Vinberg, G.G. (Edit.). The Methods for the Estimation of Production of Aquatic Animals (Handbook and Papers). Soviet National Committee of IBP of the Academy of Sciences of the USSR. Minsk. 1968. Part 2, 226-239. Production of the Chironomids of the Uchinsk reservoir*.

H. Yu Sokolova.

(Moscow State University)

Translated by J.W.G. Lund.

The method of E.V. Borutski was used for determining the production of chironomids, that is, the dynamics of the number and biomass of the larvae were analysed, their death, a calculation of emergence and the number of deposited egg layings was carried out. In addition to the method of Borutski , we also calculated the seasonal dynamics of the number of larvae of the younger age stages in the microbenthos.

Direct investigations of the production of chironomids was carried out from 1962 to 1966, this was preceded by a many-yeared study of the metamorphosis and biology of mass species by the author and a group of aspirants and students (Baz' 1959; Kalugina 1959, 1960; Koreneva-Muragina 1957, 1959a, b, 1960; Sokolova 1959a, 1961; Sokolova and Koreneva 1959; Silina 1959). Towards the beginning of the work in August 1962 there was carried out a routine survey of the species of chironomids, as a result of which have been established the ranges of separate species of chironomids and outlined the limits of the bottom biocoenoses. The localities of the most characteristic stations for a given water body were marked by buoys with traps and laying traps. The buoys were set up in the open part of the reservoir (the fauna of the chironomids of the macrophytes and protected bays was not calculated) at depths of 0.5-0.7; 2; 3; 5; 7; 10; 12; 15 m.

As our observations have shown, the trustworthyness of the catches of the traps and egg-laying traps depends on the construction of the buoys, which should comply with the following demands:

1. The above-water part of the buoy should be of small dimensions, so as not to attract insects to the firm substrate for the laying of eggs.
2. Traps should be sunk under the water sufficiently low, so as to decrease the amplitude of their oscillation during rough weather**.

The construction of the buoy, proposed by A.V. Frantsev (fig. 1), answers such demands. Laying trap and trap have a conical form with the area of the broad aperture of the cone, 0.25-0.5 m^2, made of brass net with mesh - 0.5-0.6 mm. (the egg trap can be Kapron*** mesh). The trap is crowned with the glass trap of Borutski (1955), a glass vessel is attached to the laying trap. One should take the trap and laying trap out of the water periodically and dry them out in order to avoid the appearance of overgrowths. We, as a rule, checked the traps and laying traps daily.

*Note: Here and elsewhere I have kept close to a literal translation to avoid mistakes. The translation of the title of the paper given in the back of the book is:- Production of Chironomids in the Utchinky reservoir. 'Utchinky' is incorrect, literally it is the Uchinsk Reservoir.

**Literally, 'waviness'.

***Kapron is some kind of nylon.

Close to the buoys, samples were taken with the weighted mud scoop of Ekman-Berg, 2-3 samples at each station. From June to September, samples were taken every week, in autumn and spring twice a month and in winter 2-3 times per season. In the region of a buoy there was set up a definite succession in the taking of the mud-scoop series to this end, that the apparatus did not fall twice in the same place. Samples of microbenthos were taken in summer twice a month, in autumn, spring and winter - considerably more rarely.

After careful washing through of the sediment out of the mud scoop samples, the larva were picked out, identified, measured under a binocular and weighed on a torsion balance according to species and age, after which their dry weight was determined. For this the larvae picked out of the samples were kept in byuks* in a thermostat at a temperature of 60 C. up to their attainment of constant weight, and weighed on an analytical balance. Dead specimens from the mud scoop samples were estimated separately. The dry weight of larvae from the microbenthos was estimated on the basis of the relationship P/l^3 = const. (Konstantinov 1962) and, according to the indices, the wet weight was established first and dividing it by 5 (on the average the dry weight is five times less than the wet weight) - the dry weight of the larvae. The weight of an egg was equated to the weight of a day-old larva.

Figure 1. Sketch of a buoy.

With division of the total mass of larvae (concordant with the multiplication of the given separate stations per area of mud in the limits of the range of the species) by their total number, we obtained the mean weight of a specimen of the population of a species. Such a method made it possible to reduce the error of quantitative results, mechanically increasing the number of mud scoops, because in these calculations were estimated all stages where the larvae of the investigated species were encountered. Moreover, the influence of the migration of the larvae was excluded, because the population was examined as a whole in the whole water body. All calculations and final results are given in dry weight.

As a basis for the calculations of the production of chironomids the principle of Boysen-Jensen (1919) was taken. In contrast to the enumerations of the production of chironomids according to the method of Borutski , in this case was taken as the starting point not the maximal number of larvae before the emergence of the imagos but the number of eggs laid, that is not one of the last periods of fulfilment of the life cycle but its beginning. Calculation of the number of larvae of younger age permitted the calculation of production of chironomids in those intervals of time when there occurs the increase in the numbers of larvae, as a consequence of the change over from their younger age - not estimatable by the usual methods - to older age, and also the production of small chironomid species.

