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estonian contributions to the international biological programme

Tartu 1971

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Academy of Sciences of the Estonian S.S.R.
ESTONIAN REPUBLICAN COMMITTEE FOR IBP

E S T O N I A N C O N T R I B U T I O N S
TO THE
INTERNATIONAL BIOLOGICAL PROGRAMME

Progress Report III

Tartu 1971

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The English-language preparation of the present collection of reports has been greately helped by a group of linguists: Asst. Prof. L. KivimÄgi (items 1-2, 4-9, 16-19, see table of contents), Sen. Teacher L. Luik (3), Sen. Teacher J. Soontak (10-11), Teacher R. Mustis (12), Sen. Teacher M. Rosmann (13), Sen. Teacher D. Gerschanowich (15), Sen. Teacher G. Liiv (14).

Inquires about the availability of the present collection of reports as well as the previous reports should be addressed to:
IBP Est.NC, Tiigi 61, 202400 Tartu, Estonian SSR.
In general, however, exchange of IBP materials is aimed at. The authors' addresses, research teams and topics have been indicated in the "Estonian National Programme for IBP"(1970), which is still available at the IBP Est. NC.

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Introduction

The present edition"Estonian Contributions to the International Biological Programme III" continues the publication of the IBP Progress reports by Estonian scientists started in the previous collections of articles (Vol. 1 published in Tartu in 1970, Vol.2 - 1971) in accordance with the Estonian National Programme for IBP. The articles have been arranged by sections. The present collection includes papers representing six out of eight existing sections: PT, PP, CT, PF, HA and UM.

In the PT section four articles presented are concerned with the same general subject "Primary production of the nemoral spruce forest". Two of the papers (that by T.Frey and the one by K. Kalamees,A. Kollom) were presented at the First Conference on Biological Productivity of Spruce Forests organized by the IBP Estonian Republican Committee in Tartu in January 1971. The article by R. Kõlli correspond to the theme "Biological productivity and genesis of soils in connection with their processes and regimes".

The paper published in the PP section corresponds to the approved subject of"Photosynthesis and productivity of plant communities".

The article by Prof. E. Kumari printed in the CT section represents a report delivered at the scientific conference on "Man and Environment" organized by the Chemistry,Ecology and Biology Section of the Academy of Sciences of the Estonian S.S.R. in Tallinn in November 1970.

Two articles presented in the PF section are devoted to the approved topic of "Quantitative study of the stages of production processes", in which the respective problems are discussed and solved on the basis of Lake Võrtsjärv in

Estonia.

The HA section carries articles on two themes: "Peculiarities of lipid and carbohydrate metabolism in the population of the Estonian S.S.R.(one paper by M. Saava and E.Vagane) and "Cardiovascular injuries and psychic disturbances in the people of today" (three papers).

The three papers presented by the UM section constitute a compact group of articles dealing with the topic of "Investigations of entomophages and their use in the biological pest control of crops" included in the IBP Estonian Programme.

Estonian Republican Committee
for IBP

Estonian Contributions to the International Biological Programme, III, TARTU, 1971

PRODUCTIVITY OF NORWAY SPRUCE STANDS DESERVES A COORDINATED ECOLOGICAL STUDY(Project PICEA)

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The study of the primary productivity of natural communities poses serious difficulties. For this reason the data on the productivity of various types of vegetation are very scanty and, in their overwhelming majority, not comparable to each other.

The data available in the literature on the primary productivity of vegetation have been concentrated in reviews published recently by L.E. RODIN and N.I. BAZILEVICH (1968) and A.I. UTKIN (1970).

Regardless of some obvious drawbacks and differences in the methodological approach, the available data enable us to give a tentative picture of the amount of increment and the productivity of various types of vegetation.

According to RODIN and BAZILEVICH the net primary increment of absolutely dry plant material in forests accounts for 32.5 metric tons per hectare in tropical rain forests, 24.5 t/ha in subtropical forests, 13.0t/ha in beech forests, etc., i.e. the net primary production of forests may acquire values ranging, say, from 0.5 to 50 t/ha.

Forests of the taiga zone are characterized by an increment ranging from 4.5 t/ha for the northern taiga and 8.5 t/ha for the southern taiga. For reasons which are not quite clear to us these figures do not agree with the data that

will be given below (Table 1), according to which the primary production of maturing and mature spruce stands on an average constitutes 17 to 18 t/ha. Relying on the last-named figures, European spruce forests occupy third place, second only to tropical rain forests and subtropical forests.

According to the capacity of the photosynthezing apparatus, spruce forests even take second place. The mass of the green parts of spruces accounts on an average for 13 to 19 t/ha (in rain forests 40 and marshy forests 15, in savannas and mangroves 8, in beech forests 5 t/ha, etc.).

There is another fact which indirectly confirms the trustworthiness of comparatively high indices of the net productivity of spruce stands. As is generally known, productivity is closely related to the amount of annual litter fall, which in tropical rain forests makes up 16, in subtropical forests 12, in spruce stands 6 (4 to 8), in beech forests 4.5 and in oak forests 3.5 t/ha.

It should be mentioned, however, that some other recent sources, e. g. WHITTAKER (1970), indicate that high mean net primary production values can be observed in marshlands of favorable environments, in estuaries, in attached algae, and even in tropical crops under rather intensive managament.

All these data, in spite of being quite approximate, justify one to speak of spruce forests as of highly productive communities not only on the territory of the natural distribution of the spruce but also all over the temperate zone.

Fig. 1 represents a collection of most reliable data on the net primary production of spruce stands in the European part of the U.S.S.R.. The comparatively equal level of maturing and mature stands (line A) is conspicuous (points 4-7), which is practically independent of the general biomass of stands. Young stands (8 - 10) are characterized by a sharply rising line (B) in the course of which they reach their maximum increment of the tree-layer, the value of the increment or of the subordinate layers as well as the litter

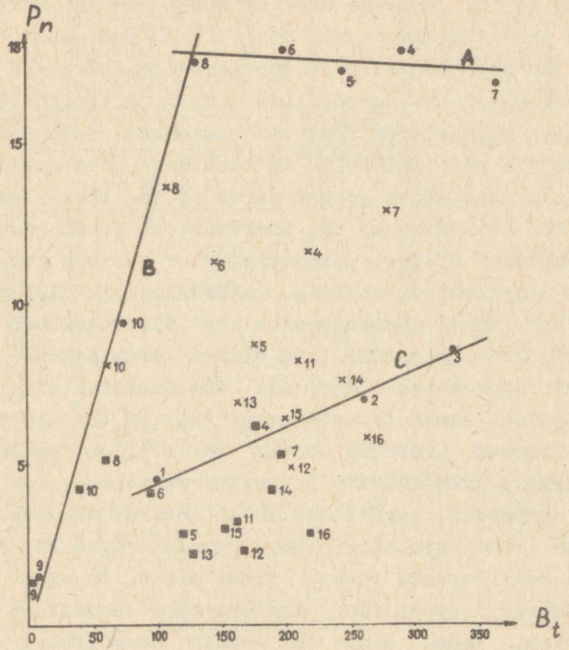

Fig. 1. Productivity of some Norway spruce stands in the European part of the U.S.S.R.. Dots desingnate total phytomass, crosses above-ground phytomass, and quadrats - tree trunk mass. The ordinate, P_n, corresponds to the net yearly production and the abscissa - to the standing crop or biomass (B_t), both expressed as absolutely dry mass in metric tons per hectare. Sources see Table 1.

fall is so far small, Line C combines the points (1 - 3) according to the average data of RODIN and BAZILEVICH. In addition to total increment, Fig. 1 also indicates the increment of the stem and that of the above-ground parts of the tree-layer which lie around line C. In this connection there arises the supposition that the increment data which were used by RODIN and BAZILEVICH in fact have been estimated on the basis of the above-ground parts of the tree-layer rather than on the estimates of the increment of total biomass.

Comparison of the productivity of various vegetation types is complicated, besides methodological difficulties, by the fact that phytocoenoses are distinguished by the degree of their maturity (in climax communities f[illegible]tual increment approaches zero) and the duration of the vegetative period. Hence the statement that on the global scale spruce forests probably occupy third place according to their primary productivity is partly senseless. The fact is that in subarctic conditions shrub-covered tundras, in the temperate zone probably spruce stands, while in tropical climates rain forests occupy first place. In other words, local climax communities are the most productive in any geographical zone. Since the spruce constitutes climax communities in the European part of the taiga zone (on comparatively rich mineral soils), spruce stands are to be regarded here as the most productive plant communities.

However, the widespread idea of agricultural crops being highly productive is not confirmed by research data. Thus, according to WASSINK (1968), when PhAR is employed, all forest communities show a high degree of efficiency which on an average constitutes 0.50 % (the remaining phytocoenoses and agricultural crops make up 0.15 %, while oceans - 0.13 %. Under conditions of irrigation and fertilization sugar cane, sun-flower and Indian corn may attain an efficiency of 0.35 %. Among the useful properties of the spruce the following may be pointed out:

(1) The spatial orientation of spruce branches and twigs

Table 1

Primary productivity of Norway spruce stands

Nos on figure 1	Nos on figure 2	Source	Absol. dry biomass t/ha: total	above ground	stem	green parts	under ground	Increment t/ha: above ground	under ground	net	Age	Forest type, Piceetum...
1.	-	Rodin, Bazilevich, 1968	100	78	70	8.0	22	?	?	4.5	?	north taiga
2.	-	—— " ——	260	200	185	16.0	60	?	?	7.0	?	middle zone
3.	-	—— " ——	330	257	240	16.5	74	?	?	8.5	?	south
4.	16	Уткин, 1970	285	220	176	16.7	65	12.0	(5.5)	17.8	85	cariceeto-quercetosum
5.	12	Кнлли, Кяхрик, 1970	250	182	120	16.9	68	11.2	6.0	17.2	84	hepatici-fragariosum
6.	(12)	—— " ——	200	152	95	13.5	48	13.0	4.9	17.9	51	
7.	14	Вятковский, Гришина, 1971	364	279	198	25.2	82	12.9	3.9	16.8	80	oxalidosum
8.	14	—— " ——	132	108	60	28.4	23	13.6	3.9	17.5	30	
9.	14	—— " ——	(7)	(5)	2	2.6	1	1.4	0.4	1.5	15	
10.	18	Малиновский, Колищук, 1971	73	60	39	10.2	13	8.1	(1.3)	9.4	20	hylocomiosum
11.	16	Носова, 1971	?	210^{x}	164	18.0^{x}	?	8.2^{x}	?	?	89	cariceeto-tiliosum
12.	16	—— " ——	?	205^{x}	168	7.4^{x}	?	4.9^{x}	?	?	93	caricosum
13.	16	—— " ——	?	163^{x}	127	11.7^{x}	?	6.9^{x}	?	?	93	coryletosum
14.	(18)	Половников, 1968	?	244^{x}	188	15.9^{x}	?	7.6^{x}	?	?	?	polytrichosum
15.	(18)	—— " ——	?	200^{x}	153	18.0^{x}	?	6.4^{x}	?	?	?	sphagno-myrtillosum
16.	(18)	—— " ——	?	263^{x}	219	12.2^{x}	?	5.8^{x}	?	?	?	myrtillosum

x - tree layer only

corresponds to the optimum one - they are at the top of the crown raised, in the middle of the crown horizontal and in the lower part descending.

(2) Average age of spruce needles is, of course, high (4-15 years), owing to which the spruce attains high values of the leaf area index. Besides, the spruce carries out photosynthesis all the year round (though in winter it does not make up for the expenditure on respiration).

(3) The photosynthesizing apparatus of the spruce is adapted to the relatively low intensities of PhAR, which is accompanied by a high concentration of chlorophyll in the needles. As a result, the dark needles of the spruce absorb a considerable part of reflected radiation, which is important in the climatical conditions obtaining in the north-western parts of the U.S.S.R., which are characterised by a high number of cloudy and foggy days.

It follows from the above that our spruce stands deserve an all-round detailed ecological study, which should be aimed at establishing concrete adaptations and regulatory mechanisms ensuring a high productivity of spruce stands as well as at receiving full energy balances for various geographic points within the area of distribution of the spruce.

The task of the next step of study is the determination of efficiency for individual stages of energy flow (separately for various species and trophic levels).

At the present time, thanks to investigations carried out in connection with the IBP, there exist preconditions for the conduction of such co-ordinated studies since many research teams in various countries are engaged in the study of the productivity of spruce communities (cf. Fig. 2). In addition, a great number of individual investigators are studying spruce stands.

It should not be overlooked that considerable support is to be expected from the latter source. A good example is the excellent work done by the German forester H. von Droste zu Hülshoff (1970) at Ebersberg near Munich.

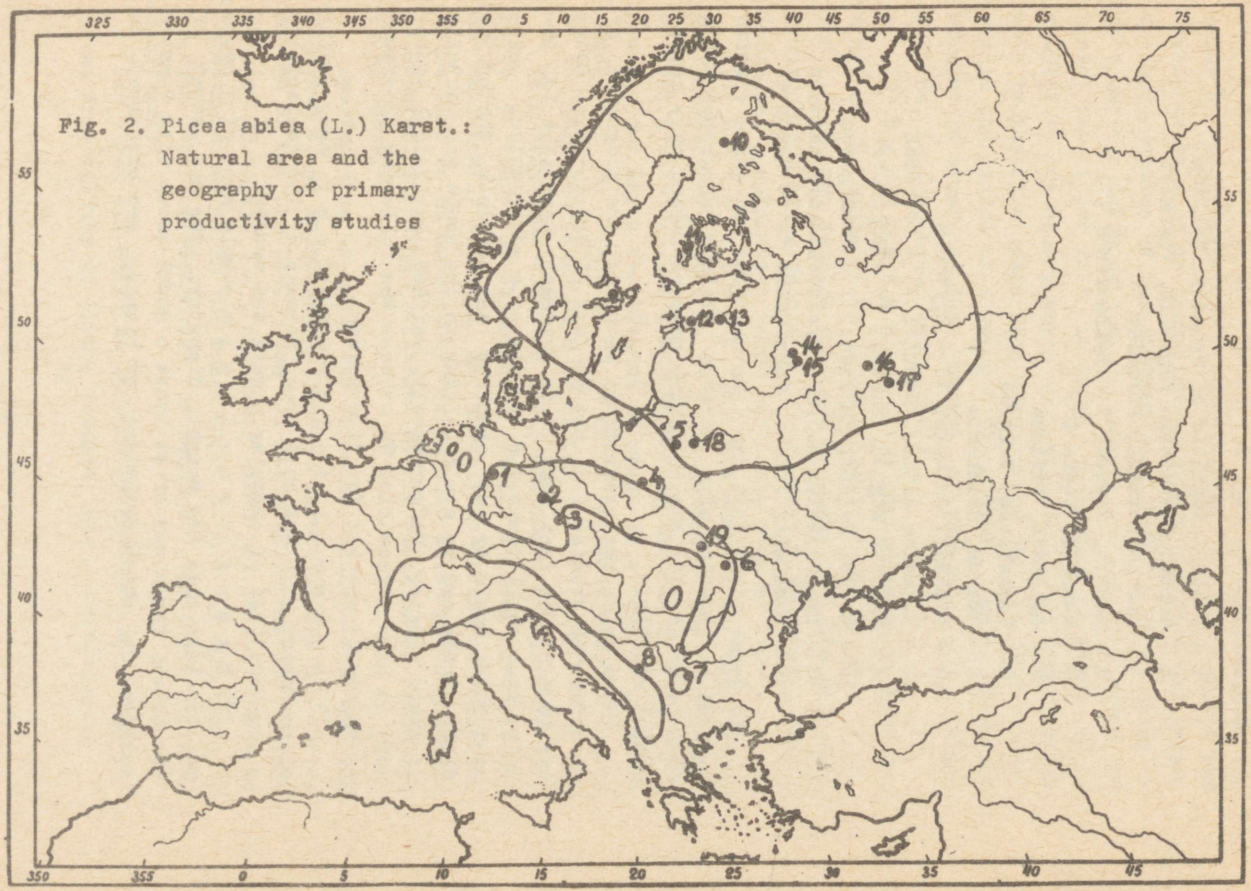

Fig. 2. Picea abies (L.) Karst.: Natural area and the geography of primary productivity studies

Explanations to Fig. 2 :

1 - Federal Republic of Germany, Solling
2 - German Democratic Republic, Tharandt
3 - Czechoslovakia, Zbraslav
4 - Poland, Warsaw; 5 - Byalowiezha (?)
6 - Romania, Redna (?)
7 - Bulgaria, Vitosha
8 - Yugoslavia, Belgrad (?)
9 - Sweden, Stockholm
10 - Finland, Oulanka; 11 - Hyytiälä
12 - Estonian S.S.R., Mihkli; 13 - Vooremaa
14 - Kalinin Region, Valdai; 15 - Nelidovo
16 - Moscow Region, Malinki; 17 - Zvenigorod
18 - Byelorussian S.S.R., Byelovezhskaya pushcha
19 - Ukrainian S.S.R., Carpathian State Reserve.

It seems to us that the time has come to unite efforts for the elaboration of a uniform minimum programme which would make it possible to obtain comparable(and only comparable) results.

There arise the question of what must the programme of co-ordinated studies,i.e. the project PICEA, contain. Bearing in mind the fact that it is extremely desirable to involve also small teams,i.e. to aim at a geographical network which would be as complete as possible, the project PICEA cannot set up strict claims to the scope and details of field studies. Unfortunately, unified ecological equipment is also infeasible. We propose the following programme of the PICEA project for discussion.

(1) G e n e r a l i n f o r m a t i o n : age, quality class,forest site and soil type, formula of the composition, a complete list of vascular plants and mosses.

(2) S t a n d d e n s i t y : a sample plot of 1 hectare; for each tree its height, diameter, size and extent of the crown, for a set of at least 5 model trees with 2-metre sections for which fractions of biomass are expressed in

terms of absolutely dry biomass: trunk, living branches and twigs, assessment of their increment, dry branches and twigs, needles, needles of the current year, roots up to a diameter of 1 mm to a depth of 1 m, assessment of the increment of roots; the litter fall is to be determined by means of 10 samples of one square metre each at 7 different dates (desirable in the first days of a month): from May 1st to November 1st in the course of 4 years (1971 - 1972), and is to be expressed in terms of the biomass of branches and twigs, needles, leaves, cones and lichens.

(3) U n d e r g r o w t h : the phytomass is to be determined on the basis of at least 3 sample plots of 10 x 10 m, stratified into 1-metre vertical sections with the following fractions: leaves, shoots of the current year, cones, timber increment , epiphytes; roots as in the case of trees.

(4) L o w e r l a y e r s : the biomass of herbs, grasses, mosses and litter is to be estimated at the beginning of July (1971-1973), on quadrats having an area of 1 sq m, for grasses and herbs the biomass of roots to a depth of 40 cm separately in layers of 10 cm in 10 replications, the area of the monolith being 50 x 50 sq cm.

This programme with the above-mentioned details may call forth a number of objections. Still, as long as there are no universally accepted and exactly co-ordinated methods, there will be no completely comparable data and no genuine collaboration in the solution of the complicated problems lying ahead.

Bearing this in mind, the Estonian Committee for the IBP regarded it as expedient to convene investigators of spruce stands of the U.S.S.R. - (an all-Union symposium was held January 25 to 29, 1971, in Tartu) since the co-ordination of investigations among the researchers of the U.S.S.R. should precede the co-ordination of studies with their foreign colleagues.

The first all-Union meeting under the heading of "Biological Productivity of Spruce Forests" was participated

by 90 scientists from about 30 institutions of the U.S.S.R..

Abstracts of the reports issued under the same heading by the Estonian IBP National Committee are still available (mimeographed, 252 pages in Russian without summaries in the western languages, Tartu, 1971).

Considerable progress was reported in relation to the initation of new IBP studies in temperate Picea abies forests. The main interest at the symposium was concentrated on the radiation regime (7 reports), the litter fall and its decomposition (8), total and net primary productivity (8), etc.. Alltogether 54 reports were presented at the symposium. The following recommendations were agreed upon:

1. Workshop activities should be encouraged with the purpose of -

a) analyzing and comparing the data collected;

b) making recommentations to researchers to conduct their investigations on the basis of methods which are as similar as possible;

c) concentrating efforts on studies of the ecology of spruce forests as related to net primary productivity and forest mensuration, enabling one to make estimates of increment in separate fractions (needles, cones, roots etc.).

2. In 1975, during the 12th International Botanical Congress to be held in Leningrad, U.S.S.R., an international symposium on PICEA should organized, i.e. the participants of both the Tartu and Kratte Masugn spruce symposia are to be included.

3. An all-Union steering committee, the Secretariat PICEA, was elected to organize the exchange of information, the comparison of methods, the assessment of novel results, the examination of IBP areas as well as of their equipment, etc., with Dr. T. Frey as the Scientific Secretary (Institute of Zoology and Botany, 21 Vanemuise St., 202400 Tartu, Estonia, U.S.S.R.), S. A. Dyrenkov (Forest Research Institute, 21 In-

stitutsky St., Leningrad K-223) and G. B. Gortinsky (Komarov Botanical Institute, 2 Prof. Popov St., Leningrad P-22) as Co-ordinators on Structure, and Ecology, respectively, and eleven representatives from different geographical regions of the U.S.S.R..

4. Due to the rather high net primary productivity of spruce forests in the western parts of the U.S.S.R. (the Baltic republics, Valdai, the Carpathians) reported as being about 15 - 19 metric tons per hectare, special attention should be paid to them in the framework of the IBP as well as of the coming international projects.

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PHYTOMASS OF UNDERGROUND PARTS IN SOME FOREST ECOSYSTEMS

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A general source of organic matter in the mineral horizons of the forest soil are the underground parts of a plant community. On the other hand the total phytomass and distribution of roots in the soil profile must depend on the structure and characteristics of a plant community as well as on the soil conditions.

We have studied the phytomass of underground parts and distribution of small roots in six forest ecosystems:

(I) - a 54-year-old spruce forest of the Fragaria-Hepatica type on rendzina; (II) - a 84-year-old spruce forest of the same type on brown typical soil; (III) - a 200-year-old oak forest of the same type on the same soil;(IV)- a 51-year-old spruce forest of the Fragaria-Hepatica-Oxalis on brown lessive soil;(V) - a 80-year-old spruce forest of the Oxalis type on brown pseudopodzolic soil; (VI) - a 75-year-old pine forest of the same type on the same soil. The floristic composition and geobotanical features of various forest layers (the tree, regrowth and underwood, herb and moss layers) of these experimental areas have been dealt with in our previous papers(2),(3), but the soils of these experimental areas have been discussed by L. REINTAM (5),(6).

Methods

The phytomass of the roots with a diameter less than 0.5 cm was determined by washing them by the RWM-50(1) root washing machine from soil samples with an area of 0.25 x 0.4 m by 0.1 m layers to a depth of 0.6-1 m; the phytomass of the roots with a diameter of 0.5-3 cm was determined by gathering them from soil samples with an area of 0.5 x 1 m to a depth of 0.5 m; that of stumps and large roots of the tree layer, regrowth and underwood (all of them only in three experimental areas) was estimated by means of sample trees (3 average sample trees from the tree layer and 50-60 samples from the layer of regrowth and underwood). All the data on phytomass were obtained in terms of dry matter.

Results

For all ecosystems studied 67-88% of the total phytomass of the roots, less than 5 mm in diameter was found in a 0-20 cm layer and 91-99% in a 0-50 cm layer.

Root distribution proves the ecologic influence of soil properties on the development of the underground parts of a plant community. The main portion of root phytomass occurs in well drained and rich-in-nutrients humus accumulative horizons, but in moraine it is less than 10%.

It can be seen from Tables 1, 2, 4 and 5 that considerable differences are observed in the distribution of root phytomass of the same forest types in various soil profiles. The data obtained also show that the root systems of spruce forests have ecological plasticity. In brown typical and lessive soils small roots are distributed more homogeneously than in brown pseudopodsolic soils. For example, of small roots (5 mm diameter) of spruce forests 52-57% are located in the upper 10-cm-layer and 70-75% in the upper 20-cm-layer of brown soils, but the corresponding proportion in brown pseudopodzolic soils is 63% and 84% respectively. As can be seen from Tables 2 and 3, there are considerably more roots in the lower layers of oak forests than in the soils of spruce forests. This proves that root distribution also depends on the physiological properties of the predomi-

Table 1

Distribution of root phytomass of the spruce forest in rendzina

(ecosystem I)

Depth, cm	Diameter of roots										
	< 5 mm							5–10 mm		10–30 mm	
	Distribution by layers		Statistical characteristics					$\bar{x} \pm \sigma_{\bar{x}}$	%	$\bar{x} \pm \sigma_{\bar{x}}$	%
	100 $\frac{kg}{x}$/ha	%	n	σ	V	$\sigma_{\bar{x}}$	P				
0–10	108,8	60,7	7	28,8	26	10,9	10,0	13,8±3,6	71,2	24,4±23,0	97,6
10–20	38,7	21,6	5	17,0	44	7,6	20,0	2,6±1,1	13,4	0,6± 0,6	2,4
20–30	14,7	8,2	4	2,6	18	1,3	8,8	1,5±0,8	7,7		
30–40	5,8	3,2	3	3,5	60	2,0	34,0	0,8±0,7	4,1		
40–50	7,2	4,0	3	2,8	39	1,6	22,0	0,3±0,3	1,5		
50–60	4,2	2,3	3	3,6	86	2,1	50,0	0,4±0,4	2,1		
0–20	147,5	82,3	–	45,8	31	18,5	12,5	16,4±4,7	84,6	25,0±23,6	100,0
0–50	175,2	97,7	–	54,7	31	23,4	13,4	19,0±6,5	89,9	25,0±23,6	100,0
0–60	179,4	100,0	–	58,3	32	25,5	14,2	19,4±6,9	100,0	25,0±23,6	100,0

Table 2

Distribution of root phytomass of the spruce forest in brown typical soil (ecosystem II)

Depth, cm	Diameter of roots										
	< 5 mm							5-10 mm		10-30 mm	
	Distribution by layers		Statistical characteristics					$\bar{x} \pm \sigma_{\bar{x}}$	%	$\bar{x} \pm \sigma_{\bar{x}}$	%
	100 kg/ha $\bar{x}$	%	n	σ	V	$\sigma_{\bar{x}}$	P				
0-10	150,0	57,2	9	50,0	33	16,7	11,1	33,8±9,7	74,0	44,0±9,3	73,2
10-20	46,1	17,6	9	23,6	51	7,9	17,1	9,5±2,4	20,7	16,3±11,1	26,8
20-30	27,1	10,3	5	11,9	44	5,3	19,6	2,0±0,9	4,4		
30-40	14,2	5,4	5	7,0	49	3,1	21,8	0,4±0,4	0,9		
40-50	17,7	6,8	5	9,3	52	4,2	23,7				
50-60	7,0	2,7	3	5,0	71	2,9	41,5				
0-20	196,1	74,8	-	73,6	38	24,6	12,5	43,3±12,1	94,7	60,0±20,4	100,0
0-50	255,1	97,3	-	101,8	40	37,2	14,6	45,7±14,5	100,0	60,9±20,4	100,0
0-60	262,1	100,0	-	106,8	41	40,1	15,3	45,7±14,5	100,0	60,9±20,4	100,0

Table 3

Distribution of root phytomass of the oak forest in brown typical soil (ecosystem III)

Depth, cm	Diameter of roots										
	< 5 mm							5-10 mm		10-30 mm	
	Distribution by layers		Statistical characteristics					$\bar{x} \pm \sigma_{\bar{x}}$	%	$\bar{x} \pm \sigma_{\bar{x}}$	%
	100 kg/ha $\bar{x}$	%	n	σ	V	$\sigma_{\bar{x}}$	P				
0-10	118,0	47,2	10	30,7	26	9,7	8,2	15,7±7,5	23,6	0 ± 0	0
10-20	48,7	19,5	10	13,0	27	4,1	8,4	8,6±3,1	12,9	12,6±5,2	19,1
20-30	35,1	14,0	7	6,7	19	2,5	7,1	23,8±8,6	35,8	17,7±6,5	26,9
30-40	20,2	8,1	5	3,4	17	1,5	7,4	5,9±3,8	8,9	17,7±9,4	26,9
40-50	19,4	7,8	5	8,3	43	3,7	19,1	11,3±5,4	17,0	15,3±6,7	23,3
50-60	8,4	3,4	3	3,4	40	2,0	23,8	1,2±1,2	1,8	2,5±2,5	3,8
0-20	166,7	66,7	-	43,7	26	13,8	8,3	24,3±10,6	36,5	12,6±5,2	19,1
0-50	241,4	96,6	-	62,1	26	21,5	8,9	65,3±28,4	98,2	63,3±27,8	96,2
0- 60	249,8	100,0	-	65,5	26	23,5	9,4	66,5±29,6	100,0	65,8±30,3	100,0

Table 4

Distribution of root phytomass of the spruce forest in brown lessive soil (ecosystem IV)

Depth, cm	Diameter of roots										
	< 5 mm							5-10 mm		10-30 mm	
	Distribution by layers		Statistical characteristics					$\bar{x} \pm \sigma_{\bar{x}}$	%	$\bar{x} \pm \sigma_{\bar{x}}$	%
	100 kg/ha $\bar{x}$	%	n	σ	V	$\sigma_{\bar{x}}$	P				
0-10	65,8	52,0	10	26,8	41	8,5	12,9	14,4±2,6	63,2	17,3±6,1	44,3
10-20	22,3	17,6	9	5,5	25	1,8	8,1	5,6±4,2	24,6	7,8±1,9	20,0
20-30	12,6	9,9	6	3,4	27	1,4	11,1	1,8±0,9	7,9	7,2±1,3	18,5
30-40	7,3	5,8	6	2,3	32	0,9	12,3	0,4±0,4	1,7	4,8±1,9	12,3
40-50	7,0	5,5	6	2,9	41	1,2	17,2	0,4±0,4	1,7	1,9±0,2	4,9
50-60	3,7	2,9	4	1,2	32	0,6	16,2	0,2±0,2	0,9		
60-70	2,0	1,6	4	1,1	55	0,5	25,0				
70-80	2,1	1,7	4	0,8	38	0,4	19,1				
80-90	2,1	1,6	3	1,0	48	0,6	28,6				
90-100	1,8	1,4	3	0,4	22	0,2	11,1				
0-20	88,1	69,6	-	32,3	37	10,3	11,7	20,0±6,8	87,8	25,1±8,0	64,3
0-50	115,0	90,8	-	40,9	36	13,8	12,0	22,6±8,5	99,1	39,0±11,4	100,0
0-100	126,7	100,0	-	45,4	36	16,1	12,7	22,8±8,7	100,0	39,0±11,4	100,0

Table 5

Distribution of root phytomass of the spruce forest in brown pseudopodzolic soil (ecosystem V)

Depth, cm	Diameter of roots										
	< 5 mm							5-10 mm		10-30 mm	
	Distribution by layers		Statistical characteristics					$\bar{x} \pm \sigma_{\bar{x}}$	%	$\bar{x} \pm \sigma_{\bar{x}}$	%
	100 $\bar{x}$ g/ha	%	n	σ	V	$\sigma_{\bar{x}}$	P				
0-10	94,0	62,8	9	37,8	40	12,6	13,4	32,7± 8,1	61,6	14,8±9,1	48,8
10-20	32,1	21,5	9	14,0	44	4,7	14,6	15,1±11,5	28,4	15,5±7,6	51,2
20-30	9,7	6,5	9	4,5	46	1,5	15,5	5,3± 2,9	10,0		
30-40	5,0	3,3	6	2,3	46	0,9	18,0				
40-50	2,9	1,9	6	1,1	38	0,5	17,2				
50-60	1,7	1,1	4	0,8	47	0,4	23,5				
60-70	1,4	0,9	4	0,4	29	0,2	14,3				
70-80	0,9	0,6	4	0,3	33	0,2	22,2				
80-90	0,8	0,6	4	0,4	50	0,2	25,0				
90-100	1,2	0,8	4	0,6	50	0,3	25,0				
0-20	126,1	84,3	-	51,8	41	17,3	13,7	47,8±19,6	90,0	30,3±16,7	100,0
0-50	143,7	96,0	-	59,7	42	20,2	14,1	53,1±22,5	100,0	30,3±16,7	100,0
0-100	149,7	100,0	-	62,2	42	21,5	14,4	53,1±22,5	100,0	30,3±16,7	100,0

Table 6

Distribution of root phytomass of the pine forest in brown pseudopodzolic soil (ecosystem VI)

Depth, cm	Diameter of roots										
	< 5 mm							5-10 mm		10-30 mm	
	Distribution by layers		Statistical characteristics					$\bar{x} \pm \sigma_{\bar{x}}$	%	$\bar{x} \pm \sigma_{\bar{x}}$	%
	100 kg/ha $\bar{x}$	%	n	σ	V	$\sigma_{\bar{x}}$	P				
0-10	71,3	66,9	8	32,24	45	11,40	16,0	19,0±7,1	56.2	35,6±7,1	67,8
10-20	22,3	20,9	7	12,41	56	4,68	21,0	7,9±1,9	23,4	11,8±4,6	22,5
20-30	9,6	9,0	5	6,79	71	3,03	31,6	3,9±1,5	11,5	5,1±2,5	9,7
30-40	1,3	1,2	4	1,14	88	0,57	43,8	1,8±0,9	5,3		
40-50	1,0	0,9	4	0,86	86	0,43	43,0	1,2±0,8	3,6		
50-60	0,6	0,6	2	0,50	83	0,35	58,3				
60-70	0,2	0,2	2	0,10	50	0,07	35,0				
70-80	0,15	0,1	2	0,07	47	0,05	33,3				
80-90	0,15	0,1	2	0,07	47	0,05	33,3				
90-100	0,1	0,1	2	0,10	100	0,07	70,0				
0-20	93,6	87,8	-	44,65	48	16,08	17,2	26,9±9,0	79,6	47,4±11,7	90,3
0-50	105,5	98,9	-	53,44	51	20,11	19,1	33,8±12,2	100,0	52,5±14,2	100,0
0-100	106,7	100,0	-	54,28	51	20,70	19,4	33,8±12,2	100,0	52,5±14,2	100,0

nant tree species. According to I.N. RAKHTEENKO (17), the oak has a deep extensively branching tap root system whereas the spruce has a superficial root system. As to the influence of root phytomass on soil forming processes, it is possible to state that on all soils it plays an essential role in weathering parent rocks, especially on brown typical soils.

