике – 2 часа 30 мин. Увел. 200.

Fig. 1. "Integumental membranes" of oligochaetes from the middle division of the intestine of a juvenile carp stained with fuchsin. Time spent in intestine 2 hr 30 min. x 200

Рис.2. "Покровная оболочка" олигохеты в экскрементах молоди карпа, окрашенная метиленовой синькой. Увел. 400

Fig. 2. "Integumental membrane" of an oligochaete in the excrement of a juvenile carp, stained with methylene blue. x 400.

Рис.3. "Покровные оболочки" олигохет из среднего отдела кишечника леща Днепродзержинского водохранилища, окрашенные генциавиолетом.
Увел.400

Fig. 3. "Integumental membranes" of oligochaetes from the middle division of the intestine of a bream from Dneprodzerzhinsk reservoir, stained with gentian violet. x 400.

Рис.4. "Покровные оболочки" олигохет из заднего отдела кишечника леща Днепродзержинского водохранилища, окрашенные метиленовой синькой.
Увел. 200

Fig. 4. "Integumental membranes" of oligochaetes from the hind division of the intestine of a bream from Dneprodzerzhinsk reservoir, stained with methylene blue. x 200.

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PROCEDURE FOR THE ESTIMATION OF OLIGOCHAETA IN FISH INTESTINES

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Summary.

It has been experimentally established that the tubificids *Limnodrilus hoffmeisteri* Clap., *L. udekemianus* Clap. and *Tubifex tubifex* (Müll.) are not completely digested in the intestine of juvenile carp; their transparent "integumental membranes" remain along with bundles of setae. "Integumental membranes" were discovered in the fore, middle and hind divisions of the intestine, as well as in the excrement of the fish. Considerable quantities of the "integumental membranes" of oligochaetes were found in the intestines of bream and white bream from Dneprodzerzhinsk reservoir following staining of their contents with weakly dilute solutions of alkaline methylene blue, fuchsin and carbol-gentian violet.

Bibliography: 22 titles.

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THE DIGESTION OF TUBIFEX TUBIFEX (MÜLLER) AND ENCHYTRAEUS ALBIDUS HENLE BY CARP UNDERYEARLINGS

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Aquatic oligochaetes (Oligochaeta limicola) are of great importance /177 in the feeding of benthophagic fishes and also in the cycle of matter in bodies of water as accelerators of the mineralization of organic matter, that this importance has hitherto been little investigated.

There is little published information on the feeding of freshwater fishes in bodies of water in Lithuania: we know of works by Kublitskas (1957a, 1957b, 1959, 1961, 1962), Lapinskaite (1959, 1964), Vashkyavichene (1960) and Vashkevichyute (1958a, 1958b, 1959).

Oligochaeta are most intensively consumed by bream (Abramis brama), especially in the summer, when there is a reduction in the quantity of larvae of aquatic insects. According to the data of Kublitskas (1957a), oligochaetes account for up to 14.6% of the food of the bream in the central part of the Kurshyu-Mares*, up to 10.7% in the southern part and even as much as 88.0% in the northern part. The percentage of oligochaetes in the food of bream in the lagoon was not the same in different years.

* Translator's note. Kurshyu-Mares = Kurisches Haff = Courland lagoon.

Quite a few oligochaetes are consumed by the white bream (Blicca bjoerkna) and the pope (Acerina cernua). In the autumn of 1955 the vimba (Vimba vimba) consumed oligochaetes very intensively in the southern part of the Kurshyu-Mares. According to the data of Kublitskas (1957b), oligochaetes constituted 30.0% of the entire food of the vimba.

In the Nyamunas (Neman) River oligochaetes have been recorded in the intestines of chub (*Leuciscus cephalus*). Kublitskas (1962) and Vashkevichyute (1959) note that juvenile perch, gudgeon and pope feed on oligochaetes.

It has been established that the frequency of oligochaetes in the food of juvenile carp in the ponds of the 'Rita Ausma' fish farm (Latvia) is 60 - 77% (Lapinskaite, 1958), which suggests that oligochaetes play a large role in the food of carp.

There is published information (Zabolotskii, 1961; Gerd, 1950) to indicate that oligochaetes play a relatively small role in the food of fishes. Gerd (1950) considers that oligochaetes burrow into the bottom to a depth of 12 - 20 cm and are therefore unavailable to fishes. Underestimation of the role of oligochaetes in the feeding of fishes stems from the extreme difficulty of detecting them in the intestine.

Borutskii, Klyuchareva and Nikol'skii (1952) note that oligochaetes frequently play a large role in the feeding of Amur fishes, although they indicate that no procedure had been developed for the identification of their remains in the intestines of fishes. In their opinion, it was a task for the immediate future to work out a procedure for identification of the remains of oligochaetes in the intestines of fishes.