The calculation of production (P) includes the following elements: the number of eggs laid, the growth of hatched larvae, elimination and loss of matter during metamorphosis (a). Elimination consists of the emergence

*I cannot find the meaning of byuks but it is probably only some kind of suitable container.

of the imagos L, ingestion by fish and carnivorous invertebrates (E), deaths from other causes (during moulting, from unfavourable conditions - M). Calculation of production we carried out according to the periods in which the life cycle of the species was divided. The shorter the period, the more exact the calculation. The elimination of the numbers and biomass of the larvae was worked out for each period separately. The elimination of biomass was estimated according to the formula of Boysen-Jensen,

$$(N_1 - N_2)\frac{W_1 + W_2}{2},$$

where N_1 is the number of larvae at the beginning of the period; N_2 is the number of larvae at the end of the period; W_1 is the mean weight of a specimen of the population at the beginning of the period (we assume that for short segments of time there will not be a big mistake in estimating the growth of the larvae as close to rectilinear); W_2 is the average weight of a specimen of the population at the end of the period. In the calculation of the elimination of biomass was estimated also the growth of the larvae.

For calculation of the decrease of larvae as a consequence of their death from unfavourable ecological conditions and during metamorphosis (M), was determined what percentage consisted of dead larvae out of the total number of larvae in the series of mud scoop samples for the period investigated. After this was established what size this percentage is from the total number of eliminated larvae for the given period. Elimination on account of grazing (E) was determined as the difference between the abundance of larvae at the beginning and end of the period, deducting death from other reasons and flying away.

Loss of matter during hatching of the gnats (a) was estimated according to Yablonskaya (1947), that is according to the weight of a mature larva, close to pupating, accepting, according to our own and published data, that during pupating and during hatching out of the pupa, the imago loses 30% of its dry weight - 30% $(L + M_i)W_p$ (loss of matter during moulting between other age stages was not estimated separately and went into the estimations of elimination of biomass in grazing and from other causes). Death of pupae and of gnats during metamorphosis M. was taken conditionally as 13.2% of the number of pupae and gnats in the traps. The percentage got in relation to live and dead pupae and gnats in early spring catches of the traps with their daily checking when, because of the low temperature of the water, the chances of their death from abnormal conditions of emergence of the adults in the traps, as compared to natural conditions, was comparatively the least. When the larvae are very small, it is impossible to calculate the dead ones directly in samples and, consequently, it is impossible during estimation of the elimination to demarcate grazing and elimination from other causes. In such cases we united both elements of elimination. Unfortunately we did not succeed in determining the production of all species. Thus, for example, we determined the production of the combined group, Procladius (Procladius ferrugineus Kieff., P. choreus Meig., P. nigriventris Kieff., Psilotanypus rufovittatus v.d.Wulp.) without separation into species, in connection with the fact that in young age stages the larvae are not morphologically discernable. Also we had to unite the production of the mass species of Tanytarsini (in the main Cladotanytarsus mancus Walk., C. atridorsum Kieff., T. holochlorus Edw., T. eminulus Walk.), in so far as it was impossible by direct weighing of the larvae from samples to establish the dry weight of representatives of the separate species. Apart from the ones enumerated above, the production was determined of the following species: Chironomus anthracinus Zett., Ch. plumosus L., Lauterborniella brachylabis Edw., Polypedilum nubeculosum Meig., P. bierenatum Schrnk., Limnochironomus pulsus var. objectans Walk., Microtendipes pedellus Deg., Cryptochironomus ex gr. defectus Kieff., Psilotanypus imicola Kieff.

During the partitioning of the life cycle of a species in separate periods we were guided by definite landmarks in its biology. Thus, for example, as in Danish water bodies according to the investigations of Johansson (1961, 1965), so also in the Uchinsk reservoir, in the course of all the years of investigations, the most intensive growth (in dry weight) of the larvae Ch. anthracinus occurs in autumn (in September-October); of winter growth there is either none or a decrease of mean dry weight of the larvae is observed with a lack of variation of the wet weight, but in spring again a small increment of weight takes place before its sharp decrease during pupation (fig. 2, 3, 4).

Figure 2. Absolute increase of weight of the larvae of Chironomus anthracinus (in mg. mean dry weight per single specimen). Horizontal axis, months; vertical axis, dry weight in rag.

Figure 3- Relative increase of dry weight of the larvae of Ch. anthracinus according to the formula of Brodie*:

$$R = \frac{c.100}{\frac{1}{2}(w_1 + w_2)}$$

c - mean absolute increase: w_1 original weight; w_2 - final weight.
Horizontal axis, months; vertical axis, percent.

The greater the growth was of the larvae in autumn, so much the less it turned out to be in spring. The growth curve in 1962 diverged from that of the remaining years. The growth of the larvae was much slowed down in the cold and wet summer of 1962, more intense growth was already beginning in August, however the absolute growth increment turned out to be insignificant. It attained the greatest size in an unusual month for this species - in June of the following year, where, as in normal years according to the meteorological conditions, towards the end of May already the emergence of the imagos is being concluded. Consequently, according to the dry weight of the larvae in autumn, it is possible to predict how early will occur the emergence of the imagoes in the following year.