Table 7

Total phytomass of underground parts of spruce forests (in tons per hectare)

No. of experimental area	Small roots		Stumps and large roots		Total	Ratio underground aboveground
	Diameter					
	<5 mm	5-30 mm	Tree storey	Regrowth and undergrowth		
II	26.2	10.7	33.7	1.2	71.8	0.40:1
IV	12.7	6.2	26.7	0.8	46.4	0.30:1
V	15.0	8.3	41.2	0.7	65.2	0.27:1

II - on brown typical soil;
IV - on brown lessive soil;
V - on brown pseudopodzolic soil.

As shown in Table 7, in the 80-84-year-old spruce forest the underground phytomass is 65-72 tons per hectare, being much more than in the 51-year-old forest (46 tons per hectare). On the basis of these data (Table 7) it is possible to note that on brown typical soils a spruce ecosystem develops a remarkably large amount of root phytomass per one unit of aboveground phytomass. It is quite understandable if we take into consideration the fact that the tree layer of the ecosystem mentioned above belongs to the second quality class, but the others (IV and V) are of the first quality class.

It may be concluded that in an ecosystem where the tree layer is of a lower quality class relatively more phytomass (or energy) is in underground parts, since the less favourable the environmental conditions are the more powerful root system is developed by an ecosystem.

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ON THE BIOLOGICAL PRODUCTIVITY OF AGARICALES IN FOREST ECOSYSTEMS

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When studying the floristic composition of fungi in various forest site types, it usually turns out that the number of the species in macroscopic fungi mostly exceeds that of vascular plants at a respective site type at least twice. Thus, the mycocoenological studies conducted in Estonia have revealed 51 species of vascular plants at the Myrtillus site type while the number of macroscopic fungi there (without the wood-destroying polyporaceous fungi) amounts to 131 species. The corresponding numbers at the Aegopodium-Mercurialis site type are 86 and 142, at the Oxalis site type - 93 and 175, at the Vaccinium site type 34 and 76, and the Corylus site type - 43 and 89 respectively. When we add to them the wood-destroying Aphyllophorales and microscopic fungi, it is clear that the number of fungal species surpasses the number of vascular plant species in forest communities many times. Recalling the universally known fact about the responsible role of fungi in the secondary biological production, i.e. in processes associated with the decomposition of forest debris, it is evident that the functional role of fungi in forest ecosystems cannot be negligible and that there is no justification for the omission of fungi from the study of the bioproductivity of forest ecosystems.

The total productivity of fungal organisms is expressed by three components : 1) the vital activity of an organism,

2) the formation of a mycelium and 3)the formation of fruit-bodies. Unfortunately, we do not know to what extent each of the above components participates in the formation of the total productivity of a fungus. For methodical reasons we have so far been unable to study the growth process of a mycelium in nature and accordingly there are no methodical techniques for the evaluation of the biomass of a mycelium, the most significant part - so-to-say the body - of a fungal organism. We can study the vital activity of a fungus to some extent by measuring,e.g., soil respiration or by establishing the intensity of the decomposition of forest debris on the part of fungi, but even here there are great methodical shortcomings. At the present time soil respiration can be measured only as a sum total of the respiratory activity of all soil organisms (including bacteria). The determination of the role of individual fungal species in this process is out of the question. The only thing which in the study of the bioproduction of fungi can most easily be carried out by the present methods is the determination of the primary production of fruit-bodies by counting and weighing them. The crux of the matter lies in the fact that fruit-bodies represent only one phenological stage in the developmental cycle of macroscopic fungi.The evaluation of the bioproduction of fungi merely on the basis of the biomass of fruit-bodies is, roughly speaking, equivalent to the estimation of the bioproduction of plants merely on the basis of fruits or flowers.Consequently,the biomass of fruitbodies is by no means an adequate estimate even from the standpoint of the net production of fungi,not to speak of the total productivity of a fungal organism and thus also its participation in the energetic balance of an ecosystem are after all

Figs. 1-3. Seasonal dynamics of the number of fungal fruit-bodies in a spruce-hardwood forest on two observation areas (I and II) in 1970.

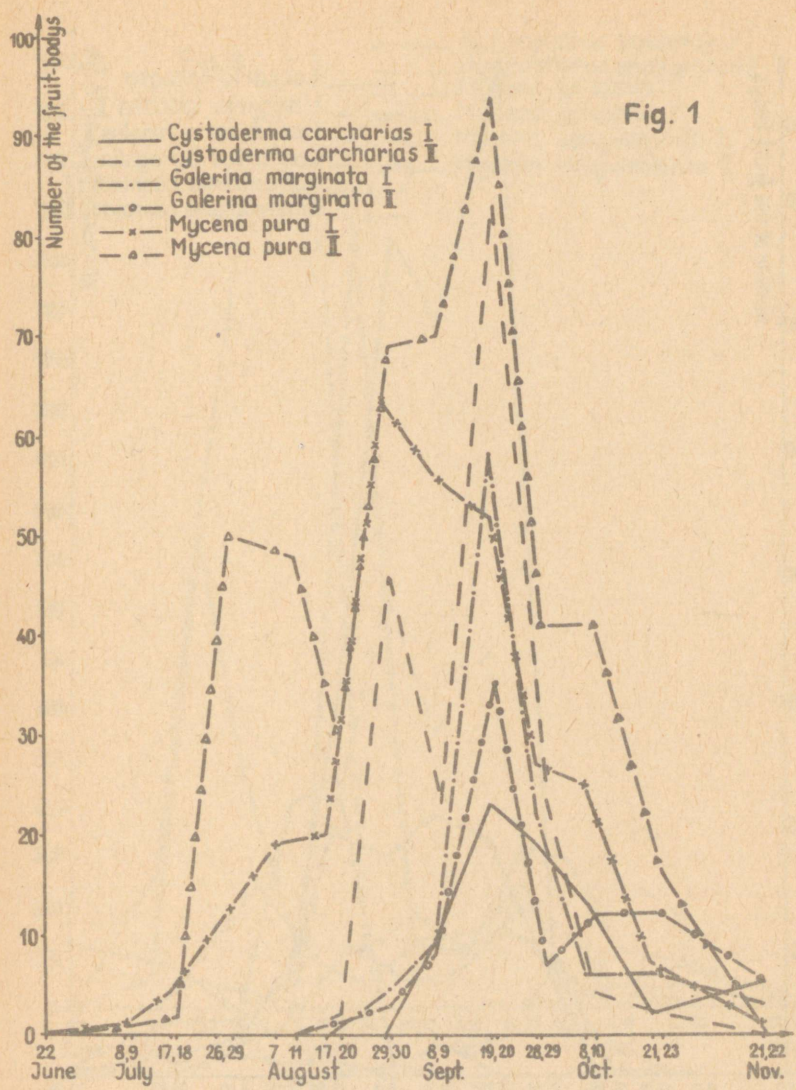

Number of the fruit-bodys
100
90
80
70
60
50
40
30
20
10
0
Cystoderma carcharias I
Cystoderma carcharias II
Galerina marginata I
Galerina marginata II
Mycena pura I
Mycena pura II
22 June
8,9 July
17,18
26,29
7 August
11
17,20
29,30
8,9 Sept.
19,20
28,29
8,10 Oct.
21,23
21,22 Nov.

Fig. 1

Fig. 2

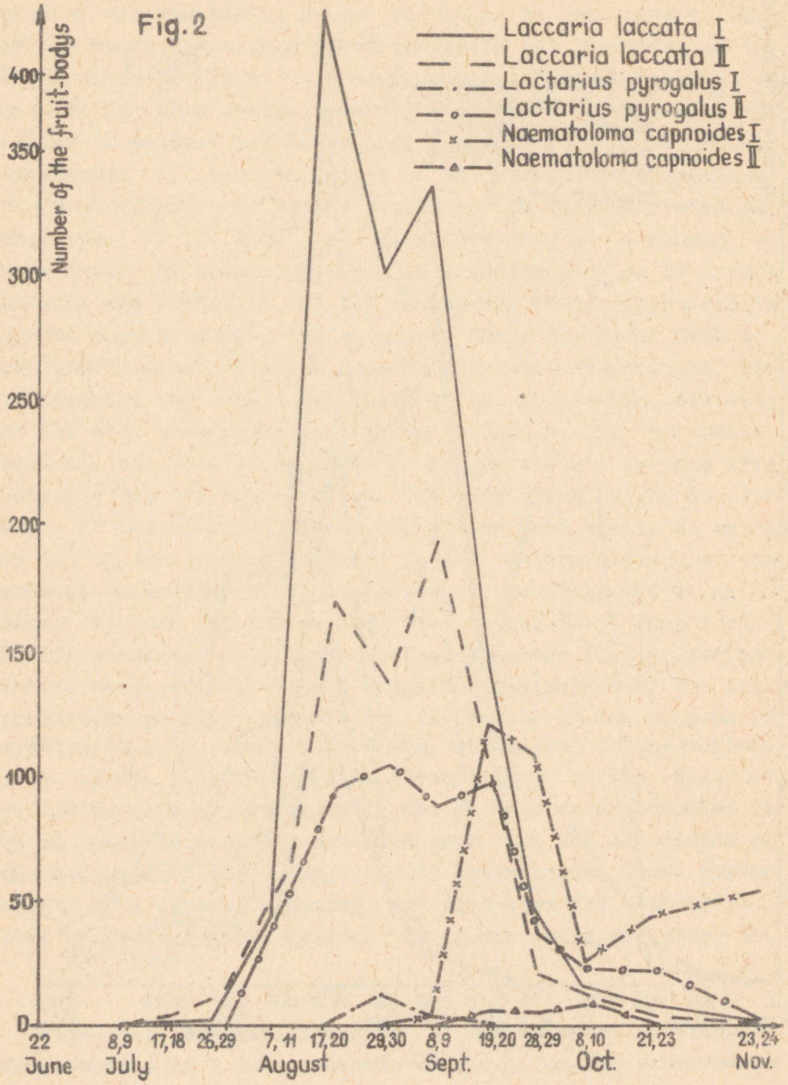
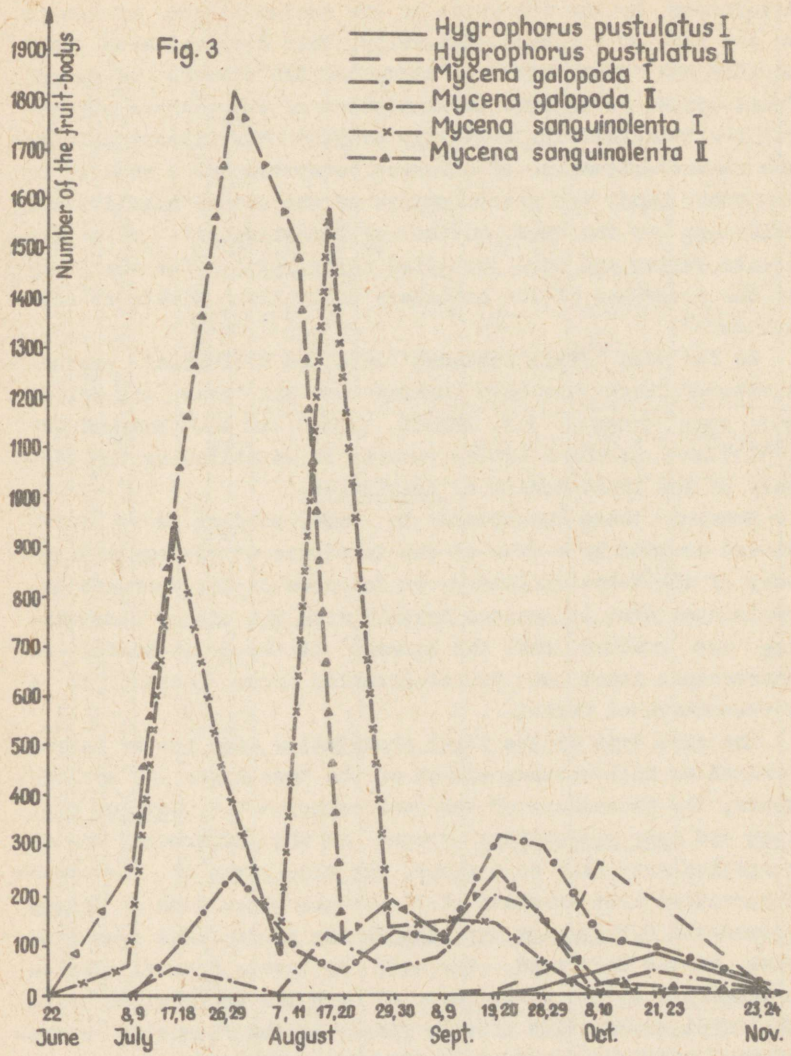

Laccaria laccata I
Laccaria laccata II
Lactarius pyrogalus I
Lactarius pyrogalus II
Naematoloma capnoides I
Naematoloma capnoides II
Number of the fruit-bodys
400
350
300
250
200
150
100
50
0
22 June
8,9 July
17,18
26,29
7, 11 August
17,20
29,30
8,9 Sept.
19,20
28,29
8,10 Oct.
21,23
23,24 Nov.

Fig. 3


Hygrophorus pustulatus I
Hygrophorus pustulatus II
Mycena galopoda I
Mycena galopoda II
Mycena sanguinolenta I
Mycena sanguinolenta II
Number of the fruit-bodys
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
22 June
8,9 July
17,18
26,29
7, 11 August
17,20
29,30
8,9 Sept.
19,20
28,29
8,10 Oct.
21, 23
23,24 Nov.

determined by the intensity of the decomposition of debris on the part of a fungus. Naturally, this does not mean that we need not deal with the study of the biomass of fungal fruit-bodies at all. The establishment of the biomass of fungal fruit-bodies will certainly provide significant data on the characterization of a forest ecosystem as a whole. On the other hand, the determination of the mutual quantitative relations of the fruit-bodies of fungal species will also create better and more justified opportunities for the study of the processes of the secondary production within an ecosystem.

So far very little research into the biological productivity of fungi has been carried out all over the world. F.B. HORA (1959), T.F. HERING (1966) and M.J. RICHARDSON (1970) have obtained better results in establishing the biomass of the fruit-bodies of Agaricales.

Bearing these prospects in mind, studies were initiated in 1969 by a team of the Institute of Zoology and Botany of the Estonian Academy of Sciences on the Vooremaa experimental area in eastern Estonia with the aim of determining the numbers and the biomass of the fruit-bodies of macroscopic fungi on two observation areas located in a spruce-hardwood forest.

The site type of the first observation area can be characterized as follows: composition of the tree-layer -10 spruces+ aspen, the closedness of the leaf canopy - 0.5, Corylus avellana and Acer platanoides abound in the underwood, the observation area lies on a slope. The tree-layer of the second observation area consists of 10 spruces birch with a canopy closedness 0.7, Corylus avellana is the predominant tree species in the underwood, the site is level. Nemoral species predominate in the grass-layer of both the observation areas. The first observation area is richer in the floristic composition. Both the areas are on brown pseudopodsol soil.

Observations were carried out on 10 sample plots. The size of a plot was 100 square metres. To facilitate the collection of friut-bodies, each sample plot was divided in-

Table 1

The number of fruit-bodies (a) and their biomass (b, dry-weight in grams) in dominant species of Agaricales in a spruce-hardwood forest in two observation area (I and II) for 1970 (+ denotes biomass below 0.05g)

Dates			Apr.	May	June		July		August			September			October		Nov.	
		I	28	7	22	8	17	26	7	17	29	8	19	28	8	21	23	
Species		II	29	8	22	9	18	29	11	20	30	9	20	29	10	23	24	
Armillariella mellea	a	I	-	-	-	-	-	-	-	-	-	12	86	15	5	5	1	124
		II	-	-	-	-	-	-	-	-	-	-	190	366	5	1	1	563
	b	I	-	-	-	-	-	-	-	-	-	2,0	63,3	3.0	1.4	2.3	+	72.0
		II	-	-	-	-	-	-	-	-	-	-	291.9	113.3	1.4	+	+	406.6
Cortinarius hemitrichus	a	I	-	-	-	-	-	-	-	-	-	2	27	27	10	4	1	71
		II	-	-	-	-	-	-	-	-	-	-	8	5	3	1	-	17
	b	I	-	-	-	-	-	-	-	-	-	0.3	2.0	1.2	0.6	0.6	+	4.8
		II	-	-	-	-	-	-	-	-	-	-	0.4	0.1	0.2	+	-	0.8
Cystoderma carcharias	a	I	-	-	-	-	-	-	-	-	-	9	23	19	13	2	5	71
		II	-	-	-	-	-	-	-	2	46	23	83	24	4	2	+	184
	b	I	-	-	-	-	-	-	-	-	-	0.5	1.3	1.0	0.6	+	0.2	3.7
		II	-	-	-	-	-	-	-	0.2	1.3	1.9	4.6	0.9	0.1	0.1	-	9.2
Cystoderma granulosum	a	I	-	-	-	-	-	-	3	13	16	20	8	5	2	-	1	68
		II	-	-	-	-	-	-	8	-	12	16	8	3	-	-	-	47
	b	I	-	-	-	-	-	-	0.1	1.3	1.0	1.3	0.6	0.2	0.1	-	0.1	4.7
		II	-	-	-	-	-	-	0.9	-	0.9	1.0	0.6	0.1	-	-	-	3.5
Galerina marginata	a	I	-	-	-	-	-	-	-	-	4	9	58	22	6	6	3	108
		II	-	-	-	-	-	-	-	1	3	8	35	7	12	12	5	83
	b	I	-	-	-	-	-	-	-	-	0.1	0.4	1.3	0.5	0.2	+	0.1	2.7
		II	-	-	-	-	-	-	-	+	+	+	0.3	0.2	0.1	0.2	+	1.0
Marasmius bulliardii	a	I	-	-	-	-	992	98	389	205	34	16	7	3	-	-	-	1744
		II	-	-	-	30	1126	619	269	6	14	1	1	-	-	-	-	2066
	b	I	-	-	-	-	1,2	0.1	0.6	0.3	+	+	+	+	-	-	-	2.5
		II	-	-	-	+	1,3	0.7	0.2	+	+	+	+	-	-	-	-	2.5

Table 1 continued

Species			Apr.	May	June	July			August			September			October		Nov.	
		I	28	7	22	8	17	29	8	17	29	8	19	28	8	21	23	
		II	29	8	22	9	18	29	11	20	30	9	20	29	10	23	24	
Galerina unicolor	a	I	-	-	-	-	-	-	-	6	8	1	5	5	4	4	-	33
		II	-	-	-	-	-	-	-	5	13	9	3	19	9	5	-	63
	b	I	-	-	-	-	-	-	-	+	+	+	+	0.1	+	+	-	0.2
		II	-	-	-	-	-	-	-	0.1	+	0.1	+	0.3	+	+	-	0.7
Gymnopilus penetrans	a	I	-	-	-	-	-	-	-	-	-	30	38	5	-	2	-	75
		II	-	-	-	-	-	-	-	-	-	21	16	-	1	-	-	38
	b	I	-	-	-	-	-	-	-	-	-	2.2	5.7	0.7	-	2.2	-	10.8
		II	-	-	-	-	-	-	-	-	-	1.9	2.0	-	+	-	-	3.9
Hygrophorus pustulatus	a	I	-	-	-	-	-	-	-	-	-	-	-	5	34	84	4	127
		II	-	-	-	-	-	-	-	-	-	-	5	46	260	171	4	486
	b	I	-	-	-	-	-	-	-	-	-	-	-	0.1	0.9	1.7	0.1	2.9
		II	-	-	-	-	-	-	-	-	-	-	0.1	1.1	3.3	2.8	+	7.4
Laccaria laccata	a	I	-	-	-	-	2	2	43	426	301	336	145	45	15	7	2	1325
		II	-	-	-	-	3	14	65	169	136	193	100	20	11	3	-	714
	b	I	-	-	-	-	+	+	1.7	142	78	10.1	4.0	1.5	0.3	0.2	+	41.9
		II	-	-	-	-	0.1	0.4	1.9	5.6	4.0	0.1	3.3	0.5	0.3	+	-	22.4
Lacterius pyrogalus	a	I	-	-	-	-	-	-	-	-	12	3	-	-	-	-	-	15
		II	-	-	-	-	-	-	54	94	103	87	96	36	22	11	2	505
	b	I	-	-	-	-	-	-	-	-	4.4	1.0	-	-	-	-	-	5.4
		II	-	-	-	-	-	-	19.6	41.3	38.6	42.4	32.0	11.7	3.3	1.9	0.4	119.2
Marasmius androsaceus	a	I	-	-	-	-	278	6	17	48	14	8	19	9	-	1	-	400
		II	-	-	-	1	107	55	7	1	2	9	7	2	4	2	-	197
	b	I	-	-	-	-	0.8	+	+	0.2	+	+	+	+	-	+	-	1.4
		II	-	-	-	+	0.3	0.1	+	+	+	+	+	+	+	+	--	0.7
Mycena epipterygia	a	I	-	-	-	-	-	-	-	9	6	36	105	68	7	9	8	248
		II	-	-	-	-	-	-	1	11	12	27	93	20	10	20	2	196
	b	I	-	-	-	-	-	-	-	0.2	+	0.7	2.3	0.7	0.1	+	0.2	4.4
		II	-	-	-	-	-	-	+	0.3	0.1	0.7	1.4	0.3	0.1	0.3	+	3.0

Species		Dates	Apr.	May	June	July			August			September			October		Nov.	
		I	28	7	22	8	17	29	8	17	29	8	19	28	8	21	23	
		II	29	8	22	9	18	29	11	20	30	9	20	29	10	23	24	
Mycena pura	a	I	-	-	-	1	4	11	19	20	63	56	52	27	25	12	1	291
		II	-	-	-	1	2	50	48	29	69	70	94	41	41	16	-	461
	b	I	-	-	-	+	0,2	0,2	0,6	0,3	1,3	1,1	1,0	0,6	0,6	0,4	0,1	6,5
		II	-	-	-	+	+	1,3	0,9	0,6	0,9	1,5	1,9	1,4	1,1	0,4	-	10,2
Mycena sanguinolenta	a	I	-	-	-	59	998	462	82	1574	132	145	138	64	2	2	-	3605
		II	-	-	-	264	1037	1816	1555	111	238	114	244	93	17	6	-	5499
	b	I	-	-	-	0,2	2,8	1,5	0,2	4,2	0,2	0,1	0,3	+	+	+	-	10,0
		II	-	-	-	1,6	2,4	5,6	5,6	0,4	0,4	0,3	0,6	0,2	+	+	-	17,5
Mycena viscosa	a	I	-	-	-	-	-	-	-	-	3	10	13	88	11	111	31	267
		II	-	-	-	-	-	-	-	-	13	8	13	109	38	27	10	218
	b	I	-	-	-	-	-	-	-	-	+	0,1	0,3	1,7	0,4	3,0	0,7	6,3
		II	-	-	-	-	-	-	-	-	0,1	0,2	0,3	2,1	0,7	0,9	0,2	4,6
Mycena vulgaris	a	I	-	-	-	-	3	-	-	2	-	187	678	802	84	328	23	1938
		II	-	-	-	-	-	-	2	-	-	1	153	260	260	89	1	766
	b	I	-	-	-	-	+	-	-	+	-	+	1,6	1,9	0,3	0,8	+	4,9
		II	-	-	-	-	-	-	+	-	-	+	0,4	0,7	0,6	0,2	+	2,1
Haematoloma capnoides	a	I	-	-	-	-	-	-	-	-	-	3	120	108	24	43	52	350
		II	-	-	-	-	-	-	-	-	-	6	6	5	8	-	-	25
	b	I	-	-	-	-	-	-	-	-	-	0,5	27,2	6,6	3,8	3,2	7,0	48,3
		II	-	-	-	-	-	-	-	-	-	0,9	0,2	0,2	1,1	-	-	2,4
Strobilurus esculentus	a	I	939	85	-	9	34	171	189	301	86	54	383	169	135	584	164	3303
		II	1821	357	-	-	128	627	611	52	103	26	107	79	94	166	40	4211
	b	I	17,8	2,0	-	0,1	+	0,5	0,5	1,3	0,5	0,3	2,7	1,5	0,3	4,2	1,7	33,9
		II	42,2	6,6	-	-	0,4	0,5	1,9	0,6	0,3	0,2	0,8	0,6	0,9	1,9	0,3	58,6
Mycena filopes S.Mos.	a	I	-	-	-	-	-	-	-	-	-	-	9	60	26	427	114	636
		II	-	-	-	-	-	-	-	-	-	-	61	298	1094	1698	94	3245
	b	I	-	-	-	-	-	-	-	-	-	-	+	0,3	+	1,8	0,5	2,9
		II	-	-	-	-	-	-	-	-	-	-	0,2	1,0	3,3	5,5	0,1	10,3
Mycena galopoda	a	I	-	-	-	-	50	31	3	127	48	75	195	163	12	40	4	748
		II	-	-	-	1	91	246	81	46	124	109	315	292	106	88	12	1511
	b	I	-	-	-	-	0,4	0,2	+	1,0	0,1	0,4	1,6	1,7	+	0,3	+	6,2
		II	-	-	-	+	0,5	1,9	0,7	0,4	1,1	1,1	2,8	2,6	0,8	0,5	-	12,9

to 5 strips with a size of 2 x 10 sq.m. Thus observations on one observation area were made altogether on an area of 0.1 hectare. Fruit-bodies were collected during the whole vegetative period from April to November, on an average every ten days, but during the period when there were few mushrooms (in June) collection was once a month. In November only one observation was made because snow fell in the first half of this month. The fruit-bodies were counted immediately after collection, their dry weight was estimated after drying at 70°C.

So far about 120 species of Agaricales have been recorded in the spruce-hardwood forest under study. For the present paper the data for 1970 have been processed on 21 dominant species of Agaricales found in the particular spruce-hardwood forest.

Summary data on the numbers and the biomass of the fruit-bodies of the above-mentioned species are presented in Table 1. Table 2 presents summary data on production per ha according to species. It is evident from the Table that both the observation areas of the same forest type differ from each other considerably in the number of the fruit-bodies as well as the biomass of the fungal species studied. The total annual production of the above-mentioned dominant species accounted for 2.8 kg/ha on observation area I and 7.7 kg/ha on area II. Remarkable differences in productivity can also be seen in individual species. The differences were particularly great in case of Lactarius pyrogalus, Armillariella mellea and Naematoloma capnoides. The remarkably higher productivity of L. pyrogalus on the second observation area is apparently related to the greater frequency of occurrence of Corylus on this sample area. The difference between the two observation areas could also be noted in seasonal dynamics. In many species such as Lactarius pyrogalus, Mycena pura, Laccaria laccata, etc., the number of fruit-bodies and their corresponding dry weight reached their maximum values on the second area three weeks later

Table 2

The number of fruit-bodies and their biomass (per 1 ha) in dominant species of Agaricales in a spruce-hardwood forest on two observation areas (I and II) for 1970

Species	Number of fruit-bodies		Biomass (dry-weight in grams)	
	I	II	I	II
Armillariella mellea	1240	563	720	4066
Cortinarius hemitrichus	710	170	48	8
Cystoderma carcharias	710	1840	37	92
C. granulosum	680	470	47	35
Galerina marginata	1080	830	27	10
G. unicolor	330	630	2	7
Gymnopilus penetrans	750	380	108	39
Hygrophorus pustulatus	1270	4860	29	74
Laccaria laccata	13250	7140	419	224
Lactarius pyrogalus	150	5050	54	1912
Marasmius androsaceus	1000	1970	14	7
M. bulliardii	17440	2066	25	25
Mycena epipterygia	2480	1960	44	30
M. filopes s. Mos.	6360	32450	29	103
M. galopoda	7480	15110	62	129
M. pura	2910	4610	67	102
M. sanguinolenta	36050	5499	100	175
M. viscosa	2670	2180	63	46
M. vulgaris	19380	7660	49	21
Naematoloma capnoides	3500	250	483	24
Strobilurus esculentus	33030	42110	339	586
Σ	152470	137798	2767	7715

Table 3

Total production (g/ha) of fruit-bodies in dominant species of Agaricales for 1970 by the month in a spruce-hardwood forest on two observation areas (I and II)

	May	June	July	Aug.	Sept.	Oct.	Nov.
I	198	-	89	451	1609	312	104
II	488	-	186	1296	5405	326	12

than on the first area. The maximum number of fruit-bodies and their biomass appeared on the first observation area in the second half of August, on the second observation area in the first half of September. The seasonal dynamics of the numbers of the fruit-bodies of the same species under study and their biomass are plotted in Figs. 1-6. It can be seen from Table 3 that the maximum of the fruit-bodies of fungi on both observation areas occurred at the same time in September. The total production of three months (August, September, October) accounted for 89.4 % of the total annual production on observation area I and 91.2 % on observation area II.