Some authors have succeeded in identifying and recording a number /178
of oligochaete species by the presence of setae in the intestines of fishes (Poddubnaya, 1962). The presence of oligochaete remains in the intestines of fishes is dependent on the length of time for which they were present in the intestines.

Since oligochaetes are digested more rapidly and completely than other benthic organisms, it is very difficult to establish their precise weight and to estimate their contribution to the food of fishes. It is thought that more are consumed by fishes than is established by investigators. We conducted an aquarial experiment to establish the rate of digestion of oligochaetes by carp underyearlings.

Experimental procedure. There were two variants of the experiment, each involving 14 carp underyearlings weighing 15 - 20 g obtained from the ponds of the T. Voke experimental base. The underyearlings were placed in aquaria in which water temperature was 18.2°C and kept there for 23 hours. Various lower benthic organisms were given as food. When the oligochaetes *Tubifex tubifex* (Müll.) were introduced into the aquarium in the morning the small fishes began to consume them. Two of the underyearlings were taken 30. min after the end of feeding, the heads were cut off and the bodies were preserved. A similar operation was conducted every 15 min., i.e. 45, 60, 75, 90, 105 and 120 min. after the underyearlings had consumed the worms.

The same experiment was conducted twice after the underyearlings had previously been fed on enchytraeids (*Enchytraeus albidus* Henle).

Research results. Analysis of the intestines revealed that the oligochaete species concerned were half disintegrated after 30 minutes in the stomachs of the carp underyearlings. Within 45 min. all that remained of them was a liquid gruel containing setae, a part of which was in the midgut. Within 60 min. approximately 50% of the liquid gruel containing setae remained in the stomachs, while the remainder had passed into the midgut. Within 75 min. there was little of the liquid gruel containing setae in the stomachs; the bulk of it was in the midgut. After 90 min. only traces of the oligochaete gruel were to be found in the carp stomachs. The bulk of the liquid gruel was in the midgut and a part of it, including setae, was in the hindgut. After 105 min. the bulk was found in the midgut and approximately a quarter in the hindgut. After 120 min. there was little of the oligochaete gruel in the midgut and the bulk was in the hind-gut.

Discussion.

It follows from the above account that carp underyearlings digest Tubifex tubifex and Enchytraeus albidus rapidly at a water temperature of 18.2°C, i.e. within 1.5 - 2.0 hr. Remains of chironomid larvae and Daphnia are to be found in the intestines of underyearling carp as long as 24 hours after their ingestion. Investigators do not agree concerning food selectivity in fishes.

It was noted under laboratory conditions that when carp under- /179 yearlings were fed on different zoobenthic organisms they took chironomid larvae and oligochaetes for preference.

There are references to the importance of oligochaetes in the food of the carp in the writings of Dunaeva (1941), Komarova and Musselius (1958) and other authors. Kruglova (1951) notes that crucian carp take oligochaetes for preference and that, for example, the incidence of oligochaetes in the food of the crucian carp in Lake Peschanoe reaches 79.9%.

Kokhnenko and Borovik (1957) analyzed the food of young eels and established that they lived mainly in the littoral zone on muddy bottoms covered with submarine vegetation and that to a depth of 4 m their food consisted of the larvae of chironomids and other insects, oligochaetes and entomostracans.

Miroshnichenko (1958) and Kaftanikova et al (1961) regard oligochaetes along with chironomid larvae, malacostracans and molluscs, as valuable food for the benthophagic fishes of Tsimlyansk reservoir.

More accurate data on the utilization and assimilation of oligochaetes by fishes and their role in the nutrition of fishes may be obtained by the use of radioisotopes and these should be used in future.

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THE DIGESTION OF *TUBIFEX TUBIFEX* (MÜLLER) AND *ENCHYTRAEUS ALBIDUS* HENLE BY CARP UNDERYEARLINGS

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Summary. /191

An account is given of the rate at which the oligochaetes (Oligochaeta limicola), *Tubifex tubifex* (Müller) and *Enchytraeus albidus* Henle are digested by carp underyearlings at a water temperature of 18.2°C on the basis of experimental data obtained by the author under laboratory conditions.

The oligochaetes *T. tubifex* and *E. albidus* consumed by the carp underyearlings were semi-disintegrated within 30 min. After 45 min. all that remained of them was a liquid gruel containing setae, a part of which was in the midgut. After 60 min. only 50% of the *T. tubifex* and *E. albidus* gruel remained in the stomachs of the carp underyearlings. The bulk of the *T. tubifex* and *E. albidus* liquid gruel was present in the midgut of the carp underyearlings at between 75 and 100 min. After 120 min. the bulk of this liquid gruel was in the hindgut.

The oligochaetes *T. tubifex* and *E. albidus* are digested in 1.5 - 2.0 hr by carp underyearlings.

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