The same intensive growth was observed in the larvae of Procladius approximately two weeks before the mass emergence of the imagos. If we had not taken into account this intensive, short period growth, the calculations of production would be found to be over-estimated.

Figure 4. Growth in weight of larvae of Chironomus anthracinus (in mg. average dry weight per single specimen). Horizontal axis, months; vertical axis, mg. per specimen.

*or, perhaps, Brodi.

For species having one generation per year with not long drawn out periods of multiplication, the calculation of production is far more simple. An example of the calculation of the production of Ch. anthracinus is given in table 1.

Table 1. Calculation of production of Chironomus anthracinus.

Headings to columns, from left to right:- period; index of period; number of specimens up to the end of period, N, millions of specimens; number of dead, M, millions of specimens; elimination in the number of specimens, F, millions of specimens; dry weight of one specimen up to the end of period, W_1 mg; mean dry weight of a specimen for the period, W, mg; biomass of dead specimens, Mw, kilograms; elimination of biomass, Ew, kg. Column below heading - period (i.e. left hand column from above down):- eggs; from laying of eggs to appearance of young; from appearance of young to period of autumn growth; autumn growth; from autumn to emergence of imagos; period of emergence of imagos; eggs. Bottom horizontal column - total.

Footnotes to table:-

1. together with dead ones, that is $(E_1 + M_1) = (N_o - N_1)$ and $(E_1 + M_1)w$.
2. number of emerged imagos.
3. number of pupae which have died during emergence of the imagos.
4. weight of imagos - w_i.
5. weight of pupae - $w_p = w_4$.
6. weight of dead imagos M_i = 36.59 x 1.6 = 58.54.
7. 1974 = 978.7 x 2.7 - 240.7 x 1.6 - 36.6 x 1.6 - 224.6; 224.6 - losses of matter during metamorphosis, . equal, according to E.A. Yablonskaya (1947), to thirty percent of the weight of a pupa: 0.3 (24l + 36.6 x 2.7) = 224.6.

$E_n = N_{n-1} - N_n - M$, for example = 22363 - 2729 - 373 = 19261.

$W_n = \frac{W_{n-1} + W_n}{2}$, for example = $\frac{0{\cdot}051 + 0{\cdot}37}{2}$ = 0·21.

Exactly in the same way we carried out the calculation of production of species having two clear-cut generations in a year. The production of species with prolonged emergence and periods of laying of eggs was more complex and, apparently, was calculated with a larger error. In connection with the prolongation of the period of multiplication up to the times of the emergence of the autumn generation, there was always in the benthos a certain part of the larvae still of the spring-summer generation. In the enumeration of the production in such a case it is fitting to carry out a double calculation - for bigger or smaller larvae, guided by the intensiveness of their growth during given temperature conditions in the water body.

Table 2. Production of mass species of chironomids in Uchinsk reservoir for the year and P/B coefficients .

Headings to columns, left-hand side - species; right-hand side, three upper headings from left to right - P. Kg of dry weight per hectare, P/B yearly mean, P/B maximum. Six lower headings in pairs under the three upper, from left to right - from 1963 to* 1964, from 1964 to 1965, from 1963 to 1964, from 1964 to 1965, from 1963 to 1964, from 1964 to 1965.

Footnote 1. In the denominator P/B in the first two columns is given the mean yearly biomass, calculated exactly for that same interval of time as production; in the second two columns is given the sum of the sizes of the maxima of biomass for that same period.

In table 2 has been listed the production of chironomids, calculated by the above-mentioned method as the average for the whole area of the reservoir (without taking account the growths** of macrophytes) approximately for a year - from the time of the laying of the eggs of the over-wintering generation and beginning of the development of the spring-summer population to the time of the laying of the eggs of the succeeding over-wintering generation.

As follows from the above table, Chironomus and Procladius have the greatest amount of production, which as a whole constitutes three quarters of the gross production of the chironomids of the Uchinsk reservoir.

Corresponding to that period of time for which was calculated the production of separate species of chironomids, was also determined their mean yearly biomass. On account of the unequal value of the number of samples in different seasons, for calculation of the average yearly biomass we found the average biomass by weight for each season. From the fact that part of the life cycle in certain species falls at the end of summer in one year, but is concluded in the summer of the following calendar year, we calculated the average biomass by weight for each corresponding section of the summer separately and divided the sum of the means for each season not by 4 but by 5. By the division of the yearly production of a species by its average yearly biomass were obtained the coefficients, P/B (see table 2).

It turned out that the lowest were species with a long life cycle (one generation per year) which were living in the profundal - Chironomus anthracinus 2.9-4.5 and Psilotanypus imicola 4.8-5.9; somewhat higher in species having one full and one part generation per year and distributed in all parts, but the most abundant in transitional regions between the littoral and profundal - Chironomus plumosus 6.8-8.8, Polypedilum nubeculosum 6.2-10.0. The littoral species with short life cycles attain the highest P/B coefficients, Tanytarsini 32.7-36.5, Limnochironomus 16.2-24.0, Polypedilum bicrenatum 6.7-7.6, Microtendipes pedellus 10.6-14.0. The collective group of species, Procladius also has high P/B coefficients (18.2-26.8), having 1.5-2.0 generations per year, with very mobile, predominantly carnivorous larvae existing in all parts. M.N. Kasatkina (1960) showed that the larvae of chironomids in the Uchinsk reservoir have two levels of metabolism - lower in Ch. anthracinus and Pseudochironomus prasinatus, higher - in littoral forms existing in the beds of macrophytes - in larvae of Endochironomus, Glyptotendipes, Cricotopus. Unfortunately we do not have available data on the intensity of the gas exchange of just those littoral species whose production was determined by us. However it is reasonable to suppose that the level of their exchange is near to the level in the above-mentioned species from weed beds, that is that it is higher than in Ch. anthracinus.