If one compares the numbers and the corresponding biomasses of fruit-bodies on the sample plots of one observation area, e.g. in the case of Laccaria laccata (see

Figs. 4-6. Seasonal dynamics of the biomass (dry-weight in grams) of fungal fruit-bodies in a spruce-hardwood forest on two observation areas (I and II) in 1970

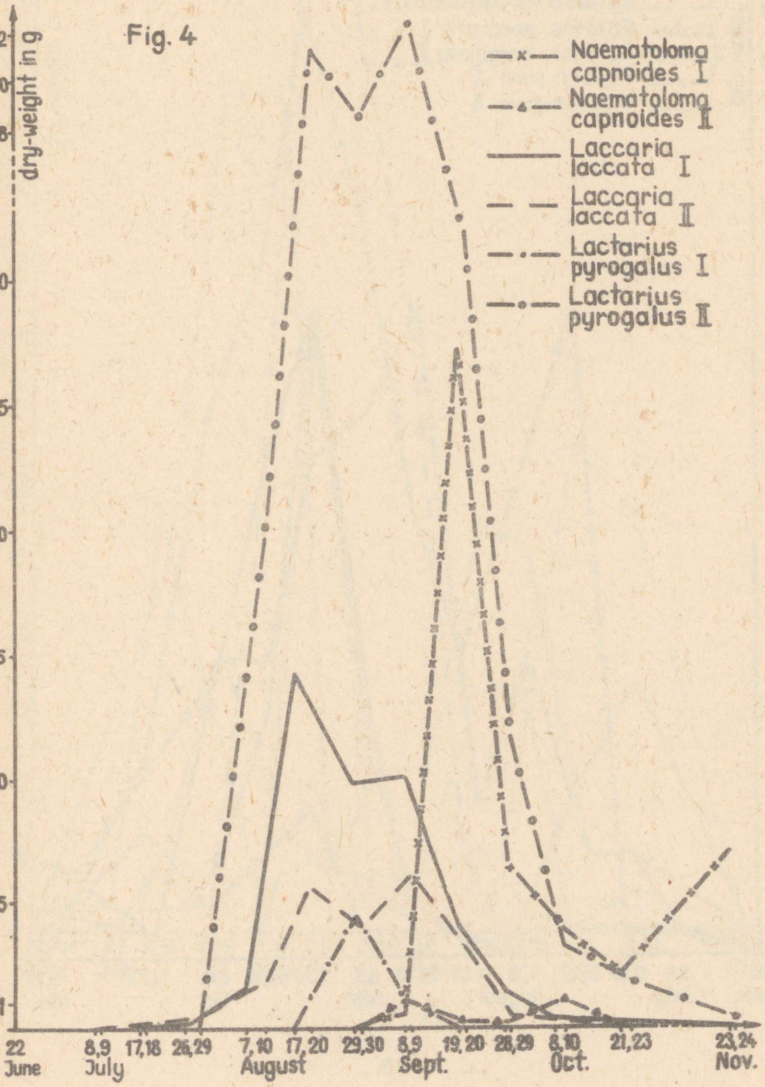


Fig. 4
dry-weight in g
42
40
38
30
25
20
15
10
5
1
Naematoloma capnoides I
Naematoloma capnoides II
Laccaria laccata I
Laccaria laccata II
Lactarius pyrogalus I
Lactarius pyrogalus II
22 June
8,9 July
17,18
26,29
7,10 August
17,20
29,30
8,9 Sept.
19,20
28,29
8,10 Oct.
21,23
23,24 Nov.

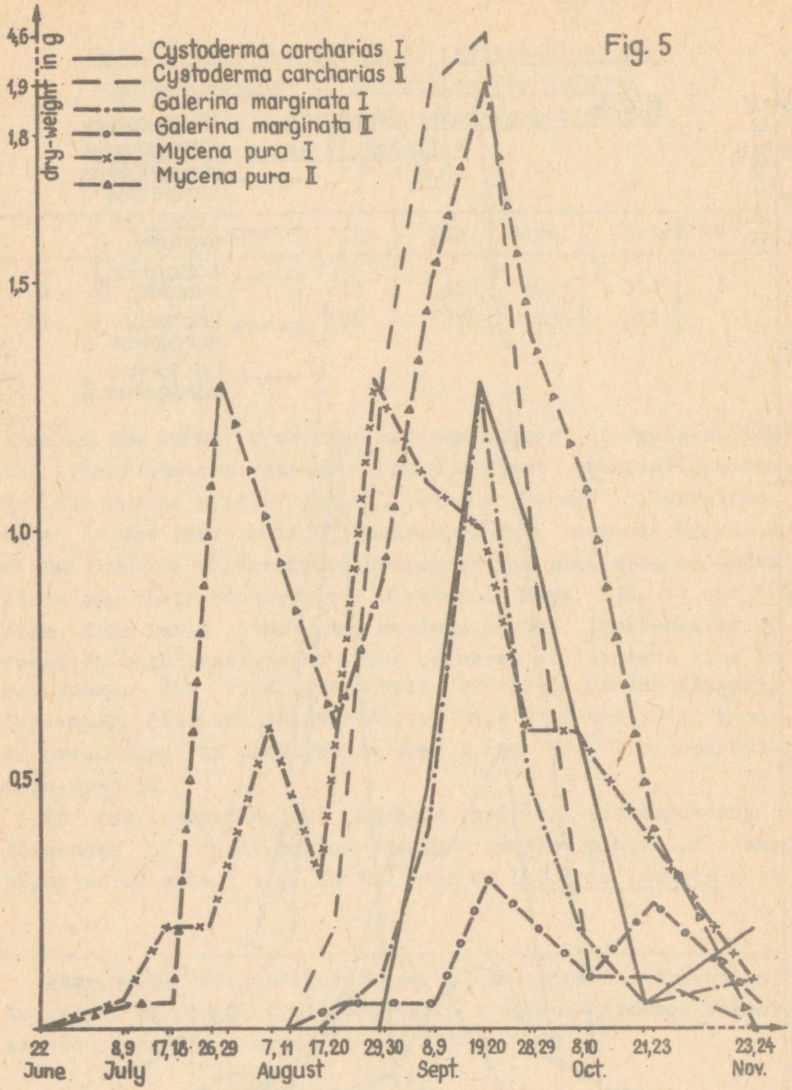


Fig. 5
dry-weight in g
4,6
1,9
1,8
1,5
1,0
0,5
Cystoderma carcharias I
Cystoderma carcharias II
Galerina marginata I
Galerina marginata II
Mycena pura I
Mycena pura II
22 June
8,9 July
17,18
26,29
7,11 August
17,20
29,30
8,9 Sept.
19,20
28,29
8,10 Oct.
21,23
23,24 Nov.

Fig. 6

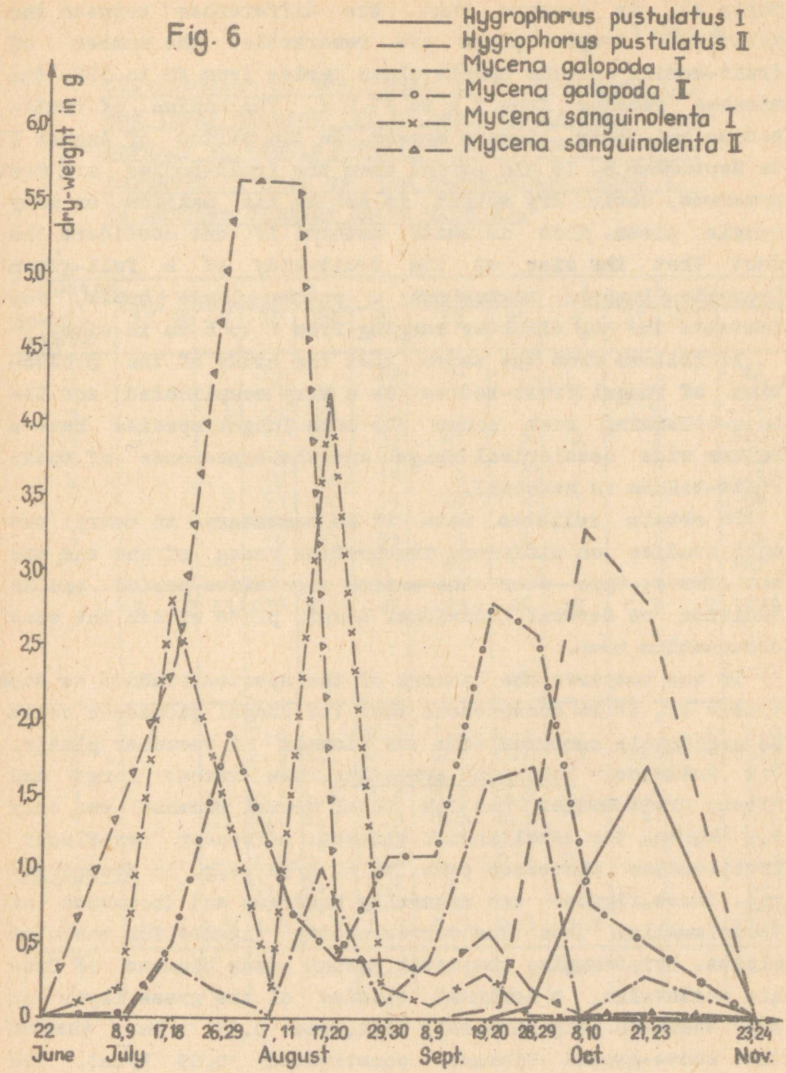

Hygrophorus pustulatus I
Hygrophorus pustulatus II
Mycena galopoda I
Mycena galopoda II
Mycena sanguinolenta I
Mycena sanguinolenta II
dry-weight in g
6,0
5,5
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0
22 June
8,9 July
17,18
26,29
7,11 August
17,20
29,30
8,9 Sept.
19,20
28,29
8,10 Oct.
21,23
23,24 Nov.

Table 4), it appears that the differences between the individual sample plots are remarkable. The number of fruit-bodies on the sample plots varies from 42 to 522, the biomass ranging from 1 g to 17.9 g. The maxima of fruit-bodies and their biomass appear in the period of August 17 to September 8. In the period when the fruit-bodies are most numerous, their dry weight is not at its maximum on many sample plots. This is quite natural if one considers the fact that the size of the fruit-body of a full-grown Laccaria laccata varies on a rather large scale, for instance the cap diameter ranging from 2 to 6 cm in size.

It follows from the above that the study of the production of fungal fruit-bodies is a very complicated and labour-consuming task since the same fungal species have a rather wide oecological range and the appearance of their fruit-bodies is seasonal.

To obtain reliable data it is necessary to carry out such studies on different observation areas of one and the same forest type over the entire vegetative period and in addition on several individual sample plots within the same observation area.

If one compares the biomass of the species studied as such (Table 1), it is conspicuous that the fungal biomasses could be negligible compared with the biomass of vascular plants. For instance, Lactarius pyrogalus has rather large and fleshy fruit-bodies but its total annual biomass was only 1.9 kg/ha, the total annual biomass of tender non-fleshy fruit-bodies decreased down to 62 g/ha (e.g. in Mycena pura). These figures are naturally hundreds and thousands of times smaller than the corresponding figures for vascular plants. For example, the total annual mean biomass of Oxalis acetosella, a dominant species of the grass layer on the Vooremaa experimental area, was 0.37 t/ha (thereof the above-ground biomass constituted 0.09 t/ha). The total annual mean biomass of Cirriphyllum piliferum, a dominant of the moss layer, was 45.5 kg/ha. Still, one must not

Table 4

Distribution of the number of fruit-bodies (A) and their biomass (B) in Laccaria laccata according to sample plots (100 sq.m.) in a spruce-hardwood forest on the observation area I (+ denotes biomass below 0,05 g).

A

Dates	July		August				September		October		Nov.	Σ
Sample plots	17	26	7	17	29	8	19	28	8	21	23	
1				13		13	10	5			1	42
2				43	25	14	7	3	3	1		96
3			3	27	23	15	4			1		73
4	1		12	14	24	33	21	9	3	3		120
5			6	68	54	66	30	7		1		232
6				15	4	15	9	2				45
7			3	53	6	17	12	2	3			96
8		1		20	12	10	3		1			47
9				19	19	21	5	1		1		66
10	1	1	19	156	134	141	44	17	8		1	522
Σ	2	2	43	428	301	345	145	46	18	7	2	1339

B

1				5,8		0.3	0.5	0.4			+	7.0
2				1.3	0.7	0.5	0.3	0.1	+	0.1		3.0
3			0.5	1.5	0.3	0.3	0.1			+		2.7
4	+		0.3	0.4	1.1	1.2	0.9	0.2	0.1	0.1		4.3
5			0.1	2.1	1.4	1.3	0.6	0.1		+		5.6
6				0.4	0.1	0.3	0.3	0.1				1.2
7		+		1.2	0.1	0.4	0.2	0.1	0.1			2.1
8		+		0.7	0.1	0.2	+		+			1.0
9				0.8	0.7	0.4	0.2	+		+		2.1
10	+	+	0.6	4.8	5.3	5.2	1.3	0.5	0.2		+	17.9
Σ	+	+	1.5	19.0	9.8	10.1	4.4	1.5	0.4	0.2	+	46.9

conclude from this that the role and productivity of fungi in a forest ecosystem is negligible. As we have emphasized above, the participation of a fungal organism in the energy flow of an ecosystem is shaded and may be altered by different kinds of circumstances.

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PECULIARITIES IN THE GROWTH AND DEVELOPMENT OF FRUIT-BODIES IN SOME FUNGAL SPECIES

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The development and growth of the fruit-bodies of fungi are closely inter-related. The development of a fruit-body lasts from the moment of its rise to the cessation of sporulation, being connected with the differentiation of the various parts of the fruit-body, including the formation of spores in the sporulation stage. The function of the fruit-body of a fungus is first and foremost the formation of spores, and the whole development of the mushroom is subjected to it. The growth of a fruit-body proceeds in parallel to the development of the fungus and is revealed in the increase of the size of the fruit-body. The cessation of growth and of development need not coincide and apparently do not coincide in the majority of cases. As a rule, the development of a fruit-body in the form of spore formation continues for some time after the final cessation of growth (see results of observations on sporulation below).

The growth of fruit-bodies takes place in an extremely intricate way since we have to do here with such a growth which simultaneously proceeds in several directions and very differently in various parts of the fruit-body. Thus, the real growth of the cap is basically revealed in the thickening of the cap as well as in the increase of its diameter. The intricacy of the situation is increased by the

fact that in many species the unrolling of the cap edge proceeds in parallel to growth, and it is very difficult to establish what part in the increase of the cap diameter belongs to unrolling. The growth of the fungal fruit-bodies as well as that of the individual parts cannot therefore be regarded as a linear but rather at least as a square-root relationship. The growth of the parts of the fruit-body in certain respects (e. g., increase of the cap diameter, height increment of the fruit-body, which cannot be expressed linearly) consequently does not characterize the growth of a given part of the fruit-body.

The present report will deal with the growth of the cap and the stipe in respect of the diameter and the growth of the fruit-body in the direction of height (the increase of the cap diameter is conditionally considered implying the unrolling of the cap edge, which has not been differentiated from actual growth). Observations were carried out on 17 fungal species in the years 1962 and 1963. The results of the observations are presented in the form of graphs in Figs. 1 to 6.

The following methods were used. At the same time of the day (9 a.m.) the intensity of sporulation, the diameter of the cap and the stipe, and the height of the fruit-body were measured. To ascertain sporulation a piece of glass was placed on a special metal plate directly under the hymenophore, and the character of sporulation was evaluated on a 3-point scale by the spore powder that had fallen on to the glass as follows: + weak sporulation (the spore powder was visible on the glass under the microscope), ++ medium sporulation (a thin layer of the spore powder was visible on the glass with the naked eye), +++ strong sporulation (a thick layer of the spore powder was visible with the naked eye). To measure the wetness of the fruit-bodies a piece of glass was placed in the moss at the base of the stipe and the height of the fruit-body was measured from that surface to the top of the cap. The diameter of the

stipe was measured at about the middle of the stipe, which was marked with damp-proof ink. The peculiarities of the rupture of the general and the circular velum as well as the degree of eatability by snails and rodents were also observed on fruit-bodies.

While with vascular plants it is possible to watch their development from their sprouting onward, the development of the fruit-bodies of fungi cannot be followed by the hitherto existing methods from the moment of their formation onward. Observations of fruit-bodies can be started only when they become observable beneath the forest trees and readily measurable. By that moment the fruit-bodies of different species are by far not in a uniform stage of development. This makes it difficult to compare various species among themselves from the point of view of the peculiarities of their growth, particularly since no reliable criteria have been established for the differentiation of the phenological stages of fruit-bodies. One of such criteria is apparently the time of the inception of sporulation but in many instances for methodological reasons its accurate determination is difficult. The only factor which can be distinctly determined by the present methods is the final moment of growth in the development of fruit-bodies. Proceeding from this criterion, it is comparatively convenient to compare the growth of fruit-bodies in different species. The establishment of this moment enables the researcher to carry out a certain comparison and this moment has been taken for the starting-point in the present study. Data on the fruit-bodies, the observations of which for some reason or other have been interrupted before the cessation of their growth, cannot be considered to be comparable and cannot therefore be made use of.

The majority of the fruit-bodies under observation was suffering from the damage caused by snails. In many cases this circumstance led to an early interruption of

observations (when the cap had been damaged by eating to the extent that its further measuring was impossible or when the stipe had been gnawn in two). Very often the caps were full of holes from eating already at the beginning of observations. Considerable damage had been caused by snails to the species Russula foetens, R. vinosa, Lactarius deliciosus and Gomphidius glutinosus; Xerocomus badius had been greatly damaged by rodents. Despite that, the fruit-bodies continued their growth even in the presence of considerable damage. This shows that partial damage by snails and rodents does not prevent fruit-bodies from growing.

As can be seen from the diagrams, the diameter of the cap and the height of the fruit-body of most fungal species increase differently in various stages of development. For this reason it is impossible to indicate their diurnal growth rate during the whole period of their development. The two species of Cantharellus cibarius and Cortinarius armillatus (see Fig. 1) are conspicuous for a more uniform growth. Average diurnal growth rates with regard to the cap diameter and the height of the fruit-body have been presented in Table 1 in periods of more or less uniform growth for species whose fruit-bodies were under observation up to the cessation of growth. The growing periods shown in Table 1 are indicated by a broken line, numbers on each species or specimen denote the average diurnal increment of the cap diameter (in line 1) and of the height of the fruit-body (in line 2) in centimetres.

Fig. 1. Growth of fruit-bodies: a - Cantharellus cibarius, b - Cortinarius armillatus.

The continuous line indicates increase of the cap diameter; the broken line denotes height increment of the fruit-body; the Arabic numerals designates increase of the stipe diameter. The arab numbers in diagram curves designate specimens of fruit-bodies of the species observed.

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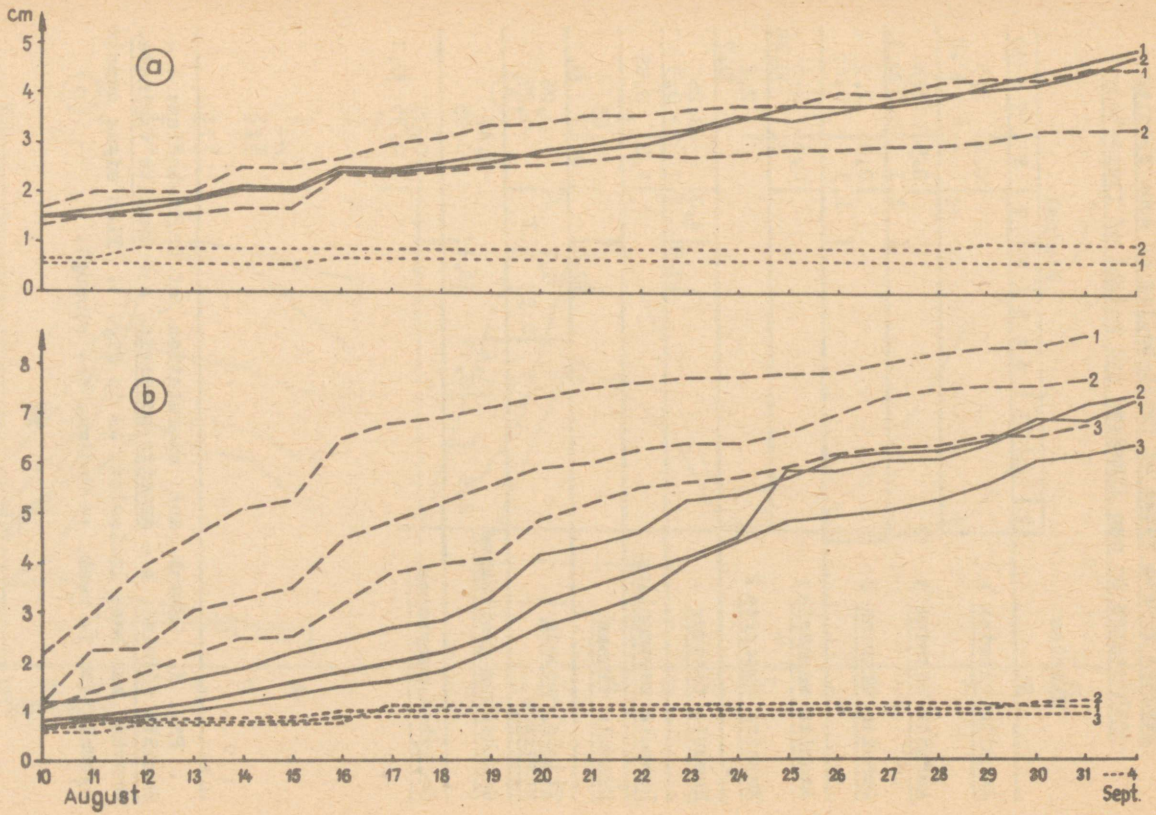


Average growth rates of fruit-bodies of some species with regard to cap diameter and height of fruit-body

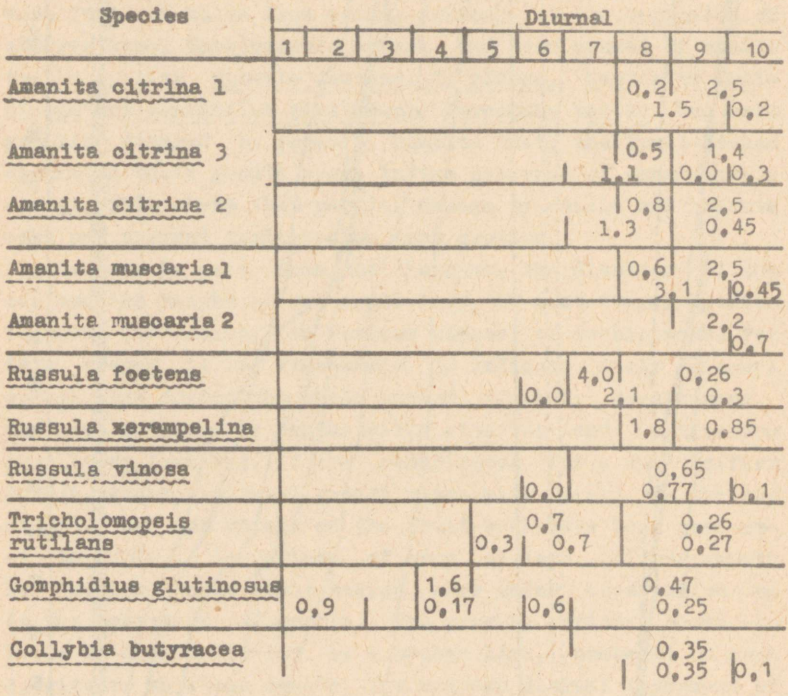
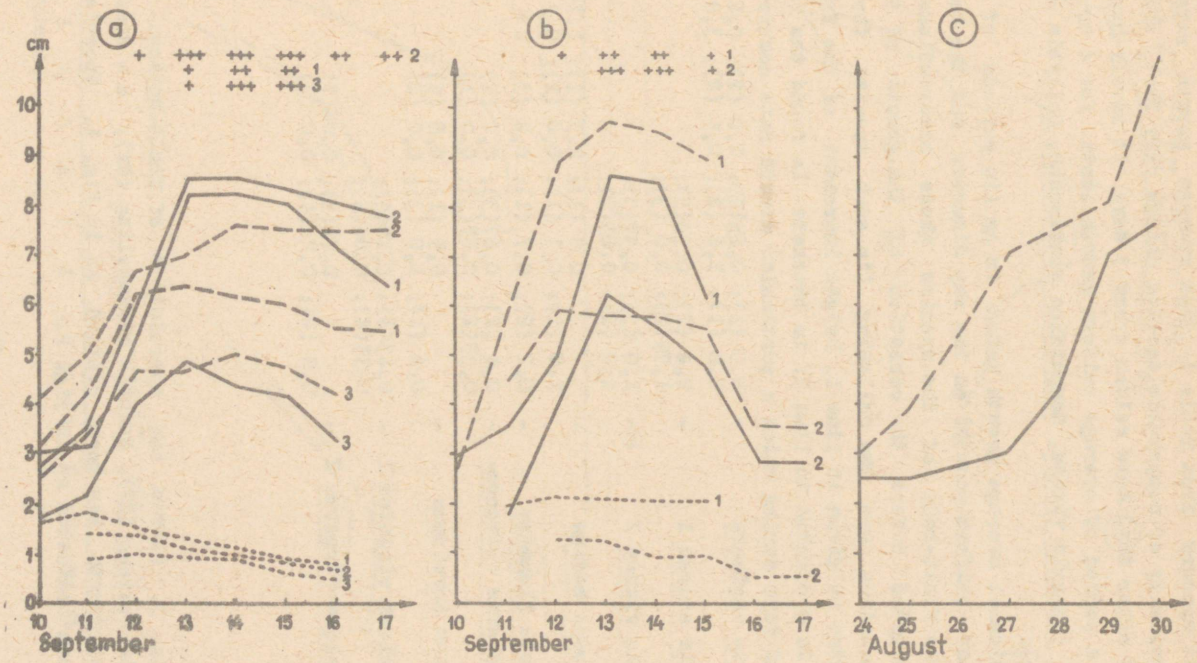


Fig. 2. Growth and sporulation of fruit-bodies: a - *Amanita citrina*, b - *Amanita muscaria*, c - *Amanita vaginata*. Growth has been indicated as in Fig. 1. Plus signs denote sporulation (+ weak, ++ medium, +++ strong).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It appears from Table 1 that average growth rates of the majority of comparable species change very fast, usually every other day, more seldom every 3 days. It rarely happens that a period of average uniform growth lasts for 4 or more days (*Russula vinosa*, *Gomphidius glutinosus*, *Collybia butyracea*).