*here and elsewhere the word 'po' is translated as 'to'. It is not clear to me whether it means 'up to' or 'through'.

**zarosl' means 'thicket' or 'undergrowth'. Therefore I presume the author refers to more or less dense weed beds.

For comparison of the amount of production and the P/B coefficient of Chironomus plumosus in various water bodies, we calculated them by exactly the same method as Borutski calculated them, that is for the original biomass we took for calculations its maximal value: in 1963 in the Uchinsk reservoir this was in spring before the mass emergence of the imagos, in the remaining years - in autumn (table 3).

Production of Ch. plumosus in White (Beloe) lake is 10-16 times greater than in the Uchinsk reservoir, however its relationship to the original biomass in both water bodies was very close, although the conditions of existence of the species differed markedly.

Equally similar values of the P/B coefficients, calculated by an analagous method (according to Borutski), were got also for the other species of Chironomus of the Uchinsk reservoir - Chironomus anthracinus 2.2, 3.2, 3.7.

Table 3. Production of Chironomus plumosus and its relationship to the original biomass in White (Beloe) lake and the Uchinsk reservoir (calculation according to Borutski).

Horizontal headings, from left to right:- Water body. Yearly production, Kg/hectare of dry weight. P/B. Author. Vertical headings: from above downwards

Left-hand White (Beloe) lake.
Uchinsk reservoir
1963
1964
1965

Right-hand (names of authors)
Borutski
Sokolova
Sokolova
Sokolova

The amounts characterising the relation of production for the period of one life cycle to the maximum biomass for this very period, with a calculation of the production of young larvae, with computations by our method, are close to these coefficients of the column. The limits of the fluctuations of these coefficients in different species are not great - from 5.1 to 1.3 - and many times less than the fluctuations of the relation of production to the average yearly biomass (see table 2). Investigations on water bodies of various types in diverse geographical zones can show how far the maximal sizes of P/B are specific for the family of chironomids as a whole.

In connection with the fact that the beginning and end of the life cycles of the separate species do not correspond in time, we were forced to have recourse to the following method for the calculation of the gross annual production of chironomids. Beginning with May, adopted conditionally as the beginning of the year, the calculated stage by stage production of each species was summed up in succession up to May of following year. The periods for which production was calculated did not correspond to the beginning and end of the life cycle of a species. In the summed-up amount has fallen part of the production of the preceding year's generation (the period from the beginning of May to the emergence of the imagos) and incomplete production of the generations (if there are two of them) of the following year, that is after deduction of the production for the period from the beginning of May to the emergence of the imagos in the following calendar year.

The summed production of chironomids, related in the character of the nutrition to the second trophic level, in the Uchinsk reservoir in 1963-1964 consisted of about 20 Kg/hectare (according to the data of Koreneva and Izvekova, certain species of Procladius and Psilotanypus, in the conditions of the reservoir, feed to a considerable degree on algae, therefore we will relate their production equally to the second and third trophic layers). The surprising constant amount of production for both years attracts attention. In 1963 the annual production of the investigated 'peaceful' species of chironomids was 18.09 and in 1964 - 17.39 Kg/hectare (table 4), the production of carnivorous species of chironomids in 1963 - about 4.5 Kg/hectare; in 1964 - about 3.7 Kg/hectare.

The annual production of the species of chironomids we investigated of the second trophic level in the littoral (to a depth of 3 m) in both years was about 22 Kg/hectare, if one rounds it off, by adding the production of the non-mass species, which we did not calculate exactly, then it is about 25 Kg/hectare. Production of carnivorous species was about 4 Kg/hectare, but in 1964 - about 3.0 Kg/hectare (table 5).

Table 4. Heading:- Annual production of chironomids of the Uchinsk reservoir and their average yearly biomass. Kg/hectare, dry weight.
Column headings, left to right:- Trophic level. Production. Average yearly biomass. Next line:- from 1963 to 1964, from 1964 to 1965, from 1963 to 1964, from 1964 to 1965. Vertical columns, 'trophic level' - Second. Third.

Table 5. Yearly production of the chironomids of the Uchinsk reservoir by depth zones, Kg dry weight per hectare.
Horizontal headings, top line, left to right:- littoral (to 3 m.). Transitional zone (from 3 to 7 m.). Profundal (from 7 m. and deeper). Lower line, left to right. From 1963 to 1964, from 1963 to 1964, from 1964 to 1965, from 1964 to 1965, from 1963 to 1964, from 1964 to 1965. Vertical headings. From top down. Trophic level. Second. Third.