Diurnal average growth rates in cm (in periods of more or less uniform growth) on the cap diameter and the height of the fruit-body of the species whose observations was interrupted before the cessation of the growth of their fruit-bodies are the following (in each species the cap diameter is given in line 1, height increment of the fruit-body is presented in line 2; in brackets is found the number of days during which a particular growth rate occurred):

Amanita vaginata - 0,0 (1); 0,25(2); 2,0 (2); 0,6 (1)
0,8 (1); 1,6 (2); 0,5 (2); 3,0 (1)

Russula vinosa 1 - 2,4 (2); 0,33(3);
1,75(2); 0,0 (3);

Russula vinosa 2 - 1,0 (3); 0,37(3);
1,2 (2); 0,23(3);

Xerocomus badius - 0,8 (1); 2,3 (1); 1,15(2)
2,0 (1); 0,7 (1); 0,0 (1); 0,3 (1)

Pholiota flammans - 0,2 (2); 0,7 (1); 0,2 (3)

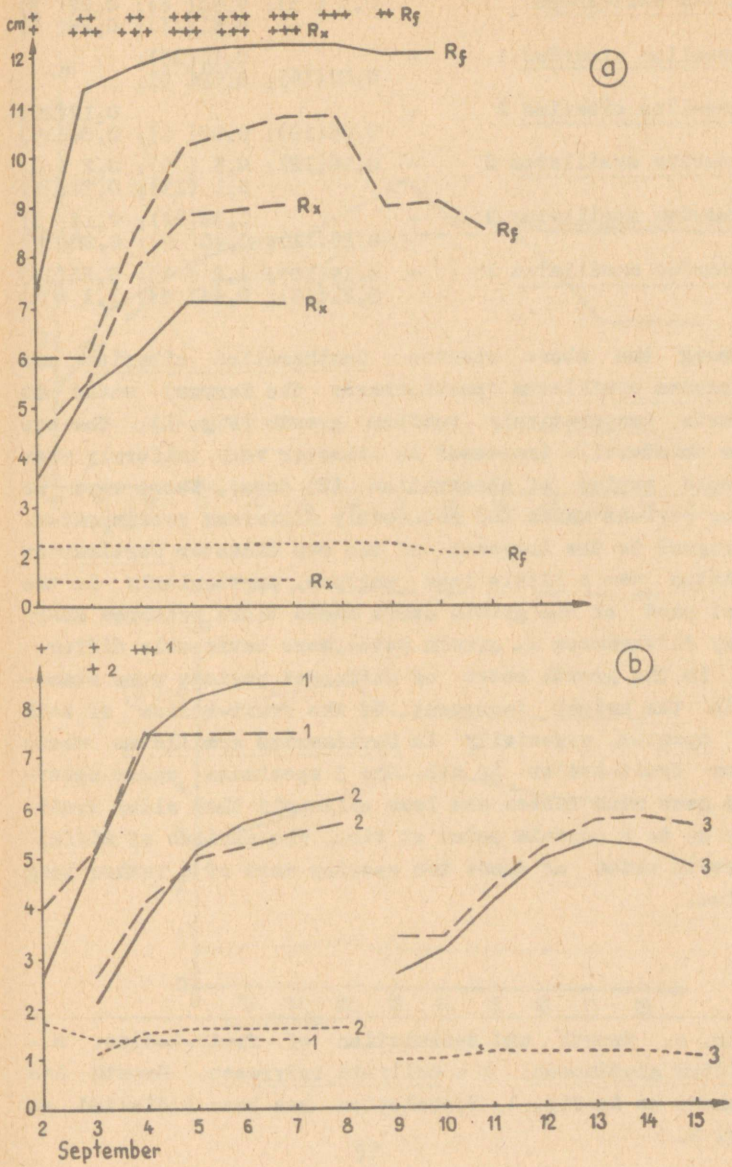
Hygrophorus olivaceo-albus - 0,4 (2); 0,67(3); 0,2 (1)
0,35(2); 0,67(3); 0,0 (1)

Paxillus involutus - 0,5 (1); 0,8 (5)
0,0 (1); 0,0 (3); 0,0 (2)

Tricholoma virgatum 1 - 0,43(4); 0,12(5);
0,55(4); 0,04(5);

Tricholoma virgatum 2 - 0,77(3); 0,06(7)
0,8 (2); 0,24(5); 0,0 (3)

Fig. 3. Growth and sporulation of fruit-bodies: a - *Russula foetens* (Rf), *Russula xerampelina* (Rx), b - *Russula vinosa*. Growth has been plotted as in Fig. 1. Sporulation has been indicated as in Fig. 2.


cm
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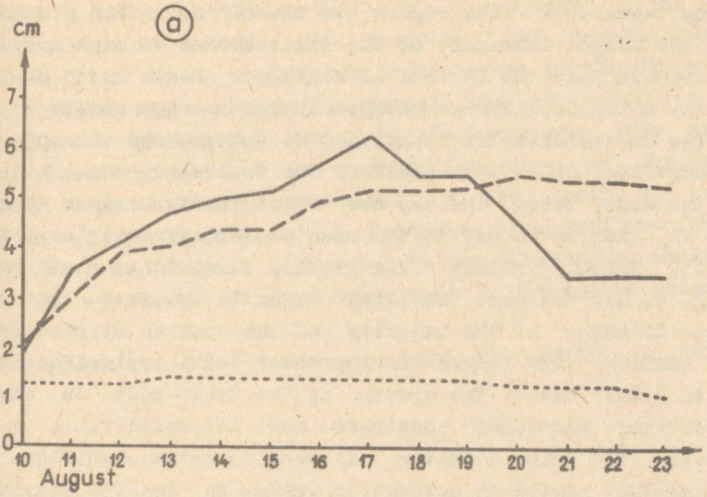
Lactarius deliciosus		0,3 (3);	0,93(6); 0,51(6);	0,27(3) 0,25(6)
Cantharellus ciberius 1	-	0,07(16);	0,12(25); 0,19(9);	
Cantharellus ciberius 2	-	0,05(19);	0,07(1);	0,12(25) 0,06(5)
Cortinarius armillatus 2	-	0,16(12);	0,5 (5); 0,1 (19);	0,2 (8) 0,71(6)
Cortinarius armillatus 3	-	0,15(11);	0,32(14); 0,48(5);	0,14(8) 0,28(5)
Cortinarius armillatus 1	-	0,15(10); 0,21(15);	1,2 (1); 0,44(5);	0,26(14) 1,1 (1)

Among the above species Cantharellus ciberius and Cortinarius armillatus (particularly the former) stand out for their comparatively uniform growth (Fig. 1). The cap of the chanterelle increased in diameter very uniformly over the whole period of observation (25 days). There were no growing periods which had noticeably different growth rates. With regard to the increase of the cap diameter Cortinarius armillatus was a little less uniform, particularly in the central part of the growth curve where there occurred sharp one-day differences in growth rates. More noticeable differences in the growth rates of different periods were observed in the height increment of the fruit-bodies of both these species, especially in Cortinarius armillatus whose younger fruit-bodies in all the 3 specimens under observation grew much faster and less uniformly than older fruit-bodies up to a certain point of time. The periods of different growth rates of these two species were of a rather long duration.

Fig. 4. Growth and sporulation of fruit-bodies: a - Gomphidius glutinosus, b - Collybia butyracea. Growth has been shown as in Fig. 1. Sporulation has been indicated as in Fig. 2.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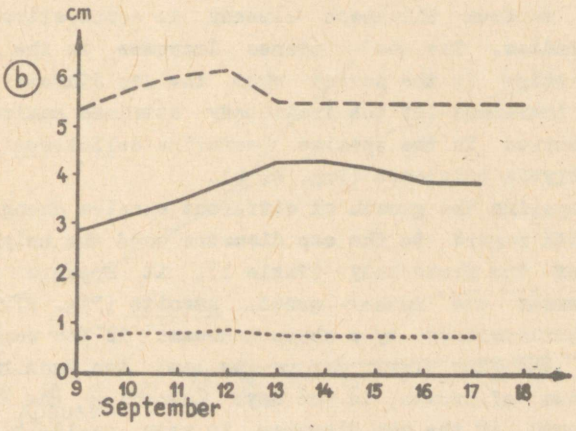
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Comparing the average growth rates of the fruit-bodies among themselves with regard to the cap and stipe diameter and the height increment of the fruit-bodies of each species, it appears that the periods of different growth rates do not mostly coincide, likewise changes in the average growth rates of the characteristics mentioned do not proceed in uniform proportions. Often the height of the fruit-body may continue to increase, though the cap has attained its maximum diameter as, for instance, in the species Amanita citrina (Fig. 2, a), Russula foetens (Fig. 3, a), Gomphidius glutinosus (Fig. 4, a). The most striking thing is the fact that the stipe diameter of the majority of the species studied does not increase any longer or increases very insignificantly (1 to 2 mm) while the growth of the fruit-body in other directions mentioned continues most intensively. In some species the stipe diameter may even decrease significantly during that period on account of drying up Amanita citrina, Russula vinosa (see Fig. 2, a, and Fig 3, b).

This shows that in most species the stipe attains a nearly maximum thickness already in comparatively young fruit-bodies. The most intense increase in the thickness of the stipe in the period when the cap diameter and the height increment of the fruit-body attained maximum values was observed in the species Lactarius deliciosus (Fig. 5) and Collybia butyracea (Fig. 4, b).

Comparing the growth of different species among themselves with regard to the cap diameter and the height increment of the fruit-body (Table 1), it appears that the differences are rather great. Amanita (Fig. 2, a, and b) are characterized by a sharp increase in the cap diameter during the very last day or the last two days before the cessation of growth; in the days preceding the last days, the growth of the cap diameter is very negligible. On the other hand, the height of the fruit-body of an Amanita shows a negligible growth in the last one or two days, but a sharp increase in the preceeding days. It follows from

the above that in Amanita the stipe grows to its almost normal length first and thereafter proceeds a sharp rise in the cap diameter. Within the last 2 or 3 days of the final cessation of growth, the fruit-body of Russula foetens (Fig. 3, a) grew negligibly in increment in the directions studied, but very noticeably during the day preceding it. Gomphidius glutinosus and Collybia butyracea grew in the cap diameter and in the height increment of the fruit-body very uniformly for nearly a week before the cessation of growth (Fig. 4, a). Tricholomopsis rutilans (Fig. 6, b), however, showed a growth in the directions mentioned which was three times slower than in the period prior to it.

From these data one can draw the conclusion that in

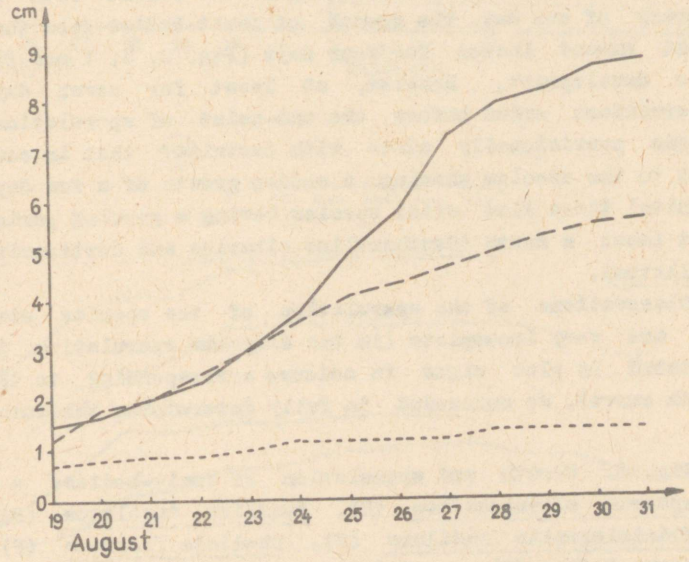


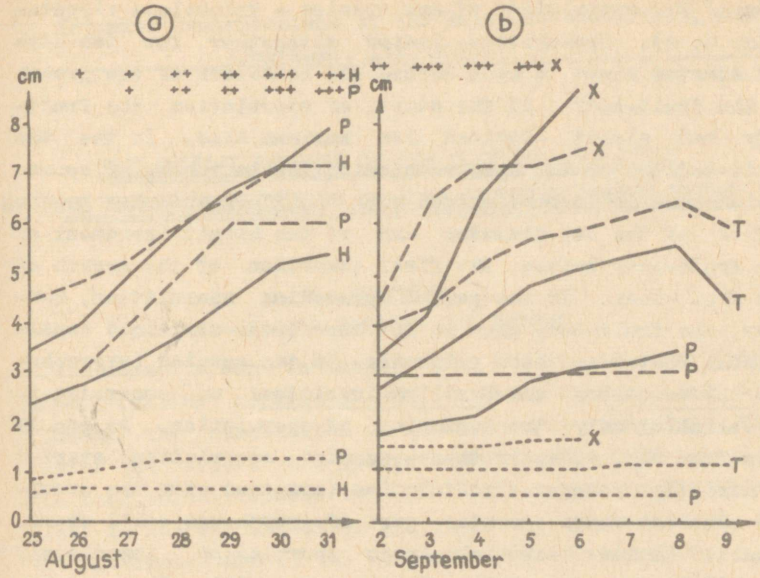
Fig. 5. Growth of fruit-body of Lactarius deliciosus. Growth has been indicated as in Fig. 1.

the majority of the species studied the cap diameter and the height increment of the fruit-body before the cessation of growth proceed more slowly than in the middle stages of development; only Amanita show a partially reverse tendency.

On the basis of the data presented it is difficult to drew any definite conclusions on the duration of the existence of the fruit-bodies of various fungal species. The reasons for this are that there are no data on the duration of the initial period of the development of fruit-bodies (i.e. on the development of the fruit-bodies not observable beneath the forest trees) and the starting-point of observations in most cases does not coincide with the moment when the fruit-body becomes visible under the forest. Only in the case of one species, namely on two specimens of Amanita citrina we succeeded in determining the moment when a fruit-body became observable under the forest with an accuracy of one day. The growth of fruit-bodies from that moment onward lasted for four days (Fig. 2, a, 1 and 2), their development, however, at least for seven days (observations ended before the end-point of sporulation). One can provisionally state with certainty that in contrast to the species showing a sudden growth of a few days (Amanita) there also exist species having a growing period of at least a month (Cantharellus cibarius and Cortinarius armillatus).

Observations of the sporulation of the species studied are very incomplete (in the diagrams sporulation is indicated by plus signs in calours corresponding to the growth curve). We succeeded in fully determining the dura-

Fig. 6. Growth and sporulation of fruit-bodies: a - Hygrophorus olivaceoalbus (H), Paxillus involutus (P), b - Tricholomopsis rutilans (T), Pholiota flammans (P), Xerocomus badius (X), c - Tricholoma virgatum. Growth has been indicated as in Fig. 1. Sporulation has been shown as in Fig. 2.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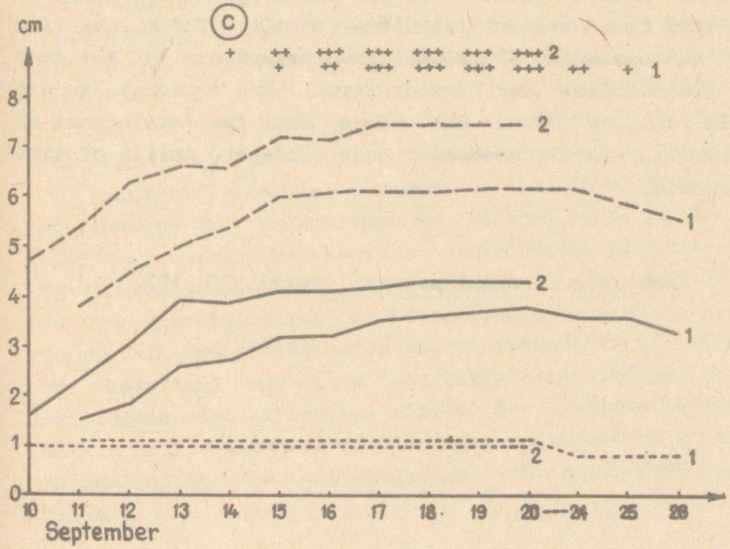
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tion of the sporulation of one species - Tricholoma virgatum (Fig. 6, c). Sporulation lasted altogether for ten days and started about a week before the cessation of the growth of the fruit-body. At the start of sporulation the fruit-body had almost attained its maximum size. In the two fruit-bodies of the species studied the beginning of sporulation more or less coincided with a uniform and slow growing period of the cap diameter and of the height increment of the fruit-body before the final cessation of the growth of the fruit-body. In the period preceding sporulation, however, the fruit-body grew in the directions mentioned considerably faster and less uniformly. In two species (Hygrophorus olivaceoalbus and Paxillus involutus) we succeeded in establishing only the beginning of sporulation. As can be seen from Fig. 4, b, in these species sporulation started on markedly younger fruit-bodies (compared with the previous species) whose greater part of growth was still ahead. Amanita showed extremely poor sporulation immediately after the rupture of the circular velum (Fig. 2, a and b).

It is also evident from the observations of sporulation that fruit-bodies sporulate usually for a long time after the cessation of growth, even regardless of the fact that fruit-bodies may already reveal the tendency to dry up. It follows from the above that the development of fruit-bodies mostly proceeds over a longer period of time than growth.

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PRELIMINARY RESULTS OF THE QUANTITATIVE STUDY OF LICHEN DISTRIBUTION IN SOME ESTONIAN FOREST TYPES

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Lichens occur in nearly all overground ecosystems. Often forming groupings with a great biomass, they influence the circulation of substances in ecosystems. The latter is valid of the ecosystems of tundra, forest tundra and some boreal forests in which lichens have an important place in the regulation of the energetic processes and of the interrelations of the components of an ecosystem.

The peculiar ecological conditions obtaining in forests exert a great influence on their lichen flora which considerably differs from that of parks and open areas. The overground lichens together with other plants can be indicators of soil conditions. They exercise their influence on the physico-chemical qualities of the soil and also have an effect on the life of vascular plants.

Epiphytic lichens covering the trunks of trees level the changes of temperature on the tree bark. At the same time they can hinder the normal development of trees.

Alongside autecological studies, attention must be paid to lichenocoenological problems. Coenologic methods are used to explain the position and the importance of lichen groups in ecosystems and also the interrelationships between cryptogams and flowering plants. The problems of the formation and development of lichen synusiae are of great significance in the investigation of ecosystems as an integrity.

Certain specific features of lichens must be especially considered when studying the structural elements of ecosystems. They are: a slow growth rate, a special type of nutrition and metabolism, specific metabolites, dependence on certain ecological conditions obtaining within a coenosis.

In the present study special attention has been paid to the relationships of lichen species and their groupings with various tree species.

In the present paper the method of recognizant investigation has been used. Forest lichens of the Estonian S.S.R. were studied in the period of 1965 - 1968. The main attention was paid to spruce, pine, birch and black alder. Vaccinium vitis-idaea, Oxalis and Alder swamp site types were studied in detail in a number of districts of the Estonian S.S.R.

Forest types were determined on the basis of a classification compiled by A. Karu and L. Muiste in 1958.

In the present study a sample quadrat of 2 x 2 dm was used. A network was used to divide it into 100 parts in order to simplify the determination of the lichen cover value. On thin-stemmed trees the size of the quadrat was 1 x 4 dm. In the case of conifers 8 quadrats on each trunk were described in 4 expositions both at the base and at breat height.

The cover value of all species was determined with a precision of 1% in each quadrat. The species with a cover less than 1% were marked with a plus sign (+). Vitality was recorded only in case it deviated from the normal one, i.e. in the case of poor or rich growth. Printed punched cards were used for recording the data (Симермаа, 1968). The trees were divided into five age-classes:

I 20 - 40 year-old trees,
II 41 - 60 year-old trees,
III 61 - 90 year-old trees,

IV 91 - 120 year-old trees,

V 121 - 200 year-old trees.

Although conifers live longer than deciduous trees and their physiological againg is slower, the total age of the substrate is far more important for lichens than its physiological age. That is why in the present paper the same age classes have been used both for deciduous trees and conifers.

20 trunks of conifers of each age-class of all forest types were investigated.

In the present paper a combination of the random and regular methods was applied when selecting sample plots. A close watch was kept that the sample plots should have as homogeneous ecologic conditions as possible, i.e. they should lie far enough from roads and forest edges and no aisles or vistas should run though them. The presence of a well-developed homogeneous forest vegetation on a large area was one of the requirements.

The composition age, canopy coverage and quality class of a stand as well as its location on the relief was recorded on each sample plot. Very many analyses were made together with forest-typologists, therefore detailed geobotanic descriptions of all strata on all sample plots have been compiled. The trees were randomly selected for analysis. To avoid the effect of inclination and of the vitality of phorophytes on lichens, slanting, non-viable and dead trunks were left out of consideration. In order to make it possible to establish the different stages of the development of lichen vegetation, the age of each tree was recorded. The age was measured by an increment borer on each trunk separately. The diameter at breast height and the total height of each tree was measured. The degree of viability was estimated by a 3-stage scale (trees with a broad crown reaching over the average tree layer, trees belonging to the average crown level, trees below the average).

Relations of lichen species to various tree species

The development of epiphytic lichens on phorophytes is due to a complex of ecological factors - so-called environmental conditions. Besides other factors, the qualities of the substrate are of an essential importance.

M.E. HALE (1967) notes that substrate specificity is an important factor in the determination of the structure of communities and that about 60% of the variation in lichen communities is due to the substrate factor and about 40% to the microclimate.

Relatively great differences in the lichen flora of the tree species studied have been recorded to exist in the forests of the Estonian S.S.R. The spruce (74 species) has proved to be the richest in lichen species. The pine (69 species) and the black alder (59 species) follow. The birch (46 species) is the poorest in lichen species.

The physical qualities of the bark of different tree species acquire similar features when trees grow older. Therefore one can find lichen species on old trees that have been regarded as substrate specific to some other tree species. For instance, Lecanactis abietina which has been regarded as inhabiting only spruces was found at the base of black alders and pines in a 200-year-old pine stand of the Myrtillus type where it had a low frequency and cover value. Arthonia lurida, which commonly inhabits spruces, can also grow on 200-year-old pines and black alders, having a low frequency and cover value on them. It is not enough if we examine the occurrence or the absence of a species on a certain tree species. We must also take into account some other factors. The scarcity of very old trees in the forests makes it difficult to study the changes in substrate specificity in connection with the age of trees.

Table 1

Coefficient of community of corticolous vegetation on various tree species

	Picea	Pinus	Betula	Alnus
Picea abies	-	71.2	48.2	51.2
Pinus sylvestris	71.2	-	51.9	42.7
Betula pend., pub.	58.2	51.9	-	69.0
Alnus glutinosa	51.2	42.7	69.0	-

If we compare the coefficients of community* of various tree species (table 1), it turns out that of all tree species investigated the spruce and the pine are most similar to each other in their floristic composition. The black alder and the birch are the next. Conifers and deciduous trees separately are far more similar than pairs of conifers and deciduous trees.

Although lichens are neither parasites nor saprophytes, the substrate exercises a considerable effect on them. Besides the lichen species that have a considerable relation to tree species, there are lichen species that are indifferent to substrate conditions.

Vertical Distribution of Lichens on the Tree Trunk

Investigation of the vertical distribution of many lichen species on the trunk is of great importance for

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* The coefficient of community calculated from the formula

$$P \frac{2c \cdot 100}{a + b},$$

where P is the coefficient of community, a is the number of lichen species found on one tree species, b is the number of lichen species found on another tree species, c is the number of common lichen species.

the understanding of their ecology since even very small areas on the trunk have very diverse ecological conditions. It is possible to record exactly the mutations of the epiphytic flora and vegetation at different heights on the trunk. Surface plants usually grow in a horisontal position. Epiphytes are adjusted to a vertical position and a cylindrical size of their substrate. A great number of epiphytic lichens have a specific vertical position on the bark (BARKMAN, 1958). Some species occur most often in the tree crown, others have been found inhabiting only the base. Variation of the environmental conditions on the trunk is a fairly complicated phenomenon. A tree is a habitat having extreme conditions of high maximum temperatures and of extreme dryness.

In the present paper a large number of trees have been studied in detail from the base to the crown. About 2.000 trunks have been investigated at the base and at breast height only. The data collected in this manner show great differences in the vertical position of lichens on tree trunks. The main attention was paid to the lichens inhabiting the lower parts of the tree. The numerous data collected enable us to draw conclusins on these zones.

According to the data collected, we are able to distinguish on a phorophyte between 4 zones which differ floristically. They are: the base (up to a height of 70 cm), the lower part of the trunk (up to a height of 2 m), the upper part of the trunk, and the crown. There are differences between the outer parts (twigs and branches) and the inner parts (thick branches) of the crown. It was not our aim to study these parts in detail in the present paper, therefore they have not been included.

There are no great differences in the total number of the species at breast height and at the base (Table 2).

Table 2

Number of species on the trunk at breast height and at the base

	1	2	3	4	5
Picea abies	62	62	50	74	80,6
Pinus sylvestris	60	53	44	69	77,8
Betula pendula, pub.	37	39	30	46	78,9
Alnus glutinosa	45	45	36	59	80,0

(1 - number of species on the trunk at breast height; 2 - number of species at the base; 3 - number of of species on both habitats; 4 - total number of species; 5 - coefficient of community).

But there appear certain regularities in the average number of species in the range of one tree trunk (at breast height and at the base) (table 3). In table 3 and 4 the following designations are used: 1 - alvar type; 2 - Vaccinium vitis-idaea type; 3 - Oxalis type; 4 - Alder swamp type; 5 - Vaccinium uliginosum type; 6 - Birch-alder swamp type; 7 - Dryopteris type; I - age-class I; II - age-class II; III - age-class III; IV - age-class IV; V - age-class V. The average number of species at breast height and at the base of conifers is nearly the same, but it is considerably smaller at the base of hardwoods. In the birch-alder swamp forest type the birch bases are often entirely free of lichens since exessive humidity creates a disproportion in the assimilation of algal cells (which require more moisture) and fungal hyphae (which need less of it). A lichen as an integrity will perish (SCOTT, 1964). In the presence of tall herbaceous plants the trunks of trees in thick grass are poorly inhabited by lichens since there is too little light for them. The average amount of lichens is considerably smaller at the base of black alders

Table 3

Average number of lichen species per tree

		Picea abies				Pinus sylvestris				Betula spp.			Alnus gl	
		1	2	3	4	1	2	3	5	6	4	3	7	4
Trunk	I	3,5				4,6	4,1	5,0	3,4	3,9	2,6			11,2
	II	3.7	4.3	4,0		4,9	5.7	3.3	5,9	5.0	2.5	4.2	5.6	7.5
	III	2.0	4.3	5.6	4.9	6.0	8.2	4.9	6.6	4.8	5.7	4.3	6.4	8.4
	IV	4.4	4.1	5.2	4.6	6.1	7.0	4.6	8.4	5.8	5.7	4.8		7.9
	V	5.1	7.0	8.2	5.2	4.9	6.6	5.8	9.5	5.8	6.2			6.8
Base	I	3.3				4.4	5.6	4.3	4.3	3.1		4.0		6.1
	II	4.1	3.6	3.9		5.9	5.4	3.2	5.1	2.5	5.8	3.3	3.8	5.3
	III	2.4	4.4	4.8	4.9	5.0	6.7	4.3	6.2	5.3	6.8	5.6	3.1	5.6
	IV	4.1	5.0	5.7	5.3	5.5	6.8	5.5	7.4		4.6			7.5
	V	5.1	8.5	8.1	5.9	5.2	8.7	6.1	7.8		5.3			3.8

Table 4

Average cover of lichens per tree in various types of forest

			Trunk					Base				
			I	II	III	IV	V	I	II	III	IV	V
Picea abies	1	N	9.0	14.5	31.6	35.6	44.3	36.1	32.4	55.1	47.5	57.5
		S	12.1	17.4	27.6	30.7	39.4	21.4	19.8	46.2	52.2	65.8
	2	N	20	20.6	43.1	41.9	21.1		29.0	57.7	71.8	48.7
		S		10.6	31.7	42.6	22.2		21.0	49.5	64.5	55.2
	3	N		26.6	47.1	40.4	43.9		43.2	61.4	56.6	62.7
		S		36.2	44.9	39.3	35.9		44.4	61.6	50.6	56.2
	4	N			44.8	48.5	51.6			49.6	67.8	51.1
		S			41.9	34.1	31.8			44.8	61.0	55.4
Pinus sylv.	1	N	13.3	27.2	29.3	26.9	20.7	18.4	35.0	29.2	58.1	48.9
		S	9.4	24.4	19.7	19.5	18.9	19.5	23.2	38.2	30.5	38.7
	2	N	12.8	42.5	43.1	54.8	31.8	12.0	48.2	48.9	42.9	48.6
		S	15.6	46.6	37.9	40.3	22.1	13.4	58.7	41.6	50.6	38.4
	3	N	57.6	18.7	20.9	38.6	44.6	60.6	24.1	26.9	38.1	44.5
		S	52.0	22.0	32.3	32.5	37.4	59.1	41.5	33.6	32.6	45.4
	5	N	7.6	31.0	21.8	31.1	36.6	22.8	35.7	31.4	34.5	40.0
		S	2.4	23.0	16.0	18.2	17.8	13.6	40.6	40.0	34.5	35.2

(which are usually covered with a thick moss cover) than on the trunks at breast height in the forest types studied.

The average cover value of lichens (Table 4) is considerably greater at the base than at breast height on all the tree species studied. The birch bases in the birch stands of the Birch-alder swamp forest type, where excessive humidity prevents the growth of lichens, and the bases of black alders in the black alder stands of the Dryopteris type, where the more competitive mosses have a more extensive cover, are exceptional.

Under favourable conditions some lichen species constitute large groupings at the base. They cover nearly the whole base (Cladonia coniocraea, Cl. chlorophaea, Cl. digitata, Ochrolechia androgyna, Lecanactis abietina, Arthonia leucopellaea, A. spadicea, Psora scalaris).

In the following table (Table 5) the lichen species are grouped according to the height at which they occur with the highest frequency and cover value. The species which occur only at the base or at breast height or which have the highest frequengy and cover value in the upper part of the trunk or on the branches, have not been included.

In some cases the vertical position of lichens on the trunk has not become distinctly established. It has already been pointed out that basal lichens may sometimes be absent in some forest types. The lichen species that are characteristic of the breast height of tree trunks occur more often at the base in young stands and young forests (Lecidea turgidula, Lecanora pinastry). In samp forests the zones may have been shifted higher. Several authors have observed that the basal communities of the trees growing on the banks of bodies of water often reach high up on the trunk on the windward side of the trunk (BILLINGS, DREW, 1938; BARKMAN, 1958; HAKULINEN, 1961).

The coefficients of community between the trunk part and the base of the trees studied were 77.8-80.6 (Table 2). It shows a great floristic similarity of the species com-

position of the lichens growing on the trunk and at the base.

Table 5

Species of lichens occurring with greatest frequency at a certain height on the trunk

On the trunk	At the base
Arthonia leucopellaea	Arthonia spadicea
A. lurida	Bacidia melaena
Bacilia griseovirens	B. sphaeroides
Calicium abietinum	Cetraria pinastri
C. salicinum	Cladonia chlorophaea
C. viride	Cl. coniocraea
Catillaria griffithii	Cl. digitata
C. prasina	Graphis scripta
Chaenotheca chlorella	Lecanactis abietina
Ch. chrysocephala	Lecidea helvola
Ch. melanophaea	L. vernalis
Lecanora conizaea	Opegrapha lichenoides
L. expallens	Parmeliopsis ambigua
L. pallida	P. aleurites
L. pinastri	P. hyperopta
Lecidea obscurella	Psora cladonioides
L. turgidula	Ps. scalaris
Lepraria candelaris	Thelotrema lepadinum
Leptorhaphis epidermidis	
Mycoblastus sanguinarius	
Ochrolechia alboflavescens	
Opegrapha vulgata	
Pertusaria amara	
P. coccodes	
Phlyctis argena	
Varicellaria kemensis	

The lower part of the trunk from the base to a height of 2 m on the trunk considerably differs from the remaining part of the trunk due to the abundant development of crustose lichens.

The upper part of the trunk can be well distinguished from a distance due to the abundant presence of foliose and fruticose lichens. Alectoria implexa, A. jubata, Cetraria chlorophylla, C. glauca, Evernia furfuracea, E. prunastri, Hypogymnia physodes, Parmeliopsis aleurites, Parmelia sulcata, Ramalina farinacea, Usnea glabrescens, U. comosa, U. hirta have the highest frequency and cover value in this area. This zone is limited on pines, reaching a height of 4-7 m; the higher parts of the trunk have no lichens on them due eo intensive bark scaling. On spruces this zone occupies the basic part of the trunk extending nearly to the top of the tree.

Either crustose, foliose or fruticose lichens inhabit the thin branches of the crown, Bacidia chlorococca Evernia furfuracea, Lecanora pinastri, Hypogymnia physodes, H. tubulosa, Lecidea symmicta being the most frequent. The branch lichens are very similar to those of the young trunks of the same tree species /Копачевская, 1965/. Foliose and crustose lichens are the first to appear on the branches, Fruticose lichens (DEGELIUS, 1964) will follow them. There are no essential differences in the lichen flora of the thin branches of pines and spruces nor are there considerable differences between the forest types.

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TABLES OF BINARY LOGARITHM PRODUCTS BY THE ARGUMENT FOR THE INTERVAL 0.0000 (0.0001) 1.0000

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Recent decades demonstrate the growing interest of biologists in the application of the Shannon - Weaver function to biological phenomena. This function is usually known as the entropy content formula: $H = -\sum_{1}^{N} p_i \text{ lb } p_i$, where p_i stands for the quantity of the 1th species expressed in terms of its probability, i.e. $\sum p_i = 1$. The estimation of the probabilities is assumed to be correct enough by way of transforming all the individual quantities (x_i) of N species in terms of the proportions of the total quantity ($x_i / \sum x_i$).