In the profundal, the production of chironomids of the second trophic level was 20.5-l8.6 Kg/hectare, of the third trophic level - about 5-4 Kg/hectare. In the transitional zone, the production is considerably less: 11-10.6 and 3.69-3.10 Kg/hectare correspondingly.

The shallow water zone is the most productive. If one takes into account the production of chironomids from the plant beds, which we have not calculated here, and also of other littoral animals, then the productivity of this zone many tens of times exceeds the productivity of the deep zones of the reservoir. This is plain, if one takes into account that in the Uchinsk reservoir a proper drainage basin is completely absent, and the larger part of the allochthonous suspended matter, which is carried with the Volga water, settles out in the higher-lying reservoirs. In the Uchinsk reservoir itself, phytoplankton develops comparatively poorly, therefore entry of plant detritus and the development of bacteria - the main sources of food for the majority of the species of chironomids - occurs in the main in the zone of the dying off of macrophytes, the distribution of which is limited to a narrow littoral belt. The transitional zone between the littoral and profundal is the poorest in food resources for herbivorous chironomids, because, as a consequence of the morphometric characteristics of the Uchinsk reservoir, more intensive sediment accumulation is observed in the profundal (Starikova 1959). Production of chironomids of the second trophic level in the littoral exceeds production of chironomids of the third trophic level by 6-7 times (the pressure* of predators here is great at the expense of larvae of other insects), but in the transitional zone and in the profundal by 3-4 times. This explains the correlation of number of the larvae of Procladius and Cryptochironomus ex. gr. defectus and of the 'peaceful' species of chironomids, which was made up in 1963, at all depths (with the exception of depths down to one metre where larvae of Procladius are absent), on the average during summer, in the proportion of one 'predatory'/two 'peaceful'** larvae. In certain periods, the number of 'predatory' larvae was even greater than the number of 'peaceful' ones. As we see (table 4), the correlation of average yearly biomass and production of chironomids of these trophic groups is an inverse one - the average yearly biomass of 'peaceful' chironomids exceeds that of 'predatory' larvae by 9 times, and production - by four times. Apart from that, as we mentioned above, the role of predation of larvae of Procladius with respect to their confreres is grossly overstressed. In natural conditions, algae (Psilotanypus rufovittatus), rhizopods and bottom-living crustacea serve as the main food of many species of Procladius and Psilotanypus. The plasticity of the nutrition of larvae of Procladius permits them to flourish in water bodies with a lowered trophic state.

Production of chironomids in the Uchinsk reservoir is very low, and, judging by the yearly changes in the average biomass of the larvae, it is yearly declining steadily. In 1951, the average summer biomass of larvae of chironomids for the open part of the reservoir was 51.8 Kg/hectare (Sokolova 1959), in 1962 - only just 9.2 Kg/hectare (weight of formalin material). The main reason for the decline in biomass and production of chironomids lies in the deterioration of the trophic conditions for the majority of the species. There is taking place a process of gradual oligotrophication of the reservoir, since the completely submerged soil cover and terrestrial vegetation have decomposed, the entry of inorganic substance into the bottom at the expense of the local drainage and of phytoplankton is very slight.

Ingestion by fishes and predatory invertebrates have a great influence on the population of chironomids. According to our calculations, about 80-85% of the production of chironomids is eaten up by animals. Our experiments with the use of little submerged cages (similar to those used by Kajak, 1966, for clarification of competing relationships between separate species of chironomids) and of large submerged cages, showed that, with protection from the entry of fish, the number of chironomids increased considerably by comparison with parts of the bottom of the water bodies which are not protected

*'press' means a press, so that the translation could be "the press of....".

**the Russian word mirny means 'peaceful' or 'non-aggressive', hence no doubt the author's use of inverted commas. I presume she means 'non-carnivorous' (herbivores and detritus-feeders). Similarly 'khishchny ' means 'predatory' and not strictly 'carnivorous' for which the Russian word is 'plotoyadny ', though I presume that predatory chironomids are carnivorous. Where I have used inverted commas, these are present in the text.

from fish (1965*). On the average about 50-60% of the biomass is eaten up by fish, the rest fall to predatory invertebrates. To the account of the flying away of the midges falls only 4-5% of the production of chironomids, to elimination as a consequence of other causes - in all only 10-15% of the production; this is clear; the oxygen regime in the reservoir is favourable for hydrobionts, and the other factors are more or less stable. Only a narrow littoral belt is subjected, at times, to fluctuations of the ecological factors as a consequence of its drying out and freezing. For the most part lowering of the level occurs in winter.

Literature**.

Baz', L.G. 1959. Biology and morphology of representatives of the genus Microtendipes inhabiting the water supply canal of the Uchinsk reservoir. Trud. vsesoyuzn. gidrobiol. obshch 9: 74-84.

Borutski , E.V. 1939. Dynamics of the biomass of Chironomus plumosus of the profundal of White (Beloe) lake. Trud. limnol. sta. Kosina 22: 156-95.

Borutski , E.V. 1955. A new trap for the quantitative calculation of the emergence of chironomids. Trud. vsesoyuzn. gidrobiol. obshch 6: 223-26.