According to the formula given above, one has to multiply the probabilities by their binary logarithms ($\log_2 p_i$). These are troublesome operations which can be performed by using the tables, where the body of a table - the term $p_i \text{ lb } p_i$ - is given according to p_i. Four places of p_i are given in the left column, and the fifth place is indicated in the table head. The tables have been worked out by using a programme written by stud. rer. math. K. Lõhmus for the computer NAIRI, Academy of Sciences of the Estonian S.S.R.

It is hoped that the tables below will be valuable for preliminary hand-performed computations in ascertaining the special features of the complicated ecosystems under study in line with most IBP projects.

p_1	0	1	2	3	4	5	6	7	8	9
0,000	–	0013	0025	0035	0045	0055	0064	0073	0082	0091
0,001	0100	0108	0116	0125	0133	0141	0149	0156	0164	0172
0,002	0179	0187	0194	0202	0209	0216	0223	0230	0237	0244
0,003	0251	0258	0265	0272	0279	0286	0292	0299	0306	0312
0,004	0319	0325	0332	0338	0344	0351	0357	0363	0370	0376
0,005	0382	0388	0395	0401	0407	0413	0419	0425	0431	0437
0,006	0443	0449	0455	0461	0466	0472	0478	0484	0490	0495
0,007	0501	0507	0513	0518	0524	0529	0535	0541	0546	0552
0,008	0557	0563	0568	0574	0579	0585	0590	0596	0601	0606
0,009	0612	0617	0622	0628	0633	0638	0644	0649	0654	0659
0,010	0664	0670	0675	0680	0685	0690	0695	0701	0706	0711
0,011	0716	0721	0726	0731	0736	0741	0746	0751	0756	0761
0,012	0766	0771	0776	0781	0785	0790	0795	0800	0805	0810
0,013	0815	0819	0824	0829	0834	0839	0843	0848	0853	0858
0,014	0862	0867	0872	0876	0881	0886	0890	0895	0900	0904
0,015	0909	0914	0918	0923	0927	0932	0936	0941	0946	0950
0,016	0955	0959	0964	0968	0973	0977	0982	0986	0991	0995
0,017	0999	1004	1008	1013	1017	1021	1026	1030	1035	1039
0,018	1043	1048	1052	1056	1061	1065	1069	1074	1078	1082
0,019	1087	1091	1095	1099	1104	1108	1112	1116	1120	1125
0,020	1129	1133	1137	1141	1146	1150	1154	1158	1162	1166
0,021	1171	1175	1179	1183	1187	1191	1195	1199	1203	1207
0,022	1212	1216	1220	1224	1228	1232	1236	1240	1244	1248
0,023	1252	1256	1260	1264	1268	1272	1276	1280	1284	1288
0,024	1292	1295	1299	1303	1307	1311	1315	1319	1323	1327
0,025	1331	1334	1338	1342	1346	1350	1354	1358	1361	1365
0,026	1369	1373	1377	1381	1384	1388	1392	1396	1400	1403
0,027	1407	1411	1415	1418	1422	1426	1430	1433	1437	1441
0,028	1445	1448	1452	1456	1459	1463	1467	1470	1474	1478
0,029	1481	1485	1489	1492	1496	1500	1503	1507	1511	1514
0,030	1518	1521	1525	1529	1532	1536	1539	1543	1547	1550
0,031	1554	1557	1561	1564	1568	1572	1575	1579	1582	1586
0,032	1589	1593	1596	1600	1603	1607	1610	1614	1617	1621
0,033	1624	1628	1631	1635	1638	1642	1645	1648	1652	1655
0,034	1659	1662	1666	1669	1673	1676	1679	1683	1686	1690
0,035	1693	1696	1700	1703	1706	1710	1713	1717	1720	1723
0,036	1727	1730	1733	1737	1740	1743	1747	1750	1753	1757
0,037	1760	1763	1767	1770	1773	1777	1780	1783	1786	1790
0,038	1793	1796	1800	1803	1806	1809	1813	1816	1819	1822
0,039	1826	1829	1832	1835	1838	1842	1845	1848	1851	1855
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,040	1858	1861	1864	1867	1871	1874	1877	1880	1883	1886
0,041	1890	1893	1896	1899	1902	1905	1908	1912	1915	1918
0,042	1921	1924	1927	1930	1934	1937	1940	1943	1946	1949
0,043	1952	1955	1958	1961	1965	1968	1971	1974	1977	1980
0,044	1983	1986	1989	1992	1995	1998	2001	2004	2007	2010
0,045	2013	2016	2020	2023	2026	2029	2032	2035	2038	2041
0,046	2044	2047	2050	2053	2056	2059	2062	2065	2068	2070
0,047	2073	2076	2079	2082	2085	2088	2091	2094	2097	2100
0,048	2103	2106	2109	2112	2115	2118	2121	2123	2126	2129
0,049	2132	2135	2138	2141	2144	2147	2150	2153	2155	2158
0,050	2161	2164	2167	2170	2173	2176	2178	2181	2184	2187
0,051	2190	2193	2196	2198	2201	2204	2207	2210	2213	2215
0,052	2218	2221	2224	2227	2229	2232	2235	2238	2241	2243
0,053	2246	2249	2252	2255	2257	2260	2263	2266	2269	2271
0,054	2274	2277	2280	2282	2285	2288	2291	2293	2296	2299
0,055	2302	2304	2307	2310	2313	2315	2318	2321	2324	2326
0,056	2329	2332	2334	2337	2340	2343	2345	2348	2351	2353
0,057	2356	2359	2361	2364	2367	2369	2372	2375	2377	2380
0,058	2383	2385	2388	2391	2393	2396	2399	2401	2404	2407
0,059	2409	2412	2415	2417	2420	2422	2425	2428	2430	2433
0,060	2436	2438	2441	2443	2446	2449	2451	2454	2456	2459
0,061	2462	2464	2467	2469	2472	2475	2477	2480	2482	2485
0,062	2487	2490	2493	2495	2498	2500	2503	2505	2508	2510
0,063	2513	2516	2518	2521	2523	2526	2528	2531	2533	2536
0,064	2538	2541	2543	2546	2548	2551	2553	2556	2558	2561
0,065	2563	2566	2568	2571	2573	2576	2578	2581	2583	2586
0,066	2588	2591	2593	2596	2598	2601	2603	2606	2608	2611
0,067	2613	2616	2618	2620	2623	2625	2628	2630	2633	2635
0,068	2638	2640	2642	2645	2647	2650	2652	2655	2657	2659
0,069	2662	2664	2667	2669	2671	2674	2676	2679	2681	2683
0,070	2686	2688	2691	2693	2695	2698	2700	2703	2705	2707
0,071	2710	2712	2714	2717	2719	2721	2724	2726	2729	2731
0,072	2733	2736	2738	2740	2743	2745	2747	2750	2752	2754
0,073	2757	2759	2761	2764	2766	2768	2771	2773	2775	2778
0,074	2780	2782	2785	2787	2789	2792	2794	2796	2798	2801
0,075	2803	2805	2808	2810	2812	2814	2817	2819	2821	2824
0,076	2826	2828	2830	2833	2835	2837	2839	2842	2844	2846
0,077	2849	2851	2853	2855	2858	2860	2862	2864	2867	2869
0,078	2871	2873	2875	2878	2880	2882	2884	2887	2889	2891
0,079	2893	2895	2898	2900	2902	2904	2907	2909	2911	2913
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0·080	2915	2918	2920	2922	2924	2926	2929	2931	2933	2935
0·081	2937	2939	2942	2944	2946	2948	2950	2953	2955	2957
0·082	2959	2961	2963	2966	2968	2970	2972	2974	2976	2978
0·083	2981	2983	2985	2987	2989	2991	2993	2996	2998	3000
0·084	3002	3004	3006	3008	3011	3013	3015	3017	3019	3021
0·085	3023	3025	3027	3030	3032	3034	3036	3038	3040	3042
0·086	3044	3046	3048	3051	3053	3055	3057	3059	3061	3063
0·087	3065	3067	3069	3071	3073	3076	3078	3080	3082	3084
0·088	3086	3088	3090	3092	3094	3096	3098	3100	3102	3104
0·089	3106	3109	3111	3113	3115	3117	3119	3121	3123	3125
0·090	3127	3129	3131	3133	3135	3137	3139	3141	3143	3145
0·091	3147	3149	3151	3153	3155	3157	3159	3161	3163	3165
0·092	3167	3169	3171	3173	3175	3177	3179	3181	3183	3185
0·093	3187	3189	3191	3193	3195	3197	3199	3201	3203	3205
0·094	3207	3209	3211	3213	3215	3217	3219	3221	3223	3224
0·095	3226	3228	3230	3232	3234	3236	3238	3240	3242	3244
0·096	3246	3248	3250	3252	3254	3256	3258	3259	3261	3263
0·097	3265	3267	3269	3271	3273	3275	3277	3279	3281	3282
0·098	3284	3286	3288	3290	3292	3294	3296	3298	3300	3301
0·099	3303	3305	3307	3309	3311	3313	3315	3317	3318	3320
0·100	3322	3324	3326	3328	3330	3332	3334	3335	3337	3339
0·101	3341	3343	3345	3347	3348	3350	3352	3354	3356	3358
0·102	3360	3361	3363	3365	3367	3369	3371	3372	3374	3376
0·103	3378	3380	3382	3384	3385	3387	3389	3391	3393	3394
0·104	3396	3398	3400	3402	3404	3405	3407	3409	3411	3413
0·105	3414	3416	3418	3420	3422	3423	3425	3427	3429	3431
0·106	3432	3434	3436	3438	3440	3441	3443	3445	3447	3449
0·107	3450	3452	3454	3456	3457	3459	3461	3463	3465	3466
0·108	3468	3470	3472	3473	3475	3477	3479	3480	3482	3484
0·109	3486	3487	3489	3491	3493	3494	3496	3498	3500	3501
0·110	3503	3505	3507	3508	3510	3512	3514	3515	3517	3519
0·111	3521	3522	3524	3526	3527	3529	3531	3533	3534	3536
0·112	3538	3540	3541	3543	3545	3546	3548	3550	3551	3553
0·113	3555	3557	3558	3560	3562	3563	3565	3567	3568	3570
0·114	3572	3574	3575	3577	3579	3580	3582	3584	3585	3587
0·115	3589	3590	3592	3594	3595	3597	3599	3600	3602	3604
0·116	3605	3607	3609	3610	3612	3614	3615	3617	3619	3620
0·117	3622	3624	3625	3627	3629	3630	3632	3634	3635	3637
0·118	3638	3640	3642	3643	3645	3647	3648	3650	3652	3653
0·119	3655	3656	3658	3660	3661	3663	3665	3666	3668	3669
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,120	3671	3673	3674	3676	3677	3679	3681	3682	3684	3686
0,121	3687	3689	3690	3692	3694	3695	3697	3698	3700	3702
0,122	3703	3705	3706	3708	3709	3711	3713	3714	3716	3717
0,123	3719	3721	3722	3724	3725	3727	3728	3730	3732	3733
0,124	3735	3736	3738	3739	3741	3743	3744	3746	3747	3749
0,125	3750	3752	3753	3755	3757	3758	3760	3761	3763	3764
0,126	3766	3767	3769	3771	3772	3774	3775	3777	3778	3780
0,127	3781	3783	3784	3786	3787	3789	3790	3792	3794	3795
0,128	3797	3798	3800	3801	3803	3804	3806	3807	3809	3810
0,129	3812	3813	3815	3816	3818	3819	3821	3822	3824	3825
0,130	3827	3828	3830	3831	3833	3834	3836	3837	3839	3840
0,131	3842	3843	3845	3846	3848	3849	3851	3852	3854	3855
0,132	3857	3858	3860	3861	3863	3864	3865	3867	3868	3870
0,133	3871	3873	3874	3876	3877	3879	3880	3882	3883	3885
0,134	3886	3887	3889	3890	3892	3893	3895	3896	3898	3899
0,135	3900	3902	3903	3905	3906	3908	3909	3911	3912	3913
0,136	3915	3916	3918	3919	3921	3922	3924	3925	3926	3928
0,137	3929	3931	3932	3933	3935	3936	3938	3939	3941	3942
0,138	3943	3945	3946	3948	3949	3950	3952	3953	3955	3956
0,139	3958	3959	3960	3962	3963	3965	3966	3967	3969	3970
0,140	3971	3973	3974	3976	3977	3978	3980	3981	3983	3984
0,141	3985	3987	3988	3990	3991	3992	3994	3995	3996	3998
0,142	3999	4001	4002	4003	4005	4006	4007	4009	4010	4011
0,143	4013	4014	4016	4017	4018	4020	4021	4022	4024	4025
0,144	4026	4028	4029	4030	4032	4033	4035	4036	4037	4039
0,145	4040	4041	4043	4044	4045	4047	4048	4049	4051	4052
0,146	4053	4055	4056	4057	4059	4060	4061	4063	4064	4065
0,147	4067	4068	4069	4071	4072	4073	4075	4076	4077	4078
0,148	4080	4081	4082	4084	4085	4086	4088	4089	4090	4092
0,149	4093	4094	4095	4097	4098	4099	4101	4102	4103	4105
0,150	4106	4107	4108	4110	4111	4112	4114	4115	4116	4117
0,151	4119	4120	4121	4123	4124	4125	4126	4128	4129	4130
0,152	4132	4133	4134	4135	4137	4138	4139	4140	4142	4143
0,153	4144	4146	4147	4148	4149	4151	4152	4153	4154	4156
0,154	4157	4158	4159	4161	4162	4163	4164	4166	4167	4168
0,155	4169	4171	4172	4173	4174	4176	4177	4178	4179	4181
0,156	4182	4183	4184	4186	4187	4188	4189	4190	4192	4193
0,157	4194	4195	4197	4198	4199	4200	4201	4203	4204	4205
0,158	4206	4208	4209	4210	4211	4212	4214	4215	4216	4217
0,159	4219	4220	4221	4222	4223	4225	4226	4227	4228	4229
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,160	4231	4232	4233	4234	4235	4237	4238	4239	4240	4241
0,161	4243	4244	4245	4246	4247	4249	4250	4251	4252	4253
0,162	4254	4256	4257	4258	4259	4260	4262	4263	4264	4265
0,163	4266	4267	4269	4270	4271	4272	4273	4274	4276	4277
0,164	4278	4279	4280	4281	4283	4284	4285	4286	4287	4288
0,165	4290	4291	4292	4293	4294	4295	4296	4298	4299	4300
0,166	4301	4302	4303	4305	4306	4307	4308	4309	4310	4311
0,167	4313	4314	4315	4316	4317	4318	4319	4320	4322	4323
0,168	4324	4325	4326	4327	4328	4329	4331	4332	4333	4334
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0,173	4379	4380	4382	4383	4384	4385	4386	4387	4388	4389
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0,180	4454	4455	4456	4457	4458	4459	4460	4461	4462	4463
0,181	4464	4465	4466	4467	4468	4469	4470	4471	4472	4473
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0,192	4572	4573	4574	4574	4575	4576	4577	4578	4579	4580
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0,202	4662	4663	4663	4664	4665	4666	4667	4668	4669	4670
0,203	4670	4671	4672	4673	4674	4675	4676	4676	4677	4678
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0,393	5296	5296	5296	5296	5295	5295	5295	5295	5295	5295
0,394	5295	5295	5295	5295	5294	5294	5294	5294	5294	5294
0,395	5294	5294	5294	5294	5293	5293	5293	5293	5293	5293
0,396	5293	5293	5293	5292	5292	5292	5292	5292	5292	5292
0,397	5292	5292	5291	5291	5291	5291	5291	5291	5291	5291
0,398	5291	5290	5290	5290	5290	5290	5290	5290	5290	5290
0,399	5289	5289	5289	5289	5289	5289	5289	5289	5288	5288
p_1	0	1	2	3	4	5	6	7	8	9