Izvekova, E.I. Nutrition of certain chironomid larvae of the Uchinsk reservoir. Trud. Inst. Biol. vnutr. vod (in the press).

Kalugina, N.S. 1959. Concerning certain age changes in the structure and biology of the larvae of chironomids (Diptera, Chironomidae). Trud. vsesoyuzn, gidrobiol. obshch 9: 85-107.

Kalugina, N.S. 1960. Systematics and biology of the phytophile chironomids of the Uchinsk reservoir. Candidate Disseration. Moscow State University.

Konstantinov, A.S. 1962. The weight of certain aquatic invertebrates as a function of their linear dimensions. Nauch. dokl. vysch. shkol. Ser. biol. Nauk. Pt. 3, 17-20.

Kasatkina, M.N. 1960. The relationship between weight and intensity of gas exchange among ecologically diverse species of chironomids. Dokl. Akad. Nauk. SSSR 135, (l): 182-84.

Koreneva-Muragina, T.A. 1957. Systematics and biology of the Pelopiinae (Diptera, Tendipedidae) of the Uchinsk reservoir. Candidate Dissertation. Moscow State University.

Koreneva, T.A. 1959a. Concerning the laying of eggs by females of the Pelopiinae in the Uchinsk reservoir. Trud. vsesoyuzn. gidrobiol. obshch 9: 108-120.

*No name given, but as Sokolova's own experiments are referred to this must be (Sokolova 1965).

**The abbreviations of the names of the journals are as in the Russian text and therefore not necessarily according to the World List of Scientific Periodicals or other standard system.

Koreneva, T.A. 1959b. Structure of the larvae of the first age stage of certain Pelopiinae (Diptera, Tendipedidae). Nauch. Dokl. vysh. shkol. Ser. biol. Nauk. 1: 11-16.

Koreneva, T.A. 1967. Systematics and ecology of Pelopiinae (Diptera, Tendipedidae) of the Uchinsk reservoir. Entomol. Obozr. 36, (2): 436-450.

Silina, Yu. P. 1959. A contribution to the systematics and morphology of chironomids of the genus Limnochironomus. Trud. vsesoyuzn. gidrobiol. obshch 9: 121-125.

Sokolova, N.Yu. 1959a. Concerning the fauna of tendipedids of the Uchinsk reservoir and its seasonal dynamics. Tr. VI soveshch. po probl. vnutr. vodoemov M-L (Transactions of the 6th Conference on Problems of inland waters). Moscow-Leningrad., 287-291.

Sokolova, N.Yu. 1959b. New data about the benthos of the Uchinsk reservoir (according to the investigations of 1950-51). Trud. vsesoyuzn. gidrobiol. obshch 9: 53-73.

Sokolova, N.Yu., and Koreneva, T.A. 1959. The biological cycles of certain mass tendipedids of the Uchinsk reservoir and the seasonal dynamics of the abundance of larvae. Byull. Mosk. Obshch. Uspymam. Prirod. Otd. Biol. 54, (2): 67-78.

Sokolova, N.Yu. 1961. Die Entwicklung der Bodenfauna des Utscha-Wasserbeckens. Verh. Internat. Verein. Limnol., Bd. XIV: 640-642.

Sokolova, N.Yu. 1965. Experimental investigations of the feeding on benthos by fish in the Uchinsk reservoir. Gidrobiol. Zh. 1, 1: 52-61.

Sokolova, N.Yu. 1966. Biologie der Massenarten und Produktivität der Chironomiden in Utscha-Stausee. Verh. Internat. Verein- Limn. Bd. XVI.

Starikova, N.D. 1959. The bottom deposits of the Uchinsk, Pyalov and Yakhrom reservoirs of the canal named Moscw. Trud. vsesoyuzn. gidrobiol. obshch. 9: 38-52.

Yablonskaya, E.A. 1947. Determination of the production of larvae of Chironomus plumosus of the Bear (Medvezh'ikh) lakes. Candidate Dissertation. Moscow.

Boysen-Jensen, P. 1919. Valuation of the Limfjord. I. Studies on the Fish-Food in the Limfjord 1909-1917. Rep. of the Danish Biol. St., 24.

Jonasson, P.M. 1961. Population dynamics in Chironomus anthracinus Zett. in the profundal zone Lake Esrom. Verh. Internat. Verein. Limnol. 14: 196-303.

Jonasson, P.M. 1965. Factors determining population size of Chironomus anthracinus Zett. in Lake Esrom. Mitt. Internat. Verein. Limnol. 13: 139-162.

Kajak, Z. 1966. Field experiment in studies on benthos density of some Mazurian lakes. Gewässer und Abwässer, H. 41/42: 150-158.

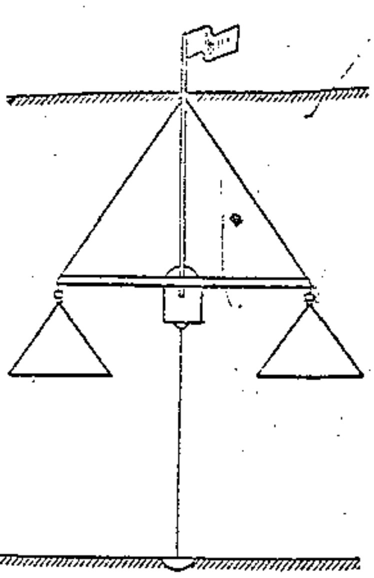

Рис. 1. Эскиз буя.

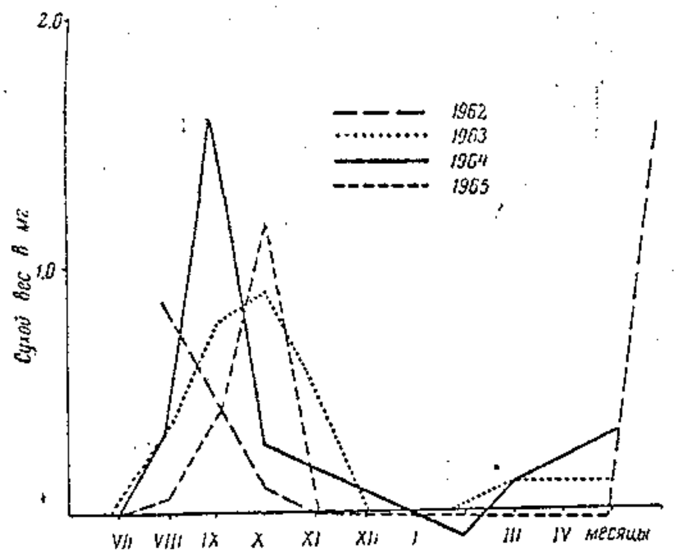

Рис. 2. Абсолютный прирост веса личинок *Chironomus anthracinus* (в мг сухого веса в среднем на одну особь).

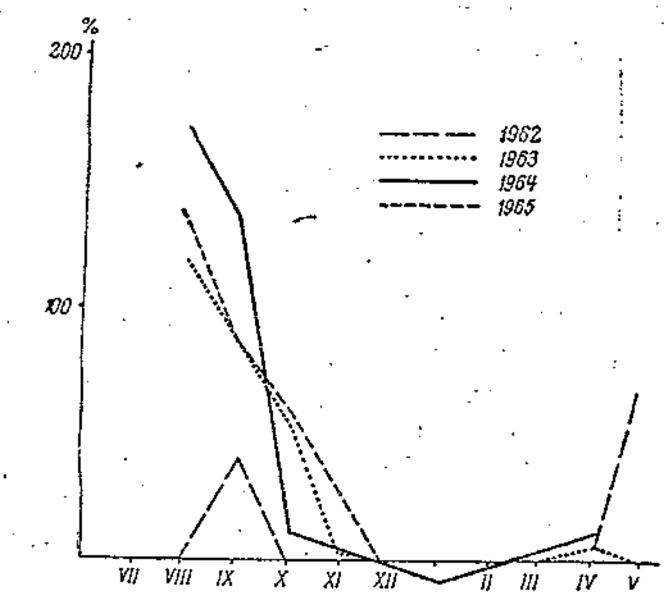

Рис. 3. Относительный прирост сухого веса личинок *Ch. anthracinus* по формуле Броди: $R = \frac{c \cdot 100}{\frac{1}{2}(w_1 + w_2)}$;

c — средний абсолютный прирост; w_1 — вес начальный; w_2 — вес конечный.

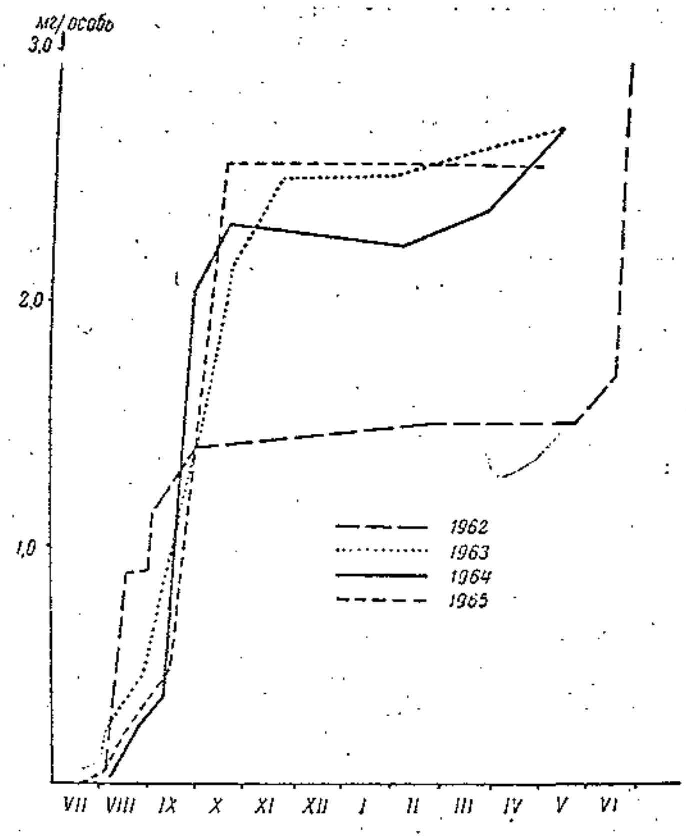

Рис. 4. Весовой рост личинок *Chironomus anthracinus* (в мг сухого веса в среднем на одну особь).