P_1	0	1	2	3	4	5	6	7	8	9
0,400	5288	5288	5288	5288	5288	5288	5288	5287	5287	5287
0,401	5287	5287	5287	5287	5287	5286	5286	5286	5286	5286
0,402	5286	5286	5285	5285	5285	5285	5285	5285	5285	5285
0,403	5284	5284	5284	5284	5284	5284	5284	5284	5283	5283
0,404	5283	5283	5283	5283	5283	5282	5282	5282	5282	5282
0,405	5282	5282	5281	5281	5281	5281	5281	5281	5281	5280
0,406	5280	5280	5280	5280	5280	5280	5279	5279	5279	5279
0,407	5279	5279	5279	5278	5278	5278	5278	5278	5278	5278
0,408	5277	5277	5277	5277	5277	5277	5277	5276	5276	5276
0,409	5276	5276	5276	5275	5275	5275	5275	5275	5275	5275
0,410	5274	5274	5274	5274	5274	5274	5273	5273	5273	5273
0,411	5273	5273	5272	5272	5272	5272	5272	5272	5272	5271
0,412	5271	5271	5271	5271	5271	5270	5270	5270	5270	5270
0,413	5270	5269	5269	5269	5269	5269	5269	5269	5268	5268
0,414	5268	5268	5267	5267	5267	5267	5267	5267	5266	5266
0,415	5266	5266	5266	5266	5265	5265	5265	5265	5265	5265
0,416	5264	5264	5264	5264	5264	5263	5263	5263	5263	5263
0,417	5263	5262	5262	5262	5262	5262	5261	5261	5261	5261
0,418	5261	5261	5260	5260	5260	5260	5260	5259	5259	5259
0,419	5259	5259	5259	5259	5258	5258	5258	5258	5257	5257
0,420	5257	5257	5257	5256	5256	5256	5256	5256	5255	5255
0,421	5255	5255	5255	5254	5254	5254	5254	5254	5253	5253
0,422	5253	5253	5253	5252	5252	5252	5252	5252	5251	5251
0,423	5251	5251	5251	5250	5250	5250	5250	5250	5249	5249
0,424	5249	5249	5249	5248	5248	5248	5248	5248	5247	5247
0,425	5247	5247	5247	5246	5246	5246	5246	5246	5245	5245
0,426	5245	5245	5244	5244	5244	5244	5244	5243	5243	5243
0,427	5243	5243	5242	5242	5242	5242	5241	5241	5241	5241
0,428	5241	5240	5240	5240	5240	5240	5239	5239	5239	5239
0,429	5238	5238	5238	5238	5238	5237	5237	5237	5237	5236
0,430	5236	5236	5236	5235	5235	5235	5235	5235	5234	5234
0,431	5234	5234	5233	5233	5233	5233	5233	5232	5232	5232
0,432	5232	5231	5231	5231	5231	5230	5230	5230	5230	5229
0,433	5229	5229	5229	5229	5228	5228	5228	5228	5227	5227
0,434	5227	5227	5226	5226	5226	5226	5225	5225	5225	5225
0,435	5224	5224	5224	5224	5224	5223	5223	5223	5223	5222
0,436	5222	5222	5222	5221	5221	5221	5221	5220	5220	5220
0,437	5220	5219	5219	5219	5219	5218	5218	5218	5218	5217
0,438	5217	5217	5217	5216	5216	5216	5216	5215	5215	5215
0,439	5215	5214	5214	5214	5214	5213	5213	5213	5213	5212
P_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,440	5212	5212	5211	5211	5211	5211	5210	5210	5210	5210
0,441	5209	5209	5209	5209	5208	5208	5208	5208	5207	5207
0,442	5207	5206	5206	5206	5206	5205	5205	5205	5205	5204
0,443	5204	5204	5204	5203	5203	5203	5202	5202	5202	5202
0,444	5201	5201	5201	5201	5200	5200	5200	5199	5199	5199
0,445	5199	5198	5198	5198	5198	5197	5197	5197	5196	5196
0,446	5196	5196	5195	5195	5195	5195	5194	5194	5194	5193
0,447	5193	5193	5193	5192	5192	5192	5191	5191	5191	5191
0,448	5190	5190	5190	5189	5189	5189	5189	5188	5188	5188
0,449	5187	5187	5187	5187	5186	5186	5186	5185	5185	5185
0,450	5185	5184	5184	5184	5183	5183	5183	5182	5182	5182
0,451	5182	5181	5181	5181	5180	5180	5180	5180	5179	5179
0,452	5179	5178	5178	5178	5177	5177	5177	5177	5176	5176
0,453	5176	5175	5175	5175	5174	5174	5174	5174	5173	5173
0,454	5173	5172	5172	5172	5171	5171	5171	5171	5170	5170
0,455	5170	5169	5169	5169	5168	5168	5168	5167	5167	5167
0,456	5167	5166	5166	5166	5165	5165	5165	5164	5164	5164
0,457	5163	5163	5163	5162	5162	5162	5162	5161	5161	5161
0,458	5160	5160	5160	5159	5159	5159	5158	5158	5158	5157
0,459	5157	5157	5156	5156	5156	5155	5155	5155	5155	5154
0,460	5154	5154	5153	5153	5153	5152	5152	5152	5151	5151
0,461	5151	5150	5150	5150	5149	5149	5149	5148	5148	5148
0,462	5147	5147	5147	5146	5146	5146	5145	5145	5145	5144
0,463	5144	5144	5143	5143	5143	5142	5142	5142	5141	5141
0,464	5141	5140	5140	5140	5139	5139	5139	5138	5138	5138
0,465	5137	5137	5137	5136	5136	5136	5135	5135	5135	5134
0,466	5134	5134	5133	5133	5133	5132	5132	5132	5131	5131
0,467	5131	5130	5130	5129	5129	5129	5128	5128	5128	5127
0,468	5127	5127	5126	5126	5126	5125	5125	5125	5124	5124
0,469	5124	5123	5123	5123	5122	5122	5121	5121	5121	5120
0,470	5120	5120	5119	5119	5119	5118	5118	5118	5117	5117
0,471	5117	5116	5116	5115	5115	5115	5114	5114	5114	5113
0,472	5113	5113	5112	5112	5111	5111	5111	5110	5110	5110
0,473	5109	5109	5109	5108	5108	5108	5107	5107	5106	5106
0,474	5106	5105	5105	5105	5104	5104	5103	5103	5103	5102
0,475	5102	5102	5101	5101	5101	5100	5100	5099	5099	5099
0,476	5098	5098	5098	5097	5097	5096	5096	5096	5095	5095
0,477	5095	5094	5094	5093	5093	5093	5092	5092	5092	5091
0,478	5091	5090	5090	5090	5089	5089	5089	5088	5088	5087
0,479	5087	5087	5086	5086	5085	5085	5085	5084	5084	5084
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0·480	5083	5083	5082	5082	5082	5081	5081	5081	5080	5080
0·481	5079	5079	5079	5078	5078	5077	5077	5077	5076	5076
0·482	5075	5075	5075	5074	5074	5074	5073	5073	5072	5072
0·483	5072	5071	5071	5070	5070	5070	5069	5069	5068	5068
0·484	5068	5067	5067	5066	5066	5066	5065	5065	5064	5064
0·485	5064	5063	5063	5062	5062	5062	5061	5061	5060	5060
0·486	5060	5059	5059	5058	5058	5058	5057	5057	5056	5056
0·487	5056	5055	5055	5054	5054	5054	5053	5053	5052	5052
0·488	5052	5051	5051	5050	5050	5049	5049	5049	5048	5048
0·489	5047	5047	5047	5046	5046	5045	5045	5045	5044	5044
0·490	5043	5043	5042	5042	5042	5041	5041	5040	5040	5040
0·491	5039	5039	5038	5038	5038	5037	5037	5036	5036	5035
0·492	5035	5035	5034	5034	5033	5033	5032	5032	5032	5031
0·493	5031	5030	5030	5030	5029	5029	5028	5028	5027	5027
0·494	5027	5026	5026	5025	5025	5024	5024	5024	5023	5023
0·495	5022	5022	5021	5021	5021	5020	5020	5019	5019	5018
0·496	5018	5018	5017	5017	5016	5016	5015	5015	5015	5014
0·497	5014	5013	5013	5012	5012	5011	5011	5011	5010	5010
0·498	5009	5009	5008	5008	5008	5007	5007	5006	5006	5005
0·499	5005	5004	5004	5004	5003	5003	5002	5002	5001	5001
0·500	5000	5000	5000	4999	4999	4998	4998	4997	4997	4997
0·501	4996	4996	4995	4995	4994	4994	4993	4993	4992	4992
0·502	4992	4991	4991	4990	4990	4989	4989	4988	4988	4988
0·503	4987	4987	4986	4986	4985	4985	4984	4984	4983	4983
0·504	4983	4982	4982	4981	4981	4980	4980	4979	4979	4978
0·505	4978	4978	4977	4977	4976	4976	4975	4975	4974	4974
0·506	4973	4973	4972	4972	4972	4971	4971	4970	4970	4969
0·507	4969	4968	4968	4967	4967	4966	4966	4966	4965	4965
0·508	4964	4964	4963	4963	4962	4962	4961	4961	4960	4960
0·509	4959	4959	4959	4958	4958	4957	4957	4956	4956	4955
0·510	4955	4954	4954	4953	4953	4952	4952	4951	4951	4951
0·511	4950	4950	4949	4949	4948	4948	4947	4947	4946	4946
0·512	4945	4945	4944	4944	4943	4943	4942	4942	4941	4941
0·513	4941	4940	4940	4939	4939	4938	4938	4937	4937	4936
0·514	4936	4935	4935	4934	4934	4933	4933	4932	4932	4931
0·515	4931	4930	4930	4929	4929	4928	4928	4927	4927	4926
0·516	4926	4926	4925	4925	4924	4924	4923	4923	4922	4922
0·517	4921	4921	4920	4920	4919	4919	4918	4918	4917	4917
0·518	4916	4916	4915	4915	4914	4914	4913	4913	4912	4912
0·519	4911	4911	4910	4910	4909	4909	4908	4908	4907	4907
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,520	4906	4906	4905	4905	4904	4904	4903	4903	4902	4902
0,521	4901	4901	4900	4900	4899	4899	4898	4898	4897	4897
0,522	4896	4896	4895	4895	4894	4894	4893	4893	4892	4892
0,523	4891	4891	4890	4890	4889	4889	4888	4888	4887	4887
0,524	4886	4886	4885	4885	4884	4884	4883	4882	4882	4881
0,525	4881	4880	4880	4879	4879	4878	4878	4877	4877	4876
0,526	4876	4875	4875	4874	4874	4873	4873	4872	4872	4871
0,527	4871	4870	4870	4869	4869	4868	4868	4867	4866	4866
0,528	4865	4865	4864	4864	4863	4863	4862	4862	4861	4861
0,529	4860	4860	4859	4859	4858	4858	4857	4857	4856	4855
0,530	4855	4854	4854	4853	4853	4852	4852	4851	4851	4850
0,531	4850	4849	4849	4848	4848	4847	4846	4846	4845	4845
0,532	4844	4844	4843	4843	4842	4842	4841	4841	4840	4840
0,533	4839	4838	4838	4837	4837	4836	4836	4835	4835	4834
0,534	4834	4833	4833	4832	4832	4831	4830	4830	4829	4829
0,535	4828	4828	4827	4827	4826	4826	4825	4824	4824	4823
0,536	4823	4822	4822	4821	4821	4820	4820	4819	4818	4818
0,537	4817	4817	4816	4816	4815	4815	4814	4814	4813	4812
0,538	4812	4811	4811	4810	4810	4809	4809	4808	4808	4807
0,539	4806	4806	4805	4805	4804	4804	4803	4803	4802	4801
0,540	4801	4800	4800	4799	4799	4798	4798	4797	4796	4796
0,541	4795	4795	4794	4794	4793	4793	4792	4791	4791	4790
0,542	4790	4789	4789	4788	4788	4787	4786	4786	4785	4785
0,543	4784	4784	4783	4782	4782	4781	4781	4780	4780	4779
0,544	4779	4778	4777	4777	4776	4776	4775	4775	4774	4773
0,545	4773	4772	4772	4771	4771	4770	4769	4769	4768	4768
0,546	4767	4767	4766	4765	4765	4764	4764	4763	4763	4762
0,547	4761	4761	4760	4760	4759	4759	4758	4757	4757	4756
0,548	4756	4755	4755	4754	4753	4753	4752	4752	4751	4751
0,549	4750	4749	4749	4748	4748	4747	4747	4746	4745	4745
0,550	4744	4744	4743	4742	4742	4741	4741	4740	4740	4739
0,551	4738	4738	4737	4737	4736	4735	4735	4734	4734	4733
0,552	4733	4732	4731	4731	4730	4730	4729	4728	4728	4727
0,553	4727	4726	4726	4725	4724	4724	4723	4723	4722	4721
0,554	4721	4720	4720	4719	4718	4718	4717	4717	4716	4715
0,555	4715	4714	4714	4713	4712	4712	4711	4711	4710	4710
0,556	4709	4708	4708	4707	4707	4706	4705	4705	4704	4704
0,557	4703	4702	4702	4701	4701	4700	4699	4699	4698	4698
0,558	4697	4696	4696	4695	4695	4694	4693	4693	4692	4692
0,559	4691	4690	4690	4689	4689	4688	4687	4687	4686	4685
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,560	4685	4684	4684	4683	4682	4682	4681	4681	4680	4679
0,561	4679	4678	4678	4677	4676	4676	4675	4675	4674	4673
0,562	4673	4672	4671	4671	4670	4670	4669	4668	4668	4667
0,563	4667	4666	4665	4665	4664	4663	4663	4662	4662	4661
0,564	4660	4660	4659	4659	4658	4657	4657	4656	4655	4655
0,565	4654	4654	4653	4652	4652	4651	4651	4650	4649	4649
0,566	4648	4647	4647	4646	4646	4645	4644	4644	4643	4642
0,567	4642	4641	4641	4640	4639	4639	4638	4637	4637	4636
0,568	4636	4635	4634	4634	4633	4632	4632	4631	4631	4630
0,569	4629	4629	4628	4627	4627	4626	4625	4625	4624	4624
0,570	4623	4622	4622	4621	4620	4620	4619	4619	4618	4617
0,571	4617	4616	4615	4615	4614	4613	4613	4612	4612	4611
0,572	4610	4610	4609	4608	4608	4607	4606	4606	4605	4605
0,573	4604	4603	4603	4602	4601	4601	4600	4599	4599	4598
0,574	4597	4597	4596	4596	4595	4594	4594	4593	4592	4592
0,575	4591	4590	4590	4589	4588	4588	4587	4587	4586	4585
0,576	4585	4584	4583	4583	4582	4581	4581	4580	4579	4579
0,577	4578	4577	4577	4576	4576	4575	4574	4574	4573	4572
0,578	4572	4571	4570	4570	4569	4568	4568	4567	4566	4566
0,579	4565	4564	4564	4563	4562	4562	4561	4560	4560	4559
0,580	4559	4558	4557	4557	4556	4555	4555	4554	4553	4553
0,581	4552	4551	4551	4550	4549	4549	4548	4547	4547	4546
0,582	4545	4545	4544	4543	4543	4542	4541	4541	4540	4539
0,583	4539	4538	4537	4537	4536	4535	4535	4534	4533	4533
0,584	4532	4531	4531	4530	4529	4529	4528	4527	4527	4526
0,585	4525	4525	4524	4523	4523	4522	4521	4521	4520	4519
0,586	4519	4518	4517	4517	4516	4515	4515	4514	4513	4513
0,587	4512	4511	4511	4510	4509	4509	4508	4507	4507	4506
0,588	4505	4505	4504	4503	4502	4502	4501	4500	4500	4499
0,589	4498	4498	4497	4496	4496	4495	4494	4494	4493	4492
0,590	4492	4491	4490	4490	4489	4488	4488	4487	4486	4485
0,591	4485	4484	4483	4483	4482	4481	4481	4480	4479	4479
0,592	4478	4477	4477	4476	4475	4474	4474	4473	4472	4472
0,593	4471	4470	4470	4469	4468	4468	4467	4466	4466	4465
0,594	4464	4463	4463	4462	4461	4461	4460	4459	4459	4458
0,595	4457	4457	4456	4455	4454	4454	4453	4452	4452	4451
0,596	4450	4450	4449	4448	4447	4447	4446	4445	4445	4444
0,597	4443	4443	4442	4441	4441	4440	4439	4438	4438	4437
0,598	4436	4436	4435	4434	4433	4433	4432	4431	4431	4430
0,599	4429	4429	4428	4427	4426	4426	4425	4424	4424	4423
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,600	4422	4422	4421	4420	4419	4419	4418	4417	4417	4416
0,601	4415	4414	4414	4413	4412	4412	4411	4410	4409	4409
0,602	4408	4407	4407	4406	4405	4405	4404	4403	4402	4402
0,603	4401	4400	4400	4399	4398	4397	4397	4396	4395	4395
0,604	4394	4393	4392	4392	4391	4390	4390	4389	4388	4387
0,605	4387	4386	4385	4384	4384	4383	4382	4382	4381	4380
0,606	4379	4379	4378	4377	4377	4376	4375	4374	4374	4373
0,607	4372	4372	4371	4370	4369	4369	4368	4367	4366	4366
0,608	4365	4364	4364	4363	4362	4361	4361	4360	4359	4358
0,609	4358	4357	4356	4356	4355	4354	4353	4353	4352	4351
0,610	4350	4350	4349	4348	4348	4347	4346	4345	4345	4344
0,611	4343	4342	4342	4341	4340	4339	4339	4338	4337	4337
0,612	4336	4335	4334	4334	4333	4332	4331	4331	4330	4329
0,613	4328	4328	4327	4326	4326	4325	4324	4323	4323	4322
0,614	4321	4320	4320	4319	4318	4317	4317	4316	4315	4314
0,615	4314	4313	4312	4311	4311	4310	4309	4308	4308	4307
0,616	4306	4306	4305	4304	4303	4303	4302	4301	4300	4300
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0,618	4291	4291	4290	4289	4288	4288	4287	4286	4285	4285
0,619	4284	4283	4282	4282	4281	4280	4279	4279	4278	4277
0,620	4276	4276	4275	4274	4273	4273	4272	4271	4270	4270
0,621	4269	4268	4267	4267	4266	4265	4264	4263	4263	4262
0,622	4261	4260	4260	4259	4258	4257	4257	4256	4255	4254
0,623	4254	4253	4252	4251	4251	4250	4249	4248	4248	4247
0,624	4246	4245	4244	4244	4243	4242	4241	4241	4240	4239
0,625	4238	4238	4237	4236	4235	4235	4234	4233	4232	4231
0,626	4231	4230	4229	4228	4228	4227	4226	4225	4225	4224
0,627	4223	4222	4221	4221	4220	4219	4218	4218	4217	4216
0,628	4215	4215	4214	4213	4212	4211	4211	4210	4209	4208
0,629	4208	4207	4206	4205	4205	4204	4203	4202	4201	4201
0,630	4200	4199	4198	4198	4197	4196	4195	4194	4194	4193
0,631	4192	4191	4191	4190	4189	4188	4187	4187	4186	4185
0,632	4184	4183	4183	4182	4181	4180	4180	4179	4178	4177
0,633	4176	4176	4175	4174	4173	4173	4172	4171	4170	4169
0,634	4169	4168	4167	4166	4165	4165	4164	4163	4162	4162
0,635	4161	4160	4159	4158	4158	4157	4156	4155	4154	4154
0,636	4153	4152	4151	4150	4150	4149	4148	4147	4147	4146
0,637	4145	4144	4143	4143	4142	4141	4140	4139	4139	4138
0,638	4137	4136	4135	4135	4134	4133	4132	4131	4131	4130
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0,645	4081	4080	4079	4078	4078	4077	4076	4075	4074	4074
0,646	4073	4072	4071	4070	4069	4069	4068	4067	4066	4065
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0,654	4007	4006	4005	4005	4004	4003	4002	4001	4000	4000
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0,657	3982	3981	3980	3980	3979	3978	3977	3976	3975	3975
0,658	3974	3973	3972	3971	3970	3969	3969	3968	3967	3966
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0,667	3897	3896	3896	3895	3894	3893	3892	3891	3890	3890
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0,669	3880	3879	3878	3877	3877	3876	3875	3874	3873	3872
0,670	3871	3871	3870	3869	3868	3867	3866	3865	3864	3864
0,671	3863	3862	3861	3860	3859	3858	3858	3857	3856	3855
0,672	3854	3853	3852	3851	3851	3850	3849	3848	3847	3846
0,673	3845	3845	3844	3843	3842	3841	3840	3839	3838	3838
0,674	3837	3836	3835	3834	3833	3832	3831	3831	3830	3829
0,675	3828	3827	3826	3825	3824	3824	3823	3822	3821	3820
0,676	3819	3818	3817	3817	3816	3815	3814	3813	3812	3811
0,677	3810	3809	3809	3808	3807	3806	3805	3804	3803	3802
0,678	3802	3801	3800	3799	3798	3797	3796	3795	3794	3794
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0,681	3775	3774	3773	3772	3771	3771	3770	3769	3768	3767
0,682	3766	3765	3764	3763	3763	3762	3761	3760	3759	3758
0,683	3757	3756	3755	3754	3754	3753	3752	3751	3750	3749
0,684	3748	3747	3746	3746	3745	3744	3743	3742	3741	3740
0,685	3739	3738	3737	3737	3736	3735	3734	3733	3732	3731
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0,687	3721	3720	3719	3719	3718	3717	3716	3715	3714	3713
0,688	3712	3711	3710	3710	3709	3708	3707	3706	3705	3704
0,689	3703	3702	3701	3701	3700	3699	3698	3697	3696	3695
0,690	3694	3693	3692	3691	3691	3690	3689	3688	3687	3686
0,691	3685	3684	3683	3682	3681	3681	3680	3679	3678	3677
0,692	3676	3675	3674	3673	3672	3671	3670	3670	3669	3668
0,693	3667	3666	3665	3664	3663	3662	3661	3660	3660	3659
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0,698	3621	3620	3619	3618	3617	3616	3615	3614	3613	3613
0,699	3612	3611	3610	3609	3608	3607	3606	3605	3604	3603
0,700	3602	3601	3601	3600	3599	3598	3597	3596	3595	3594
0,701	3593	3592	3591	3590	3589	3588	3587	3587	3586	3585
0,702	3584	3583	3582	3581	3580	3579	3578	3577	3576	3575
0,703	3574	3573	3573	3572	3571	3570	3569	3568	3567	3566
0,704	3565	3564	3563	3562	3561	3560	3559	3559	3558	3557
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0,706	3546	3545	3544	3543	3543	3542	3541	3540	3539	3538
0,707	3537	3536	3535	3534	3533	3532	3531	3530	3529	3528
0,708	3527	3527	3526	3525	3524	3523	3522	3521	3520	3519
0,709	3518	3517	3516	3515	3514	3513	3512	3511	3510	3509
0,710	3509	3508	3507	3506	3505	3504	3503	3502	3501	3500
0,711	3499	3498	3497	3496	3495	3494	3493	3492	3491	3490
0,712	3490	3489	3488	3487	3486	3485	3484	3483	3482	3481
0,713	3480	3479	3478	3477	3476	3475	3474	3473	3472	3471
0,714	3470	3469	3468	3468	3467	3466	3465	3464	3463	3462
0,715	3461	3460	3459	3458	3457	3456	3455	3454	3453	3452
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0,717	3442	3441	3440	3439	3438	3437	3436	3435	3434	3433
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0,722	3393	3392	3391	3390	3389	3388	3387	3386	3385	3384
0,723	3383	3383	3382	3381	3380	3379	3378	3377	3376	3375
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0,726	3354	3353	3352	3351	3350	3349	3348	3347	3346	3345
0,727	3344	3343	3342	3341	3340	3339	3338	3337	3336	3335
0,728	3334	3334	3333	3332	3331	3330	3329	3328	3327	3326
0,729	3325	3324	3323	3322	3321	3320	3319	3318	3317	3316
0,730	3315	3314	3313	3312	3311	3310	3309	3308	3307	3306
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0,734	3275	3274	3273	3272	3271	3270	3269	3268	3267	3266
0,735	3265	3264	3263	3262	3261	3260	3259	3258	3257	3256
0,736	3255	3254	3253	3252	3251	3250	3249	3248	3247	3246
0,737	3245	3244	3243	3242	3241	3240	3239	3238	3237	3236
0,738	3235	3234	3233	3232	3231	3230	3229	3228	3227	3226
0,739	3225	3224	3223	3222	3221	3220	3219	3218	3217	3216
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0,741	3205	3204	3203	3202	3201	3200	3199	3198	3197	3196
0,742	3195	3194	3193	3192	3191	3190	3189	3188	3187	3186
0,743	3185	3184	3183	3182	3181	3179	3178	3177	3176	3175
0,744	3174	3173	3172	3171	3170	3169	3168	3167	3166	3165
0,745	3164	3163	3162	3161	3160	3159	3158	3157	3156	3155
0,746	3154	3153	3152	3151	3150	3149	3148	3147	3146	3145
0,747	3144	3143	3142	3141	3140	3139	3138	3137	3136	3135
0,748	3134	3133	3132	3131	3130	3128	3127	3126	3125	3124
0,749	3123	3122	3121	3120	3119	3118	3117	3116	3115	3114
0,750	3113	3112	3111	3110	3109	3108	3107	3106	3105	3104
0,751	3103	3102	3101	3100	3099	3098	3097	3096	3095	3094
0,752	3092	3091	3090	3089	3088	3087	3086	3085	3084	3083
0,753	3082	3081	3080	3079	3078	3077	3076	3075	3074	3073
0,754	3072	3071	3070	3069	3068	3067	3066	3065	3064	3063
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0,756	3051	3050	3049	3048	3047	3046	3045	3044	3043	3042
0,757	3041	3040	3039	3038	3037	3035	3034	3033	3032	3031
0,758	3030	3029	3028	3027	3026	3025	3024	3023	3022	3021
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0,762	2988	2987	2986	2985	2984	2983	2982	2981	2980	2979
0,763	2978	2977	2976	2975	2974	2973	2972	2970	2969	2968
0,764	2967	2966	2965	2964	2963	2962	2961	2960	2959	2958
0,765	2957	2956	2955	2954	2953	2951	2950	2949	2948	2947
0,766	2946	2945	2944	2943	2942	2941	2940	2939	2938	2937
0,767	2936	2935	2933	2932	2931	2930	2929	2928	2927	2926
0,768	2925	2924	2923	2922	2921	2920	2919	2918	2916	2915
0,769	2914	2913	2912	2911	2910	2909	2908	2907	2906	2905
0,770	2904	2903	2902	2901	2899	2898	2897	2896	2895	2894
0,771	2893	2892	2891	2890	2889	2888	2887	2886	2885	2883
0,772	2882	2881	2880	2879	2878	2877	2876	2875	2874	2873
0,773	2872	2871	2870	2868	2867	2866	2865	2864	2863	2862
0,774	2861	2860	2859	2858	2857	2856	2855	2853	2852	2851
0,775	2850	2849	2848	2847	2846	2845	2844	2843	2842	2841
0,776	2839	2838	2837	2836	2835	2834	2833	2832	2831	2830
0,777	2829	2828	2827	2825	2824	2823	2822	2821	2820	2819
0,778	2818	2817	2816	2815	2814	2812	2811	2810	2809	2808
0,779	2807	2806	2805	2804	2803	2802	2801	2799	2798	2797
0,780	2796	2795	2794	2793	2792	2791	2790	2789	2788	2786
0,781	2785	2784	2783	2782	2781	2780	2779	2778	2777	2776
0,782	2774	2773	2772	2771	2770	2769	2768	2767	2766	2765
0,783	2764	2763	2761	2760	2759	2758	2757	2756	2755	2754
0,784	2753	2752	2751	2749	2748	2747	2746	2745	2744	2743
0,785	2742	2741	2740	2738	2737	2736	2735	2734	2733	2732
0,786	2731	2730	2729	2728	2726	2725	2724	2723	2722	2721
0,787	2720	2719	2718	2717	2715	2714	2713	2712	2711	2710
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0,789	2698	2697	2696	2695	2693	2692	2691	2690	2689	2688
0,790	2687	2686	2685	2684	2682	2681	2680	2679	2678	2677
0,791	2676	2675	2674	2673	2671	2670	2669	2668	2667	2666
0,792	2665	2664	2663	2661	2660	2659	2658	2657	2656	2655
0,793	2654	2653	2651	2650	2649	2648	2647	2646	2645	2644
0,794	2643	2641	2640	2639	2638	2637	2636	2635	2634	2633
0,795	2631	2630	2629	2628	2627	2626	2625	2624	2623	2621
0,796	2620	2619	2618	2617	2616	2615	2614	2613	2611	2610
0,797	2609	2608	2607	2606	2605	2604	2603	2601	2600	2599
0,798	2598	2597	2596	2595	2594	2592	2591	2590	2589	2588
0,799	2587	2586	2585	2584	2582	2581	2580	2579	2578	2577
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P_1	0	1	2	3	4	5	6	7	8	9
0,800	2576	2575	2573	2572	2571	2570	2569	2568	2567	2566
0,801	2564	2563	2562	2561	2560	2559	2558	2557	2555	2554
0,802	2553	2552	2551	2550	2549	2548	2546	2545	2544	2543
0,803	2542	2541	2540	2539	2537	2536	2535	2534	2533	2532
0,804	2531	2530	2528	2527	2526	2525	2524	2523	2522	2521
0,805	2519	2518	2517	2516	2515	2514	2513	2511	2510	2509
0,806	2508	2507	2506	2505	2504	2502	2501	2500	2499	2498
0,807	2497	2496	2495	2493	2492	2491	2490	2489	2488	2487
0,808	2485	2484	2483	2482	2481	2480	2479	2477	2476	2475
0,809	2474	2473	2472	2471	2470	2468	2467	2466	2465	2464
0,810	2463	2462	2460	2459	2458	2457	2456	2455	2454	2452
0,811	2451	2450	2449	2448	2447	2446	2444	2443	2442	2441
0,812	2440	2439	2438	2436	2435	2434	2433	2432	2431	2430
0,813	2428	2427	2426	2425	2424	2423	2422	2420	2419	2418
0,814	2417	2416	2415	2414	2412	2411	2410	2409	2408	2407
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0,816	2394	2393	2392	2391	2389	2388	2387	2386	2385	2384
0,817	2383	2381	2380	2379	2378	2377	2376	2374	2373	2372
0,818	2371	2370	2369	2368	2366	2365	2364	2363	2362	2361
0,819	2359	2358	2357	2356	2355	2354	2353	2351	2350	2349
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0,821	2336	2335	2334	2333	2332	2331	2329	2328	2327	2326
0,822	2325	2324	2322	2321	2320	2319	2318	2317	2315	2314
0,823	2313	2312	2311	2310	2309	2307	2306	2305	2304	2303
0,824	2302	2300	2299	2298	2297	229	2295	2293	2292	2291
0,825	2290	2289	2288	2286	2285	2284	2283	2282	2281	2279
0,826	2278	2277	2276	2275	2274	2272	2271	2270	2269	2268
0,827	2267	2265	2264	2263	2262	2261	2260	2258	2257	2256
0,828	2255	2254	2253	2251	2250	2249	2248	2247	2245	2244
0,829	2243	2242	2241	2240	2238	2237	2236	2235	2234	2233
0,830	2231	2230	2229	2228	2227	2226	2224	2223	2222	2221
0,831	2220	2218	2217	2216	2215	2214	2213	2211	2210	2209
0,832	2208	2207	2206	2204	2203	2202	2201	2200	2198	2197
0,833	2196	2195	2194	2193	2191	2190	2189	2188	2187	2185
0,834	2184	2183	2182	2181	2180	2178	2177	2176	2175	2174
0,835	2172	2171	2170	2169	2168	2167	2165	2164	2163	2162
0,836	2161	2159	2158	2157	2156	2155	2154	2152	2151	2150
0,837	2149	2148	2146	2145	2144	2143	2142	2140	2139	2138
0,838	2137	2136	2135	2133	2132	2131	2130	2129	2127	2126
0,839	2125	2124	2123	2121	2120	2119	2118	2117	2116	2114
P_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,840	2113	2112	2111	2110	2108	2107	2106	2105	2104	2102
0,841	2101	2100	2099	2098	2096	2095	2094	2093	2092	2090
0,842	2089	2088	2087	2086	2084	2083	2082	2081	2080	2079
0,843	2077	2076	2075	2074	2073	2071	2070	2069	2068	2067
0,844	2065	2064	2063	2062	2061	2059	2053	2057	2056	2055
0,845	2053	2052	2051	2050	2049	2047	2046	2045	2044	2043
0,846	2041	2040	2039	2038	2037	2035	2034	2033	2032	2031
0,847	2029	2028	2027	2026	2025	2023	2022	2021	2020	2018
0,848	2017	2016	2015	2014	2012	2011	2010	2009	2008	2006
0,849	2005	2004	2003	2002	2000	1999	1998	1997	1996	1994
0,850	1993	1992	1991	1990	1988	1987	1986	1985	1983	1982
0,851	1981	1980	1979	1977	1976	1975	1974	1973	1971	1970
0,852	1969	1968	1967	1965	1964	1963	1962	1960	1959	1958
0,853	1957	1956	1954	1953	1952	1951	1950	1948	1947	1946
0,854	1945	1943	1942	1941	1940	1939	1937	1936	1935	1934
0,855	1933	1931	1930	1929	1928	1926	1925	1924	1923	1922
0,856	1920	1919	1918	1917	1915	1914	1913	1912	1911	1909
0,857	1908	1907	1906	1904	1903	1902	1901	1900	1898	1897
0,858	1896	1895	1893	1892	1891	1890	1889	1887	1886	1885
0,859	1884	1882	1881	1880	1879	1878	1876	1875	1874	1873
0,860	1871	1870	1869	1868	1867	1865	1864	1863	1862	1860
0,861	1859	1858	1857	1856	1854	1853	1852	1851	1849	1848
0,862	1847	1846	1844	1843	1842	1841	1840	1838	1837	1836
0,863	1835	1833	1832	1831	1830	1828	1827	1826	1825	1824
0,864	1822	1821	1820	1819	1817	1816	1815	1814	1812	1811
0,865	1810	1809	1808	1806	1805	1804	1803	1801	1800	1799
0,866	1798	1796	1795	1794	1793	1791	1790	1789	1788	1787
0,867	1785	1784	1783	1782	1780	1779	1778	1777	1775	1774
0,868	1773	1772	1770	1769	1768	1767	1765	1764	1763	1762
0,869	1761	1759	1758	1757	1756	1754	1753	1752	1751	1749
0,870	1748	1747	1746	1744	1743	1742	1741	1739	1738	1737
0,871	1736	1734	1733	1732	1731	1729	1728	1727	1726	1724
0,872	1723	1722	1721	1720	1718	1717	1716	1715	1713	1712
0,873	1711	1710	1708	1707	1706	1705	1703	1702	1701	1700
0,874	1698	1697	1696	1695	1693	1692	1691	1690	1688	1687
0,875	1686	1685	1683	1682	1681	1680	1678	1677	1676	1675
0,876	1673	1672	1671	1670	1668	1667	1666	1665	1663	1662
0,877	1661	1660	1658	1657	1656	1655	1653	1652	1651	1649
0,878	1648	1647	1646	1644	1643	1642	1641	1639	1638	1637
0,879	1636	1634	1633	1632	1631	1629	1628	1627	1626	1624
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,880	1623	1622	1621	1619	1618	1617	1616	1614	1613	1612
0,881	1611	1609	1608	1607	1605	1604	1603	1602	1600	1599
0,882	1598	1597	1595	1594	1593	1592	1590	1589	1588	1587
0,883	1585	1584	1583	1581	1580	1579	1578	1576	1575	1574
0,884	1573	1571	1570	1569	1568	1566	1565	1564	1563	1561
0,885	1560	1559	1557	1556	1555	1554	1552	1551	1550	1549
0,886	1547	1546	1545	1543	1542	1541	1540	1538	1537	1536
0,887	1535	1533	1532	1531	1530	1528	1527	1526	1524	1523
0,888	1522	1521	1519	1518	1517	1516	1514	1513	1512	1510
0,889	1509	1508	1507	1505	1504	1503	1502	1500	1499	1498
0,890	1496	1495	1494	1493	1491	1490	1489	1488	1486	1485
0,891	1484	1482	1481	1480	1479	1477	1476	1475	1473	1472
0,892	1471	1470	1468	1467	1466	1465	1463	1462	1461	1459
0,893	1458	1457	1456	1454	1453	1452	1450	1449	1448	1447
0,894	1445	1444	1443	1441	1440	1439	1438	1436	1435	1434
0,895	1433	1431	1430	1429	1427	1426	1425	1424	1422	1421
0,896	1420	1418	1417	1416	1415	1413	1412	1411	1409	1408
0,897	1407	1406	1404	1403	1402	1400	1399	1398	1397	1395
0,898	1394	1393	1391	1390	1389	1388	1386	1385	1384	1382
0,899	1381	1380	1378	1377	1376	1375	1373	1372	1371	1369
0,900	1368	1367	1366	1364	1363	1362	1360	1359	1358	1357
0,901	1355	1354	1353	1351	1350	1349	1347	1346	1345	1344
0,902	1342	1341	1340	1338	1337	1336	1335	1333	1332	1331
0,903	1329	1328	1327	1325	1324	1323	1322	1320	1319	1318
0,904	1316	1315	1314	1313	1311	1310	1309	1307	1306	1305
0,905	1303	1302	1301	1300	1298	1297	1296	1294	1293	1292
0,906	1290	1289	1288	1287	1285	1284	1283	1281	1280	1279
0,907	1277	1276	1275	1274	1272	1271	1270	1268	1267	1266
0,908	1264	1263	1262	1260	1259	1258	1257	1255	1254	1253
0,909	1251	1250	1249	1247	1246	1245	1244	1242	1241	1240
0,910	1238	1237	1236	1234	1233	1232	1230	1229	1228	1227
0,911	1225	1224	1223	1221	1220	1219	1217	1216	1215	1213
0,912	1212	1211	1209	1208	1207	1206	1204	1203	1202	1200
0,913	1199	1198	1196	1195	1194	1192	1191	1190	1189	1187
0,914	1186	1185	1183	1182	1181	1179	1178	1177	1175	1174
0,915	1173	1171	1170	1169	1167	1166	1165	1164	1162	1161
0,916	1160	1158	1157	1156	1154	1153	1152	1150	1149	1148
0,917	1146	1145	1144	1142	1141	1140	1139	1137	1136	1135
0,918	1133	1132	1131	1129	1128	1127	1125	1124	1123	1121
0,919	1120	1119	1117	1116	1115	1113	1112	1111	1109	1108
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,920	1107	1105	1104	1103	1102	1100	1099	1098	1096	1095
0,921	1094	1092	1091	1090	1088	1087	1086	1084	1083	1082
0,922	1080	1079	1078	1076	1075	1074	1072	1071	1070	1068
0,923	1067	1066	1064	1063	1062	1060	1059	1058	1056	1055
0,924	1054	1052	1051	1050	1048	1047	1046	1044	1043	1042
0,925	1040	1039	1038	1037	1035	1034	1033	1031	1030	1029
0,926	1027	1026	1025	1023	1022	1021	1019	1018	1017	1015
0,927	1014	1013	1011	1010	1009	1007	1006	1005	1003	1002
0,928	1001	0999	0998	0997	0995	0994	0993	0991	0990	0988
0,929	0987	0986	0984	0983	0982	0980	0979	0978	0976	0975
0,930	0974	0972	0971	0970	0968	0967	0966	0964	0963	0962
0,931	0960	0959	0958	0956	0955	0954	0952	0951	0950	0948
0,932	0947	0946	0944	0943	0942	0940	0939	0938	0936	0935
0,933	0934	0932	0931	0930	0928	0927	0926	0924	0923	0921
0,934	0920	0919	0917	0916	0915	0913	0912	0911	0909	0908
0,935	0907	0905	0904	0903	0901	0900	0899	0897	0896	0895
0,936	0893	0892	0891	0889	0888	0886	0885	0884	0882	0881
0,937	0880	0878	0877	0876	0874	0873	0872	0870	0869	0868
0,938	0866	0865	0864	0862	0861	0859	0858	0857	0855	0854
0,939	0853	0851	0850	0849	0847	0846	0845	0843	0842	0841
0,940	0839	0838	0836	0835	0834	0832	0831	0830	0828	0827
0,941	0826	0824	0823	0822	0820	0819	0818	0816	0815	0813
0,942	0812	0811	0809	0808	0807	0805	0804	0803	0801	0800
0,943	0799	0797	0796	0794	0793	0792	0790	0789	0788	0786
0,944	0785	0784	0782	0781	0779	0778	0777	0775	0774	0773
0,945	0771	0770	0769	0767	0766	0765	0763	0762	0760	0759
0,946	0758	0756	0755	0754	0752	0751	0750	0748	0747	0745
0,947	0744	0743	0741	0740	0739	0737	0736	0735	0733	0732
0,948	0730	0729	0728	0726	0725	0724	0722	0721	0719	0718
0,949	0717	0715	0714	0713	0711	0710	0709	0707	0706	0704
0,950	0703	0702	0700	0699	0698	0696	0695	0693	0692	0691
0,951	0689	0688	0687	0685	0684	0683	0681	0680	0678	0677
0,952	0676	0674	0673	0672	0670	0669	0667	0666	0665	0663
0,953	0662	0661	0659	0658	0656	0655	0654	0652	0651	0650
0,954	0648	0647	0645	0644	0643	0641	0640	0639	0637	0636
0,955	0634	0633	0632	0630	0629	0628	0626	0625	0623	0622
0,956	0621	0619	0618	0617	0615	0614	0612	0611	0610	0608
0,957	0607	0606	0604	0603	0601	0600	0599	0597	0596	0594
0,958	0593	0592	0590	0589	0588	0586	0585	0583	0582	0581
0,959	0579	0578	0577	0575	0574	0572	0571	0570	0568	0567
p_1	0	1	2	3	4	5	6	7	8	9

p_1	0	1	2	3	4	5	6	7	8	9
0,960	0565	0564	0563	0561	0560	0559	0557	0556	0554	0553
0,961	0552	0550	0549	0547	0546	0545	0543	0542	0541	0539
0,962	0538	0536	0535	0534	0532	0531	0529	0528	0527	0525
0,963	0524	0522	0521	0520	0518	0517	0516	0514	0513	0511
0,964	0510	0509	0507	0506	0504	0503	0502	0500	0499	0497
0,965	0496	0495	0493	0492	0490	0489	0488	0486	0485	0484
0,966	0482	0481	0479	0478	0477	0475	0474	0472	0471	0470
0,967	0468	0467	0465	0464	0463	0461	0460	0458	0457	0456
0,968	0454	0453	0451	0450	0449	0447	0446	0444	0443	0442
0,969	0440	0439	0437	0436	0435	0433	0432	0430	0429	0428
0,970	0426	0425	0423	0422	0421	0419	0418	0416	0415	0414
0,971	0412	0411	0409	0408	0407	0405	0404	0402	0401	0400
0,972	0398	0397	0395	0394	0393	0391	0390	0388	0387	0386
0,973	0384	0383	0381	0380	0379	0377	0376	0374	0373	0372
0,974	0370	0369	0367	0366	0365	0363	0362	0360	0359	0358
0,975	0356	0355	0353	0352	0351	0349	0348	0346	0345	0343
0,976	0342	0341	0339	0338	0336	0335	0334	0332	0331	0329
0,977	0328	0327	0325	0324	0322	0321	0320	0318	0317	0315
0,978	0314	0312	0311	0310	0309	0307	0305	0304	0303	0301
0,979	0300	0298	0297	0296	0294	0293	0291	0290	0288	0287
0,980	0286	0284	0283	0281	0280	0279	0277	0276	0274	0273
0,981	0272	0270	0269	0267	0266	0264	0263	0262	0260	0259
0,982	0257	0256	0255	0253	0252	0250	0249	0247	0246	0243
0,983	0243	0242	0240	0239	0238	0236	0235	0233	0232	0230
0,984	0229	0228	0226	0225	0223	0222	0220	0219	0218	0216
0,985	0215	0213	0212	0211	0209	0208	0206	0205	0203	0202
0,986	0201	0199	0198	0196	0195	0193	0192	0191	0189	0188
0,987	0186	0185	0183	0182	0181	0179	0178	0176	0175	0174
0,988	0172	0171	0169	0168	0166	0165	0164	0162	0161	0159
0,989	0158	0156	0155	0154	0152	0151	0149	0148	0146	0145
0,990	0144	0142	0141	0139	0138	0136	0135	0134	0132	0131
0,991	0129	0128	0126	0125	0124	0122	0121	0119	0118	0116
0,992	0115	0114	0112	0111	0109	0108	0106	0105	0104	0102
0,993	0101	0099	0098	0096	0095	0093	0092	0091	0089	0088
0,994	0086	0085	0083	0082	0081	0079	0078	0076	0075	0073
0,995	0072	0071	0069	0068	0066	0065	0063	0062	0060	0059
0,996	0058	0056	0055	0053	0052	0050	0049	0048	0046	0045
0,997	0043	0042	0040	0039	0037	0036	0035	0033	0032	0030
0,998	0029	0027	0026	0025	0023	0022	0020	0019	0017	0016
0,999	0014	0013	0012	0010	0009	0007	0006	0004	0003	0001
p_1	0	1	2	3	4	5	6	7	8	9

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A CALCULATION METHOD FOR DETERMINING THE LEAF AREA AND ITS VERTICAL DISTRIBUTION IN THE BARLEY CROP

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The amount of the assimilating leaf area in agricultural crops is a significant characteristic indispensable both for the estimation and analysis of the photosynthetic activity of a crop stand and for the forecasting of the yield. A detailed treatment of these problems and particularly the study of the radiation and water-thermal regimes in a crop stand need data on the total leaf area as well as on its vertical distribution. The "stratifying clip method" proposed by the Japanese scientists MONSI and SAEKI [1], which is still one of the principal methods for determining the vertical distribution of the leaf area, made it possible to collect interesting experimental data. But in spite of its simplicity this method is too labour-consuming for the obtainment of reliable data. For this reason several attempts have been made [3, 4] to work out new calculation methods based on the mathematical simulation of the growth of plant stands and designed for the determination of the leaf area and its vertical distribution.