Таблица 1

Расчет продукции Chironomus anthracinus

Период	Индекс периода	Число особей к концу периода N, млн. экз.	Количество отмерших M, млн. экз.	Элиминация в числе особей E, млн. экз.	Сухой вес 1 особи к концу периода w, мг	Средний сухой вес особи за период w, мг	Биомасса отмерших особей Mw, кг	Элиминация биомассы, Ew, кг
Яйца	0	47544	—	—	0,00014	—	—	—
От откладки яиц до появления молоди	1	22363	?	25180[1]	0,051	0,025	?	630[1]
От появления молоди до периода осеннего роста	2	2729	373	19261	0,37	0,21	78,34	4045
Осенний рост	3	1214	0	1515	2,14	1,25	0	1894
От осени до вылета имаго	4	978,7	25,86	209	2,7	2,42	62,58	506
Период вылета имаго		240,7[2]	36,6[3]	701	1,6[4]	2,7[5]	58,54[6]	1974[7]
Яйца	—	17094	—	—	0,00014			
Всего . . .							199,46	9049

[1] Вместе с мертвыми, т. е $(E_1 + M_1) = (N_0 - N_1)$ и $(E_1 + M_1)\,w$.
[2] Количество вылетевших имаго.
[3] Количество куколок, погибших при вылуплении имаго.
[4] Вес имаго — w_i.
[5] Вес куколки — $w_p = w_4$.
[6] Вес мертвых имаго $M_i = 36{,}59 \cdot 1{,}6 = 58{,}54$.
[7] $1974 = 978{,}7 \cdot 2{,}7 - 240{,}7 \cdot 1{,}6 - 36{,}6 \cdot 1{,}6 - 224{,}6$; 224,6 — потери вещества при метаморфозе, равные, по Е. А. Яблонской (1947), 30% веса куколки: $0{,}3\,(241 + 36{,}6 \cdot 2{,}7) = 224{,}6$.

$$E_n = N_{n-1} - N_n - M, \text{ например, } = 22363 - 2729 - 373 = 19261.$$

$$w_n = \frac{w_{n-1} + w_n}{2}, \text{ например, } = \frac{0{,}051 + 0{,}37}{2} = 0{,}21.$$

Таблица 2

Продукция массовых видов хирономид в Учинском водохранилище за год и P/B-коэффициенты[1]

Вид	P кг сух. веса/га		P/B среднегод.		P/B макс.	
	с 1963 по 1964	с 1964 по 1965	с 1963 по 1964	с 1964 по 1965	с 1963 по 1964	с 1964 по 1965
Ch. anthracinus	5,39	4,84	4,5	2,9	2,3	1,5
Ch. plumosus	5,92	6,25	8,8	6,8	2,8	1,3
Procladius	4,61	6,85	18,2	26,8	3,3	5,0
Tanytarsus	1,60	1,37	36,5	32,7	2,8	4,1
Polypedilum nubeculosum	0,63	1,03	10,0	6,2	3,6	1,6
Microtendipes pedellus	0,93	1,09	10,6	14,0	2,4	4,3
Limnochironomus pulsus	0,86	0,69	16,2	24,0	2,3	5,1
Psilotanypus imicola	0,39	0,81	5,9	4,8	2,9	1,9
Lauterborniella brachyla	0,31	0,27	15,7	12,2	2,3	2,7
Polypedilum bicrenatum	0,27	0,23	16,7	17,6	3,0	3,8

[1] В знаменателе P/B в первых двух столбцах дана среднегодовая биомасса, рассчитанная точно за тот же промежуток времени, что и продукция, во вторых двух столбцах дана сумма величин максимумов биомассы за этот же период.

Таблица 3

Продукция Chironomus plumosus и отношение ее к исходной биомассе в Белом озере и в Учинском водохранилище (расчет продукции по Боруцкому)

Водоем	Годовая продукция, кг/га сухого веса	P/B	Автор
Белое озеро	74,4	1,9	Боруцкий
Учинское водохранилище:			
1963 г.	5,24	2,3	Соколова
1964 г.	4,61	1,9	»
1965 г.	7,13	3,7	»

Таблица 4

Годовая продукция хирономид Учинского водохранилища и их среднегодовая биомасса, кг/га сухого веса

Трофический уровень	Продукция		Среднегодовая биомасса	
	с 1963 по 1964	с 1964 по 1965	с 1963 по 1964	с 1964 по 1965
Второй	18,09	17,39	2,24	2,94
Третий	4,48	3,74	0,25	0,33

Таблица 5

Годовая продукция хирономид Учинского водохранилища по глубинным зонам, кг сухого веса/га

Трофический уровень	Литораль (до 3 м)		Переходная зона (от 3 до 7 м)		Профундаль (от 7 м и глубже)	
	с 1963 по 1964	с 1963 по 1964	с 1964 по 1965	с 1964 по 1965	с 1963 по 1964	с 1964 по 1965
Второй	22,42	21,61	10,99	10,56	20,46	18,58
Третий	3,69	3,10	3,69	3,1	5,07	4,25

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