Unfortunately, there are few data in the literature on the vertical distribution of the assimilating leaf area of

cereals [5, 8, 9] , in which besides the leaf area also the area of stems and ears is taken into account. Simulating stems and ears by vertical cylinders, the lateral area can be calculated in case the diameters and heights of stems and the number of ears are given. The determination of the vertical distribution of the leaf area is more complicated. It requires the cutting of the leaves and the determination of the leaf area separately in each layer.

In the present report an empirical calculation method for determining the leaf area index as well as the downward cumulative leaf area index in the barley crop, which in our opinion could also be applied to other cereals, will be proposed. To make calculations by means of the formulae presented here, it is supposed that some numerical characteristics of a plant variety , determined by certain experiments, and three standard agrometeorological characteristics of a crop must be known. The latter include the period of time from the emergence of plants up to their turning completely yellow in a certain locality, the density of crop stands, and the change of the maximum height of a mean plant during the vegetative season.

Basic notions and formulae

The determination of the vertical distribution of the leaf area by the "stratifying clip method" lies in the following [8] : 50–100 plants (depending on the homogeneity of a crop) are chosen in which the amount of the leaf area is determined separately in each layer, over 5, 10, 20 cm etc., in accordance with the height of the crop stands. Dividing the sampled results by the number of the plants chosen, the leaf area in each layer per plant is calculated. On the basis of these data a corresponding histogram is constructed and a smoothed curve $u'(z)$ is drawn, which represents the leaf area in a layer of unit thickness at the height z calculated per plant. Multiplying $u'(z)$ by the density of the crop

stand N, i.e. by the number of plants per square metre, the leaf area density in a crop is obtained:

$$u(z) = N u'(z). \tag{1}$$

The leaf area density $u(z)$, determining the area of the upper leaf area per unit volume in a crop stand at a height z, is the main characteristic for the vertical distribution of the leaf area in a crop. The dimensions of $u(z)$ are $m^2/m^3 = m^{-1}$.

Instead of the leaf area density $u(z)$ the downward cumulative leaf area index

$$L(z) = \int_z^{z_s} u(z)\, dz \tag{2}$$

is often used. It represents the leaf area in the layer of a crop stand between the heights z and z_s per square metre of the ground surface; z_s is the height of the upper boundary of foliage.

The quantity

$$L_o = \int_{z_H}^{z_s} u(z)\, dz \tag{3}$$

is called the leaf area index of a crop stand; z_H is the height of the lower boundary of foliage.

The dimensions of $L(z)$ and L_o are m^2/m^2.

The curves for $u(z)$ of the barley crop in different vegetative phases, determined by "stratifying clip method", are presented in Fig.1. The density of this crop stand is 1.100 plants per square metre; the number of plants chosen to determine $u(z)$ were 100. Taking into account that $u'(z) = u(z)/N$, we obtain analogous curves also for a mean plant.

The study of Fig.1 makes us think of the possibility of simulating the curves of $u'(z)$ by triangles which should coincide with the curves of $u'(z)$ as exactly as possible and

have an area equal to L_o.

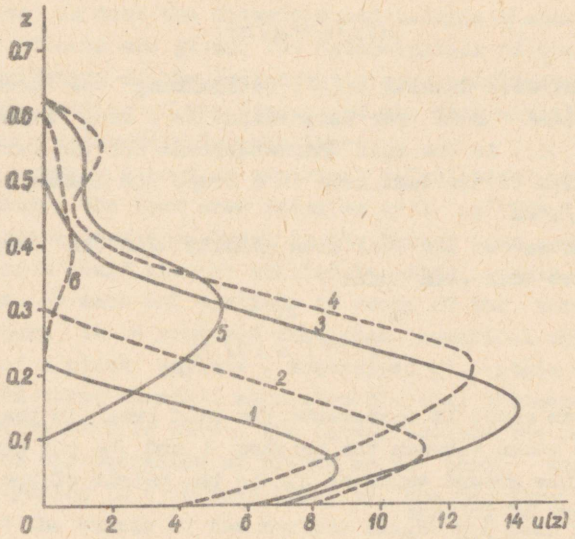

Fig.1. Vertical distribution of the green leaf area density $u(z)$ in a barley stand at Tartu in 1965. Height of the stand z expressed in metres and $u(z)$ in m^{-1}. 1 - 10 June; 2 - 15 June; 3 - 25 June; 4 - 5 July; 5 - 20 July; 6 - 5 August.

The triangle pattern is given and the parameters describing it are presented in Fig.2.

where u_m - the height DC of the triangle ABC determining the amount of the leaf surface u' in the densest layer, i.e. $u_m = max\ u'(z)$;

h_m - height of a layer of maximum density u_m taken from the ground surface;

$K_1 = \frac{u_m}{a_1}$ - inclination of the straight line AC;

$K_2 = \frac{u_m}{a_2}$ - inclination of the straight line BC;

$$z_o = h_m + \frac{u_m}{K_1} \approx z_B \qquad (4)$$

- point of intersection of the straight line AC with the vertical axis, which determines the effective height of the upper boundary of foliage

and

$$z_{oo} = h_m - \frac{u_m}{K_2} \qquad (5)$$

- point of intersection of the straight line BC with the vertical axis. If $z_{oo} < 0$, the lower boundary of foliage $z_H = 0$; if $z_{oo} > 0$, $z_H \approx z_{oo}$.

It can be seen from Fig.2 that the equations of the straight lines AC and BC give the quantity $u'(z)$ approximately, that is:

$$u'(z) \approx \begin{cases} u_m - K_1(z - h_m) & , \text{if} \quad h_m \le z \le z_o , \\ u_m - K_2(h_m - z) & , \text{if} \quad z_H \le z \le h_m , \end{cases} \qquad (6)$$

and considering (1)

$$u(z) = \begin{cases} N[u_m - K_1(z - h_m)] & , \text{if} \quad h_m \le z \le z_o , \\ N[u_m - K_2(h_m - z)] & , \text{if} \quad z_H \le z \le h_m . \end{cases} \qquad (7)$$

Since

$$\int_z^{z_o} u'(z)\,dz = \frac{K_1}{2}\left(\frac{u_m}{K_1} + h_m - z\right)^2$$

and

$$\int_z^{h_m} u'(z)\,dz = \left[u_m - \frac{K_2}{2}(h_m - z)\right](h_m - z),$$

then considering (1), (2) and (3), we obtain

$$L(z) = N\int_z^{z_o} u'(z)\,dz \approx \begin{cases} \frac{NK_1}{2}\left(\frac{u_m}{K_1} + h_m - z\right)^2 & , \text{if} \quad h_m \le z \le z_o , \\ \frac{Nu_m^2}{2K_1} + N(h_m - z)\left[u_m - \frac{K_2}{2}(h_m - z)\right] & , \text{if} \quad z_{oo} \le z \le h_m , \end{cases} \qquad (8)$$

and

$$L_0 = N\int_{z_H}^{z_0} u'(z)\,dz \approx \begin{cases} N\left(\frac{u_m^2}{2\kappa_1} - \frac{\kappa_2 h_m^2}{2} + u_m h_m\right) & \text{,if } h_m < \frac{u_m}{\kappa_2}, \\ \frac{N u_m^2}{2}\left(\frac{1}{\kappa_1} + \frac{1}{\kappa_2}\right) & \text{,if } h_m > \frac{u_m}{\kappa_2}, \end{cases} \tag{9}$$

respectively.

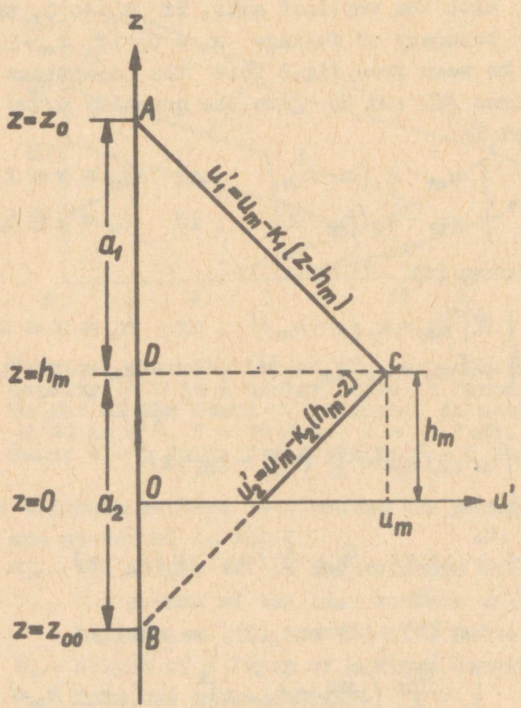

Fig.2. Triangle pattern for the calculation of the vertical distribution of the leaf area density.

Equations (7) and (8) enable one to calculate the characteristics of the vertical distribution of the leaf area in the crop $u(z)$ and $L(z)$, and equation (9) makes it possible to calculate the leaf area index L_o, if the five structural parameters are known: N, h_m, u_m, K_1 and K_2.

As the plants grow, these parameters may change and thus serve as the functions of time τ characterizing the course of the vegetative period.

To be able to apply the calculation formulae proposed, the structural parameters of a crop must be easy to determine and more or less constant during the whole vegetative period.

Determination of structural parameters

According to the data of the phytometrical measurements carried out on an experimental farm of the Estonian Agricultural Academy near Tartu with the barley crop ("Domen" variety) in 1964–1966 on plots with a different level of mineral nutrients, it can be concluded that the structural parameters are quite steady, if the growth of a crop proceeds under normal climatic conditions. Extreme weather conditions and large differences in fertilizer level cause instability in structural parameters and our calculation method cannot be applied.

Proceeding to the discussion of separate parameters, it can be pointed out that the density of the crop stand N can actually be considered as a constant quantity during the vegetative season and it is enough to determine it once in the middle of the latter.

The field measurement of the height of the densest layer h_m is very labour-consuming. For this reason it would be more expedient to determine it through other phytometrical parameters of a crop stand which are easy to determine. Various comparisons have shown that the correlation between h_m and the maximum height of a mean plant $\bar{h}$ (Fig.3), taken from

the ground surface up to the upper boundary of the topmost leaf in its vertical position, is sufficiently significant. In case the upper boundary of an ear is higher than that of the topmost leaf, the former must be considered as $\bar{h}$. The relation between h_m and $\bar{h}$ shown in Fig.3 is

$$h_m(\tau) = \alpha_m \bar{h}(\tau) - 0.1, \qquad (10)$$

where α_m is the constant characterizing a given variety. In the present case $\alpha_m = 0.57$. The maximum height of a mean plant $\bar{h}$ is determined by field measurements in each 5 to 7 days during the vegetative period.

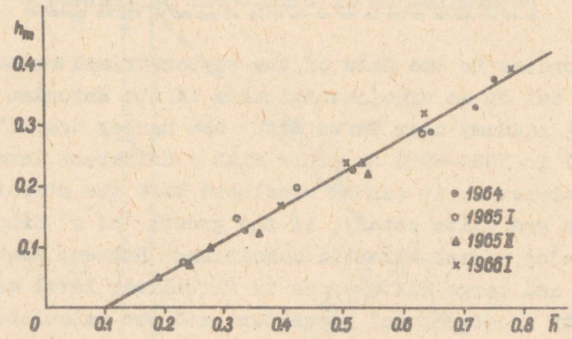

Fig.3. Relation of the height of a layer with the maximum density h_m to the maximum height of a mean plant $\bar{h}$ in a barley stand at Tartu in 1964–1966.

The course of the change of the maximum density of the leaf surface of a mean plant u_m during the vegetative period is presented in Fig.4a. At the beginning of the period u_m is growing, it attains its maximum in the middle of the season just before earing, and when the leaves start to turn yellow, it begins to decrease. The course of the change of $u_m(\tau)$ is illustrated by a sinusoid in Fig.4a and expressed

by the formula

$$u_m(\tau) = u_m^o \sin \pi \frac{\tau}{\tau_o}, \qquad (11)$$

where u_m^o is the maximum value of $u_m(\tau)$ in the middle of the vegetative period, τ denotes time in days from the day of the emergence of plants, τ_o denotes the duration of the period, on the average, from the emergence of plants until the leaves of a given variety turn completely yellow.

In connection with seasonal conditions (Fig.4a) u_m^o and τ_o can change a little in some years. u_m^o can differ in different varieties. The barley variety "Domen" has u_m^o = $= 14(\pm 1) \cdot 10^{-3}$ m^2/m^3.plant, $\tau_o = 75 \pm 5$ days.

Changes in the angular coefficients $\kappa_1(\tau)$ and $\kappa_2(\tau)$ of the model triangle during the vegetative season are presented in Figs.4b and 4c, respectively.

It is seen that the decrease of $\kappa_1(\tau)$ is linear with time and can be expressed by the formula

$$\kappa_1(\tau) = \kappa_1^o \left(1 - \frac{\tau}{\tau_o}\right). \qquad (12)$$

In the present case $\kappa_1^o = 9.2 \cdot 10^{-2}$ m^2/m^4.plant. The angular coefficient $\kappa_2(\tau)$ is practically constant up to the phase of milk-ripeness, but later on towards the end of the vegetative season it decreases quickly to zero.

Thus, the calculation method proposed here presupposes the determination of the parameters α_m, u_m^o, κ_1^o and κ_2 typical of a given variety by means of special phytometrical measurements as well as the determination of the length of the period of photosynthetic activity of the leaves τ_o. If these data are known, then, to determine the characteristics of the vertical distribution of the leaf area in a crop, only the density of the crop stand N and the course of the maximum height of a mean plant $\bar{h}(\tau)$ during the vegetative season are to be obtained.

The course of the calculation process is the following: $h_m(\tau)$ is determined by formula (10), $u_m(\tau)$ by formula

(11) and $K_1(\tau)$ by formula (12). Further, $u_m(z)$ is calculated by formula (7); $L(z)$ by formula (8) and L_o by formula (9).

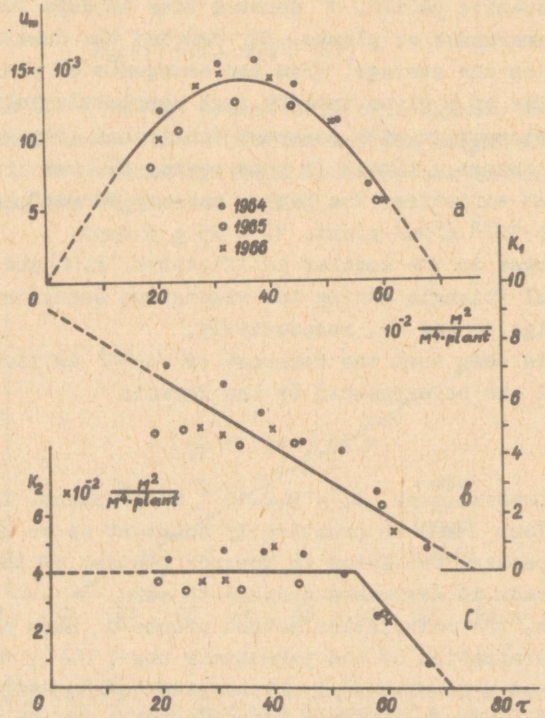

Fig.4. Course of the maximum density of the green leaf area u_m (curve a) and of the slopes K_1 (curve b) and K_2 (curve c) respectively throughout the vegetative period for a mean plant at Tartu in 1964–1966. τ denotes days from emergence of plants. The dimensions of u_m are m^{-1} per plant and those of slopes are indicated in the figure.

By way of example the change of the relative leaf area L_o throughout the vegetative season of 1965 according to the actual and calculated data is presented in Fig.5.

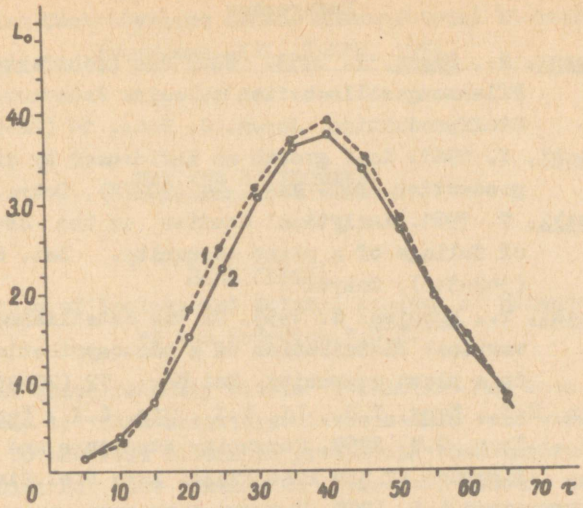

Fig.5. Course of the relative green leaf area L_o in a barley stand at Tartu in 1965. τ denotes days from emergence of plants. 1 - calculated curve, 2 - actual curve.

The mean values of h_m, u_m, K_1 and K_2 for three years (1964–1966) were used for the calculation. We may see that the calculated values of L_o are larger than the actual ones. This is due to the fact that the points on graphs 4a, 4b and 4c for the year 1965 are below the mean curves. The scatter of these points on the graphs demonstrates also the error of the calculation method, constituting about 10 to 15%.

Conclusion

We think that the calculation method of determining the leaf area index as well as the downward cumulative leaf area index can be applied not only to the barley crop but also to other cereals like wheat, rye and oats. However, this method as well the constancy of the characteristics τ_o, α_m, u_m^o, K_1^o and K_2 need to be tested experimentally.

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MAN AND ENVIRONMENT

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Until quite recently little attention has been paid in Estonia to the relations between man and environment and to the role of man in preserving the environment inhabitable. We have considered ourselves lucky as in our country there are still places which have remained nearly untouched by man, and there exist beautiful unspoilt scenery as well as an unpolluted environment. In our lectures and public speeches we have mentioned as a warning example the spoilt nature and the polluted environment of Western Europe and America, pointing out that fortunately these problems are still far away from us.

But the development of human society is making rapid progress in our country, too, due to the great advances in technology. What a few decades ago was considered to be a Utopia has become a reality nowadays. On our highways horses have almost completely been replaced by modern cars and lorries. In place of the navvies of the former days powerful excavators dig drainage systems in our marshes. Labour-consuming operations in construction, agriculture. (e.g. hay-making, harvesting, etc.) and in industry (e.g. oil-shale mining) have been mechanized. Urbanisation is going on at a rapid pace. In summer thousands of urban residents go into the country reaching the most distant localities. Summer cottages and rest-homes are mushrooming

up everywhere. Great changes in the relations between man and environment have taken place during the last few decades, the chief witness of which is the ever-growing utilisation of the surrounding nature by man.

At the present time (particularly during the very last decade) we are faced with the same problems as our colleagues in older civilized countries. We must learn from their sad experiences and save our landscape from the results which these countries have undergone.

First of all, let us deal with the objective factors which have started to influence the natural environment in conditions obtaining in Estonia. The existence of such factors has been caused by technological progress and economic development. Inevitable as these phenomena are, their harmful effects can be either alleviated or neutralized. This can be done in case scientists as well as economic and administrative bodies join their efforts to ensure the preservation of nature for the benefit of the present generation as well as for those to come.

The condition of atmospheric air in our Republic is in general considerably better than that in industrial countries with a greater population density. The pollution of air can be observed to a greater extent only locally--e.g. in the areas of the oil-shale industry and a few larger towns. It does not mean, however, that we should sit idle and not deal with the problem. Even a single incident which points to the deterioration of the circumstances should be sufficient for taking preventive measures. Smoke from factory funnels, dust arising from traffic and particularly the exhaust gases of motor vehicles are the concrete facts which should be in the centre of attention of everybody working in this field, scientists included. More attention should also be paid to applied research into these problems.

Noise is also among the phenomena that inevitably grow in connection with increasing industrialization

and the development of motor transport. Traffic noise has been investigated in Tallinn, but noise at industrial enterprises, in airfields and on trunk roads has not received the slightest attention. Noise made by portable transistor sets disturbs people in nature and places of recreation. We have managed to get rid of loudspeakers in public places, and now it is necessary to ensure that nature should not be polluted with sounds not belonging to it.

The preservation of the purity of water (including ground water) is a highly complicated problem. The Fundamentals of Water Legislation in the U.S.S.R. and Union Republics have already been worked out, and when the Water Code is enacted it will contribute to the elimination of a number of shortcomings. Pure water is one of the most expensive natural resources, but often only the countries lacking it can appreciate it properly. It is common knowledge that it has become a difficult problem to provide Tallinn with drinking-water of good quality, but also Tartu and a few other towns of Estonia will be facing similar difficulties in the near future. The shortage of pure water grows according as waste waters from local enterprises are directed into natural bodies of water. The purification of waste waters and their subsequent partial utilization constitute the most important tasks for our specialists in water economy. The problem has become so urgent owing to the wasteful utilization of water as well as due to the fact that enterprises have not been charged for the use of water.

Lately the Press has carried numerous articles on the expediency of the drainage of peat bogs and various marshy areas. Different points of view have been expressed: to preserve peat bogs as natural reservoirs, to drain them only partially, or to continue drainage at the present rate. Even such opinions have been expressed that the drainage of peat bogs does not noticeably change the balance in nature. Contrary to the optimistic views of

practical workers, ecologists are of the opinion that in our geographical zone and under our climatic conditions the peat bogs constitute an important factor for the normal existence of the environment and therefore they should be preserved. Peat bogs have been formed in the course of many millenniums and in nature it is impossible to reproduce or replace them by any other ecosystem.

The above-mentioned ideas can be applied to the practice of draining lakes which was thoughtlessly carried out in the past. In a number of cases it is necessary to raise the problem of damming up the lakes again (particularly the former mill-ponds). Contrary to peat bogs, it is possible to create new lakes, reservoirs and ponds with the help of modern technology.

Likewise, little consideration has been given to the dredging and straightening of rivers and to the creation of new reservoirs. Flowing waters in their natural form constitute a necessary factor in preserving the balance in nature, including the cases when the fishing industry has not been the chief cause for their existence and remaking. Therefore some reservoirs should be liquidated and the former river-beds and the former landscape of the river valley should be restored (e.g. the Ahja River between Kiidjärve and Taevaskoda).

Problems related to the preservation of the natural balance and purity of the Baltic Sea are still more complicated and many-sided. The Baltic Sea is an international water-body and its water-economic and biological resources are used by several countries. Though engineering-technological considerations are of great importance for the preservation and transformation of the Baltic Sea, biological aims are of decisive importance when deciding these problems. The chief tasks are to prevent the pollution of the Baltic Sea and to increase its biological productivity. The pollution of this inland sea with oil from ships is particularly dangerous. We are looking forward to the speedy ra-

tification of the international convention on the prevention of the pollution of seas (including the Baltic Sea).

The chief pollutants of the living landscape in Estonia are pesticides, some fertilisers, detergents, partly mercury compounds that get into nature from agriculture and communal enterprises. No large-scale pollutions have occurred in our country, but in certain localities the harmful influence of these substances has been observed. The chemical control of pests is going on, as up to the present time we havn't managed to replace it by anything else. The role of biological control is still insignificant. But we should like to point out that Estonian chemists have contributed to the prevention of the pollution of nature, since it was on their initiative that in 1970 a commission for nature conservation was set up within the framework of the Estonian Branch of the All-Union Mendeleyev Chemical Society.

As is known, populations of several species of insects become resistant to concentrations of pesticides. This makes it necessary either to increase the toxic concentration of a given pesticide or to introduce new control methods. As to the vertebrates, nothing certain can be said. Our previous experience has shown that higher animals are unable to raise their resistance to the increasing use of chemical toxicants and perish. Man, whose organism is being continually poisoned by pesticides, will face the same fate. The great adaptivity of man to the poisoned environment is not plausible and the only solution of the problem lies in preserving the environment pure. Therefore our urgent task is to improve the condition of the biosphere and not to set our hopes on the adaptability to toxicants.

It is also in Estonia that the towns and the urban population are growing and the process of urbanisation is under way. In our country it is also necessary to register, analyse and pay more attention to the hygienic conditions

of urban residents. Smoke, dust, noise, rapid development of city transport, etc., make it necessary to improve the organization of public services and amenities as well as to cover ever larger areas with verdure. Urban residents will be physically and mentally fit only on condition that they are in close contact with nature.

It is to be regretted that our people very modestly grow indoor plants while gardening is wide-spread at private and even state-owned houses. It is beyond doubt that these things enable urban residents to be in contact with nature. Co-operative gardening, which only recently has come into vogue, probably also serves this aim, though in many cases it is used to obtain extra food. New parks, avenues and verdant areas should be laid out on a larger scale and those existing already ought to be taken greater care of. The number of bodies of water in our towns is particularly scarce; no decorative water-fowl can be seen on our water-bodies. Local authorities should include these problems among their activities.

The removal of communal waste (rubbish, refuse) has become a serious problem in the last few years. For instance, the residents of Tartu daily produce over 40 tons of communal waste which is taken to the refuse dumps outside the town. Here scrap should be separated and the rest of organic matter should be composted, which would help to improve the environment as well as be of use for the municipal economy.

During the recent years much attention has been paid to the organization of recreation: the planning of places and areas of recreation, the setting up of rest-homes, pioneer and other camps, tourist campings, etc. The Finnish sauna has come into fashion, but it does not do much good as often parties held there are associated with the consumption of alcoholic drinks. Tourism and hiking have become very popular at week-ends, both private and communal means of transport being used for that purpose.

All the above-mentioned things involve great dangers for the environment. Urbanized people cannot properly appreciate nature as a place for recreation. Nature is becoming littered to a greater extent than before (even in nature reserves). Much should be done in the field of environmental conservation by using a system of fines and penalties as well as by re-educating people. Of special value in creating a proper attitude to the natural environment are organized group hikes and outings on bicycles and motor vehicles. Such undertakings should be guided by people knowing nature as well as the locality.

In this connection the general problems of landscape and environmental conservation come to the fore. It is high time to replace our present nature conservation law by a more up-to-date environmental conservation law, as it has been done in Sweden, the GDR and several other countries. The most beautiful landscapes of Estonia (the majority of them being landscape reserves) should be preserved and developed further taking into account the principles of modern landscape management. The shores of the bodies of water (seas and inland waters) need particular attention as thousands of unsuitable buildings, which have been erected there without any plan, should be removed. It is also necessary to limit improper advertising near the highways, at public meeting-places, in houses of assembly, etc.

At the present time the territorial planning of the Republic is taking place and it remains to be hoped that it will constribute to the goal-directed formation and preservation of Estonian landscape. A particularly labour-consuming task is the recultivation of the territory of exhausted quarries (e.g. in the oil-shale mining areas). The existence of old mines and quarries, oil-shale and ash tips, and various other artificial formations of several decades makes it difficult to solve current problems of environmental conservation. We need not only a clean

and healthy, but also a beautiful landscape which is as natural as possible and in harmony with the specific character of our geographical area. Our landscape reserves should serve as an example for such landscape and it is therefore necessary to prevent these reserves from becoming recreational areas and places for mass gatherings of people, such as popular festivals, sports competitions, etc.

Summing up what has been said above, we arrive at the conclusion that modern nature conservation in Estonia should primarily be biological and environmental conservation. Violation of the balance of our ecosystems, which took place in the past, should be compensated for at the present time so that the landscape that we bequeath to the future generations will be inhabitable. All this calls for scientific foresight and good planning as well as considerable economic expenditure coupled with a sensible attitude towards nature. Landscape ecology as a scientific and applied branch of biology should be given a worthy place also in our Republic by teaching it not only to biologists and geographers, but also to architects, engineers, cyberneticists, economists and lawyers.

The above-mentioned principles served as the basic ideas for the scientific conference "Man and Environment" devoted to the 150th anniversary of the birth of F. Engels held in Tallinn on November 26-27, 1970. The conference was organized by the department of chemical, geological and biological sciences of the Academy of Sciences of the Estonian S.S.R. Twenty papers were read and discussed at the conference by our leading chemists (O. Kirret, M. Gubergrits, E. Ilmoja, E. Ott, E. Siirde), biologists (T. Orav, R. Kumari, M. Margus, Ivar Veldre, O. Renno), geographers (E. Kildema, K. Laas, A. Miine), medical people (Ingeborg Veldre, G. Loogna, H. Lutsoja, E. Vagane) and specialists in applied sciences (E. Vint, R. Ratas, L. Volkov, A. Mäas). The papers dealt with a wide range of problems connected with the relations of man and environment in the Estonian

S.S.R. at the present time. It was decided to publish the abridged texts of the papers which would serve as our introductory contribution to the international research programme "Man and Biosphere" of 1972 and the subsequent years.

The conference adopted a detailed resolution, the essential items of which will be presented below.

It is suggested that the research institutes of the Academy of Sciences of the Estonian S.S.R. and various other research institutions should give particular importance to the problems of environmental conservation. At the same time it is necessary that specialists in biology and hygiene should take part in solving the problems aimed at the rational utilization and management of the resources of the environment. During their training specialists in technology have to be introduced to the problems of landscape ecology. The task facing the specialists in chemistry is to work out measures for the prevention of the pollution of the environment with chemical substances.

Tasks of environmental conservation ought to be introduced to the territorial planning of the Republic. The study of the processes of urbanization and such a formation of ecosystems of urban settlements which contributes to the improvement of the conditions of the biosphere are considered to be tppical tasks. The investigation of the oil-shale producing districts and of other industrial areas should be carried out by specialists employed for this purpose.

The problems of the conservation of internal waters must be solved as a complex; it is necessary to implement the water conservation law; the conditions of the Baltic Sea ecosystems should continually be in the centre of attention, particularly avoiding the pollution of its water with oil and waste products from industry.

The protection of man's health should also be based upon the environmental conservation for which purpose coope-

ration between naturalists, medical men and engineering scientists is needed.

Nature reserves serve as important stationary bases for the scientific study of natural resources and the environment and the plans of such activities should be co--ordinated with those of the research institutes of the Academy of Sciences of the Estonian S.S.R.

The resolution also contains an appeal to the research institutions of the Republic to deal with the theoretical problems of biological and environmental conservation as well as to employ internationally co-ordinated terminology in research and practical activities.

It was proposed to appeal to the governmental institutions to discuss at a high level the problems related to the struggle against the pollution of the environment and to other nature conservation problems.

Both scientists and practicians took a great interest in the conference on "Man and Environment". We hope that from this time on the problems connected with the rational use and conservation of the environment will be among the topics of study and discussion for Estonian scientists and that the results obtained will essentially contribute to the improvement of the conditions of our biosphere.

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PRELIMINARY CHARACTERIZATION OF ZOOPLANKTON IN LAKE VÕRTSJÄRV

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In connection with the investigations carried out in Lake Võrtsjärv within the framework of the International Biological Programme (IBP), it became necessary to survey all earlier data on zooplankton (littoral fauna included) in the lake and both qualitatively and quantitatively characterize the zooplankton of this eutrophic Estonian lake (total area - 270 sq. km., greatest depth - 6.0 m, average depth - 2.8 m) at the first stage of investigations. Simultaneously an attempt is made to elucidate the main regularities of the seasonal dynamics of zooplankton (mainly on the basis of the material dating from the years 1965 and 1966)and ascertain the dominants.

The earliest reliable data on the zooplankton of Lake Võrtsjärv have been published in the monograph by M. zur Mühlen and G. Schneider "Der See Wirzjerw in Livland"(1920). The samples made use of in the report were taken from the pelagic part of the lake in the years 1912-1913. The food of fish was also analyzed. The materials were chiefly treated by K.M. Levander, an outstanding Finnish specialist. The presence of 14 species and intraspecific taxonomic units of protozoans, 24 of Rotatoria, 8 of Copepoda and 21 of Cladocera among the zooplankton of L. Võrtsjärv is mentioned, similarities between the lakes of Võrtsjärv and Ülemiste as

regards their zooplankton are pointed out and Võrtsjärv is considered as a Chydorus-lake rich in food. The role of zooplankton in the food of the fish in L. Vortsjärv is also treated. Some data on the food of the fish of L. Võrtsjärv can also be found in G. Schneider's preliminary summary published earlier (Шнейдер 1911).

After a longer interval, in the years of 1952-1954, the zooplankton of L. Võrtsjärv was studied by N. Schönberg (Шенберг 1958, 1961), who indentified the occurrence of 63 species of zooplankers in L. Võrtsjärv and for the first time provided some quantitative data on zooplankton (numbers and biomass). She also studied how the fish of L. Võrtsjärv use zooplankton. A rather essential part of N. Schönberg's materials have unfortunately not been published.

Notes on the zooplankton of L. Võrtsjärv can also be found in a paper by A. Mäemets (Мяэметс 1966). There are several articles where the data collected by M. zur Mühlen, G. Schneider and N. Schönberg have been made use of (Taube 1924, Lepiksaar 1932, Микельсаар 1962).

Some material on the zooplankton of L. Võrtsjärv may also be found in some candidate's dissertations analyzing the food of the fish of L. Võrtsjarv (e.g. Haberman 1964). The same applies to a short summary published by the authors of the present paper in 1968 (Haberman, Mäemets 1968).

The present summary is mainly based on 152 quantitative samples of zooplankton taken from the open-water region of L. Võrtsjärv by J. Haberman in 1965 and 1966 and treated by herself. In addition, data on 14 pelagic and littoral samples analyzed by A. Mäemets in 1954-1966 have been used.

In 1965 and 1966 samples were taken at 6 open-water sampling spots (Fig. 1), 12 times at sampling spot 6, 8-11 times a year at the rest of them. Samples were taken by means of a small quantitative closable Juday plankton net (silk No. 49), with an orifice of 100 sq. cm. Depending on the depth of the water at the respective sampling spot, a layer of water 1 to 3 metres thick was filtered by means of

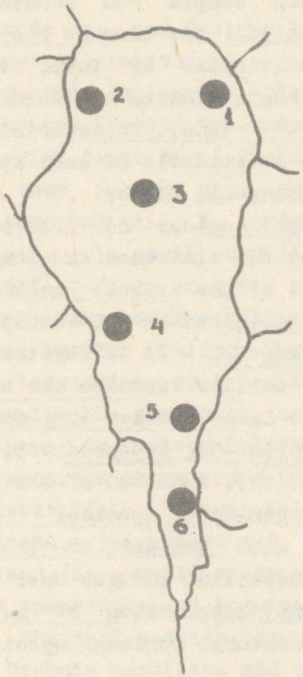

Fig. 1. Distribution of sampling spots in the pelagic zone of L. Võrtsjärv.

the net, moving the net vertically upwards. At deeper sampling spots (Nos.5 and 6) samples were taken from two layers: 3 to 0 m and 5 (4) to 3 m thick. 50-litre scooped samples were collected from the littoral zone (straining the water by means of a 5-litre bucket through the plankton net). A standard counting method was applied, using 2.5 ml portion pipettes and the Bogorov chamber (see Киселев 1956). As a rule, 1/10 of each sample was counted, in winter whole samples were counted. The biomass was found by multiplying the number of individuals by their average weight; the weights of zooplankters given by Mordukhai-Boltovski were mainly used (Киселев 1956). To ascertain the average length of a species, 20 individuals of each species were measured on the average during all months.

The temperature, colour and transparency of the water were determined at the time when the samples were taken.

In the course of the present work 103 species of zooplankters were established in L. Võrtsjärv (Rotatoria - 45, Copepoda - 15, Cladocera - 43). Together with the species identified by the earlier authors the number of the species established in the lake reaches 109, together with protozoans 124 (Rotatoria -50, Copepoda -15, Cladocera -44; see the survey of species). About 40 of the identified zooplankters are typical open-water species.

A comparison with the data on the years 1912 - 1913 reveals that no essential changes have taken place in the composition of the zooplankton of L. Võrtsjärv over the period of half a century. Dominant species are also essentially the same.

The zooplankton of L. Võrtsjärv in summer is characterized by the open-water complex of Daphnia cucullata-Bosmina coregoni-Chydorus sphaericus, which is typical of the Estonian eutrophic lakes (Мяэметс 1961). Some forms preferring oligotrophic water (they obviously occur in L. Võrtsjärv as relicts), like Ploesoma hudsoni, Conochilus unicornis, Bosmina obtusirostris, Drepanothrix dentata, etc., can also be

found in the lake, although their role is rather small and they usually do not belong to dominant species. The occurrence of certain species of the Cladocera (Bosmina berolinensis and Bythotrephes longimanus) points to good oxygen conditions in L. Vôrtsjärv in summer. In the open-water region of L. Vôrtsjärv, littoral zone species can often be met with.

In January Synchaeta sp. and Cyclops kolensis predominated in the open-water zooplankton of L. Vôrtsjärv. The nauplii of Copepoda and Asplanchna priodonta were also rather numerous. In February Cyclops kolensis (especially in 1965) and nauplii occupied first place. In March Eudiaptomus gracilis was added to them, in 1965 also Synchaeta sp. and Keratella hiemalis together with K. quadrata (these species were counted together). In April nauplii, Synchaeta sp., Keratella hiemalis and K. quadrata occurred as dominant species. In the April of 1966 the rotifer Kellicottia longispina was rather numerous, too. The rotifers Keratella cochlearis and Kellicottia longispina predominated in May while Keratella quadrata, Asplanchna priodonta, species of Polyarthra, nauplii and copepodids, Cyclops kolensis and Bosmina coregoni may also be regarded as numerous. In June the domination of rotifers (Keratella cochlearis, Kellicottia longispina, Keratella quadrata, Polyarthra and to some extent Conochilus unicornis) and the nauplii of copepoda continued. Cladocerans Chydorus sphaericus and Bosmina coregoni were added to them as new dominant species. Remarkably abundant were the cladoceran Daphnia cucullata and the copepod Eudiaptomus gracilis. In July Chydorus sphaericus and the nauplii of copepods still retained first place. Daphnia cucullata, juvenile copepods, Bosmina coregoni (1965) and Filinia limnetica (1966) were numerous. As regards the dominant species, August was similar to July. In September the cladocerans Chydorus sphaericus and Bosmina coregoni, nauplii and copepodids, and in 1965 also Asplanchna priodonta occurred most frequently. In October Chydorus sphaericus and

Bosmina coregoni predominated in the zooplankton of L. Võrtsjärv, the nauplii of copepods and Eudiaptomus gracilis were numerous. In 1965 species of Asplanchna and Polyarthra were also numerous. In November Asplanchna priodonta (1965), Chydorus sphaericus, Bosmina coregoni, Eudiaptomus gracilis and nauplii took the first place among the dominant species. In December Synchaeta sp. predominated while Eudiaptomus gracilis, nauplii and Asplanchna priodonta (1965) were numerous .

Figs. 2 and 3 provide a survey of the dynamics of the numbers and biomass of the open-water zooplankton of L. Võrtsjärv.

The average monthly number of zooplankton ranged from 3,600 to 612,000 individuals per cubic metre during the years of observation. The average monthly biomass in L. Võrtsjärv fluctuated between 0.024 and 2.629 g per cubic metre. Minimum average numbers of zooplankton occurred in the March (14,900 ind./m^3) and December (13,300 ind./m^3) of 1965 and in the March of 1966 (3,600 ind./m^3). Maximum average numbers occurred in the June (401,550 ind./m^3) and August (314,100 ind./m^3) of 1965 and in the May of 1966 (612,000ind./m^3). The last-named figure was mainly due to the large numbers of rotifers (520,600 ind./m^3), which constituted 85.1 % of the total number of zooplankton.

Fluctuations in the biomass were considerable (Fig. 3). The minimum biomass occurred in the February (0.083 g/m^3) and December (0.098 g/m^3) of 1965 and in the March of 1966 (0.024 g/m^3). The maximum biomass was observed in the July (1.441 g/m^3) and August (1.348 g/m^3) of 1965 and in the May of 1966 (2.629 g/m^3). In the last case the large number was due to the high amount of rotifers (first of all Asplanchna priodonta), which accounted for 74.5 % of the total mass of zooplankton.

In general, at certain periods, the role of rotifers in the numbers and biomass of the zooplankton of L. Võrtsjärv, in contradistinction to N. Schönberg's assumption (Шенберг 1958), seems to be rather large. As regards their numbers,

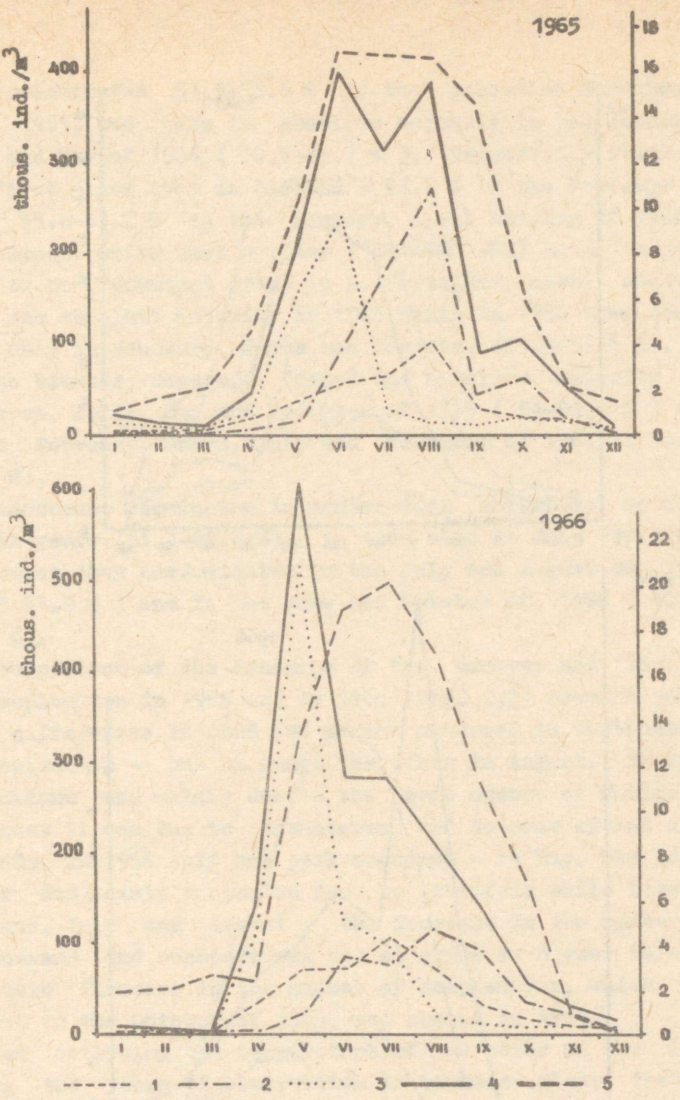

Fig. 2. Seasonal dynamics of the numbers of pelagic zooplankton in L. Võrtsjärv in 1965 and 1966. 1 - Copepoda, 2 - Cladocera, 3 - Rotatoria, 4 - zooplankton (all groups), 5 - average diurnal temperature.

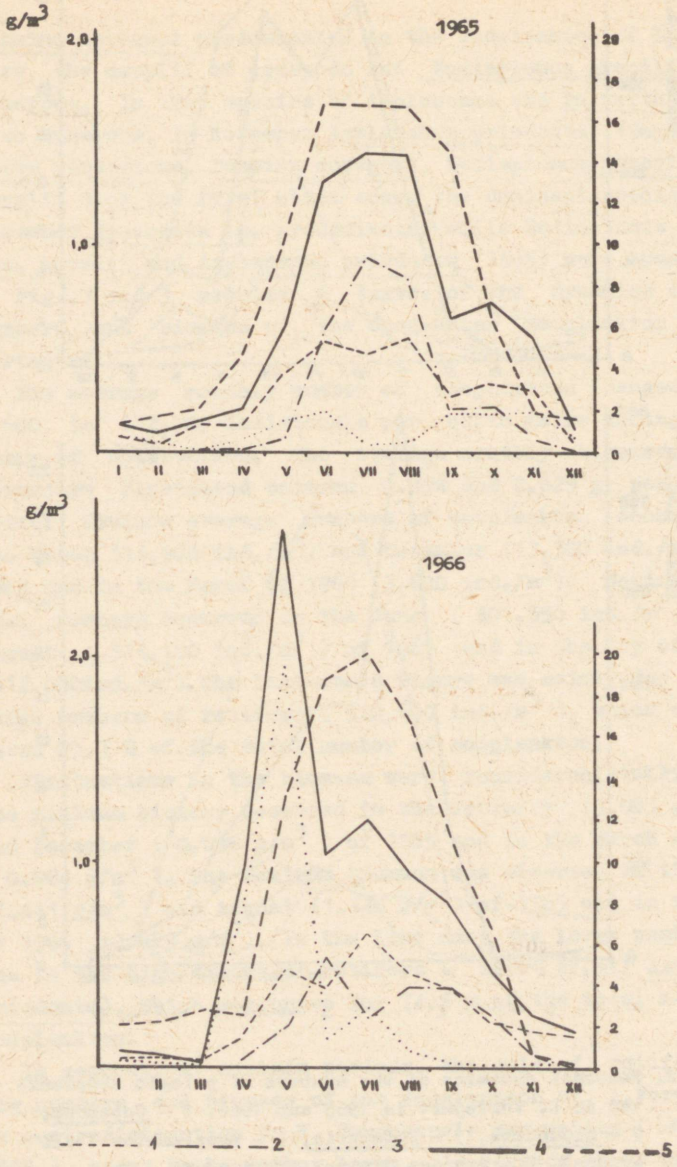

Fig. 3. Seasonal dynamics of the biomass of pelagic zooplankton in L. Võrtsjärv in 1965 and 1966. 1 - Copepoda, 2 - Cladocera, 3 - Rotatoria, 4 - zooplankton (all groups), 5 - average diurnal temperature.

they constituted 51.3-73.6 % in the period of January to June, 1965, and were in absolute majority in the January, April and May of 1966 (70.7-85.1 %). Temporarily rotifers took first place even in biomass (54.2 % in the February of 1965, 55.6-81.7 % in the January, April and May of 1966).

Copepods, which have earlier (Шенберг 1958) been considered to be a dominant group in L. Võrtsjärv, never constituted the absolute majority in 1965 while in 1966 they dominated only in February, March and December (51.3-58.6 %). As for the biomass, copepods formed the absolute majority in the March, April, May and November of 1965 (54-90.1 %) and in the February, March, July and November of 1966 (54.3--87.5 %).

Cladocerans dominated in number from August to October in both years (51.4-69.4 %), in 1965 also in July (58.5 %). In biomass they predominated in the July and August of 1965 (58.5-64.9 %) and in the June and October of 1966 (50.8--54.2 %).

A comparison of the dynamics of the numbers and biomass of zooplankton in 1965 and in 1966 (Fig. 2,3) reveals rather great differences.In 1965 two maxima occurred in the numbers of zooplankton - one in June, the other in August. In June the maximum was mainly due to the large number of rotifers, in August it was due to cladocerans and to some extent also copepods. In 1966 only one peak occurred - in May. The large number was mainly accounted for by rotifers while later - in June, July and August - the increase in the number of cladocerans and copepods was not so great as a year before. A certain increase in the number of zooplankton, which was present in the October of 1965, was absent in 1966.

When analyzing the temperature of the water in the lake during the years of observation it becomes clear that in 1966 the warming of the water proceeded much quicker than in 1965 and the temperature of the water in May 1966 was noticeably higher than that in May 1965. The rise in the temperature of the water in 1966 went on till July when the aver-

age diurnal temperature reached 20.1° C. In 1965 the temperature in July and August remained on the same level as in June. It seems that the quick warming of the water in the spring of 1966 promoted the rapid reproduction of rotifers while a high temperature in the summer of the same year restrained the increase of the number of cladocerans (this applies above all to Bosmina coregoni and Chydorus sphaericus).

The cooling of the water in the lake and a decrease in the number of zooplankton in 1966 occurred at a higher rate than in 1965. In the summer and autumn of 1965 the water-level in L. Võrtsjärv was noticeably lower than during the corresponding periods in 1966 - a fact which could also favour the reproduction of cladocerans, as it increased the amount of their food (bacteria, algae and detritus) in the water. In favour of our assumption is also the fact that the transparency of the water in 1965 was, as a rule, smaller than in 1966 (Fig. 4).

The dynamics of the biomass of zooplankton was rather similar to that of their numbers. The main difference lay in the occurrence of one maximum of the biomass, which corresponded to the higher numbers in July and August, while the maximum number occurring in the general dynamics of biomass in June was not noticeable because of the small biomass of rotifers.

When analysing the number of zooplankton (in the whole water layer) in different areas of the open-water region of the lake, it may be stated that it was rather similar in both years (Fig. 5). In 1965 it was somewhat higher at the northern sampling spots of the lake (1-4) where the average monthly number of zooplankters during the year was 140,000 ind./m^3 while the corresponding figure for the southern spots (5 and 6) ranged between 103,000- 121,000 ind./m^3 . In the winter months of 1965 there was more zooplankton at the northern sampling spots than at spots 5 and 6. A comparison between the upper layer (3-0 m) of spots 5 and 6 on the

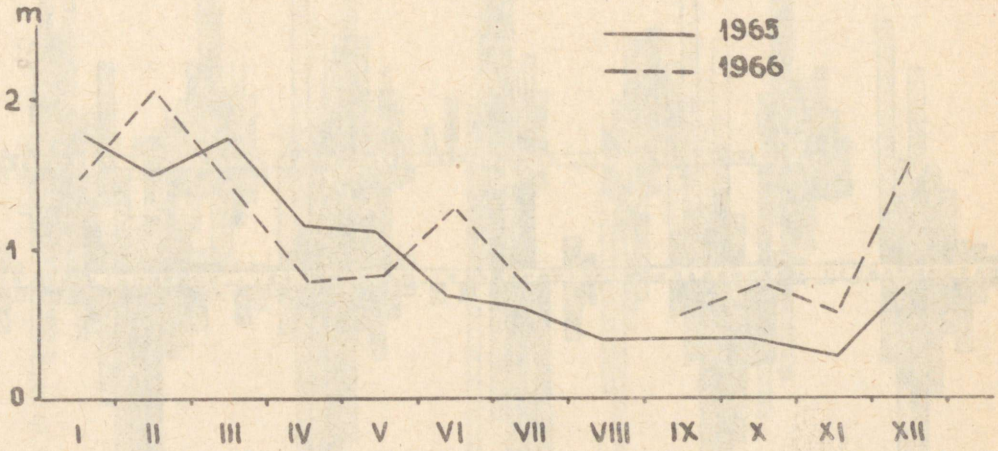

Fig. 4. Water transparency in L. Võrtsjärv in 1965 and 1966 (Secchi disc).

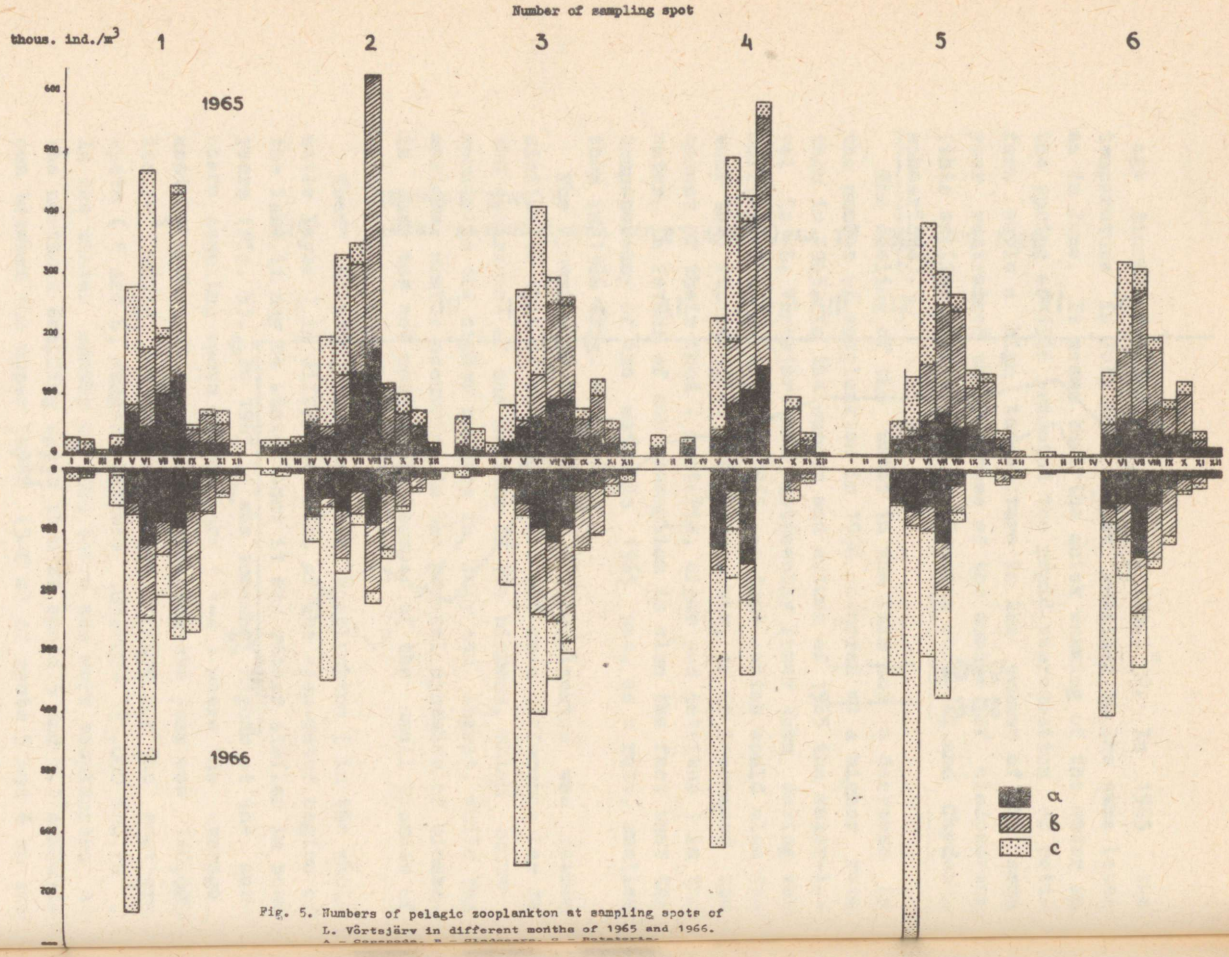

Fig. 5. Numbers of pelagic zooplankton at sampling spots of L. Võrtsjärv in different months of 1965 and 1966.
A – Copepoda, B – Cladocera, C – Rotatoria

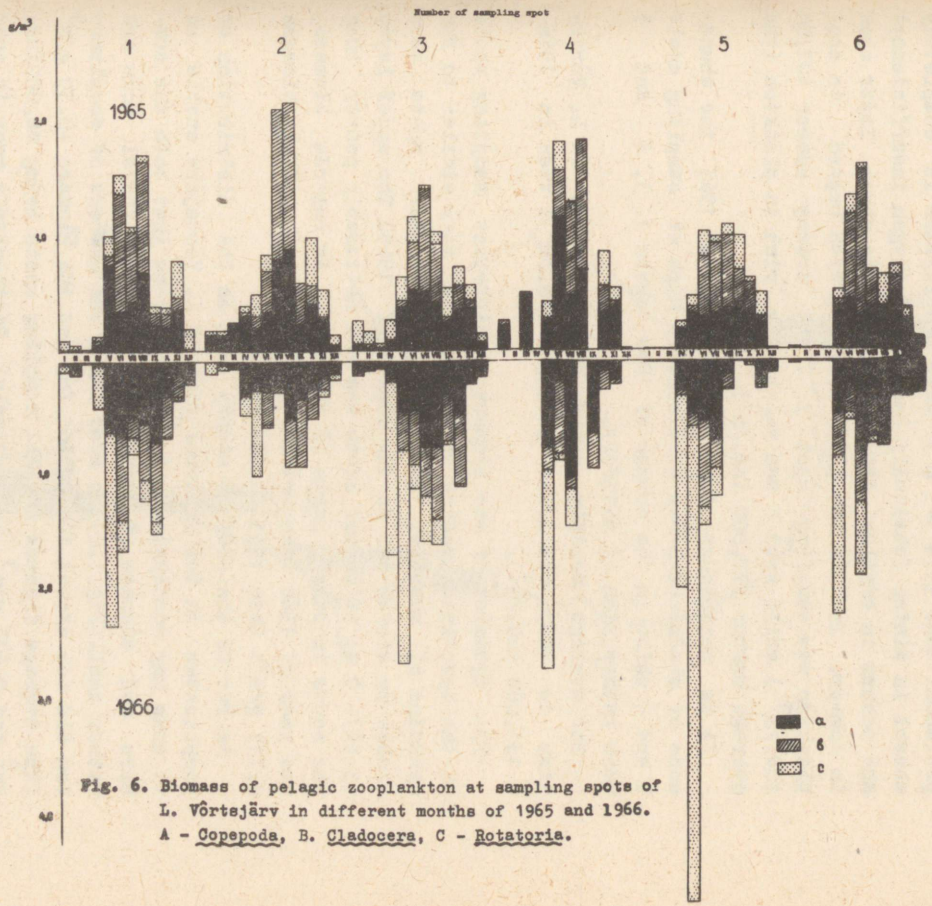

Fig. 6. Biomass of pelagic zooplankton at sampling spots of L. Võrtsjärv in different months of 1965 and 1966. A - Copepoda, B. Cladocera, C - Rotatoria.

one hand, and the upper layer (3(2)-0 m) of the northern sampling spots reveals no essential differences between them. The relatively small numbers of zooplankton at the southern spots are mainly due to the greater depth of the profundal zone (5(4)-3 m) where zooplankton is completely absent in winter (obviously because of oxygen insufficiency) and occurs in smaller amounts than in the upper layer even in summer. In 1966 the poorest of all with regard to zooplankton was sampling spot 2 (the average number 102,00 ind./m^3) while spot 5 was relatively rich in plankton (the average number 172,000 ind./m^3).

It is conspicuous that in the summer of 1965 the abundance of cladocerans was particularly high at sampling spots 2 and 4 while in the summer of 1966 spots 1, 3, 4 and 5 were rather rich in rotifers.

The average monthly number of zooplankton in L. Võrtsjärv in 1965 was lower (134,00 ind./m^3) than in 1966 (151,000 ind./m^3).

The dynamics of the biomass at different sampling spots of the open-water region of the lake is very similar to the dynamics of numbers. Here, also, the northern spots were richer in winter and in the summer of 1965. The upper layer (3 (2)- 0 m) of deeper spots was not noticeably poorer than the spots in other parts of the lake. As regards biomass, the year of 1966 was richer (the average monthly biomass 0.717 g/m^3) than 1965 (0.594 g/m^3).

As far as the present scanty data on the distribution of zooplankton in the littoral zone of L. Võrtsjärv enable us to draw any conclusions at all, it seems that both the numbers and biomass of zooplankton in the littoral zone are rather small(Fig.7,8).In most cases the numbers of zooplankton did not exceed 100,000ind./m^3 and the biomass -0.30 g/m^3 (the average figures for all sampling spots being 86,000ind. /m^3 and 0.675 g/m^3 respectively). Particularly poor in zooplankton were Phragmites and Scirpus bushes near the eastern and western coast of the lake which are open to undulation

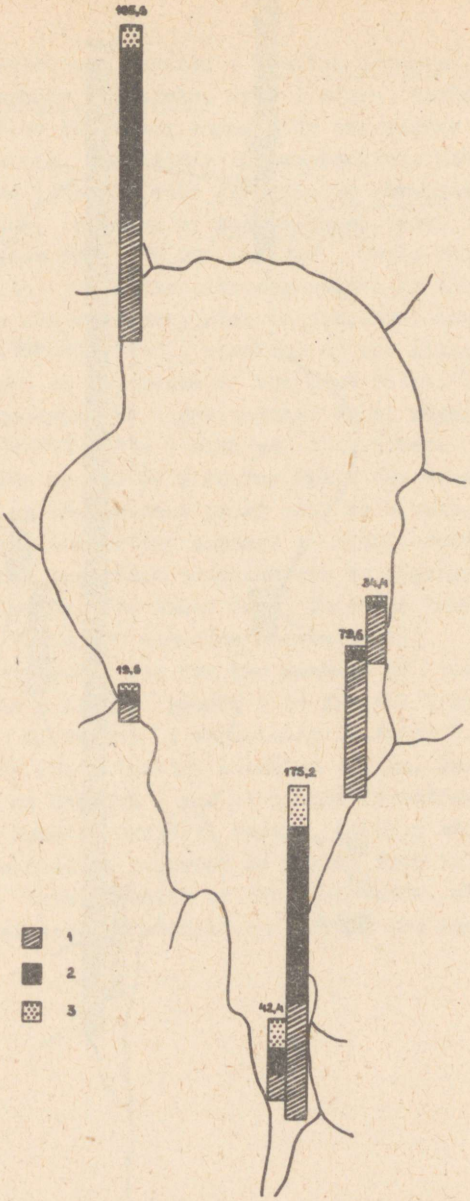

Fig. 7. Numbers (thous. ind./m^3) of littoral zooplankton at different sampling spots of L. Võrtsjärv in August-September, 1966. 1 - Cladocera, 2 - Copepoda, 3 - Rotetoria.

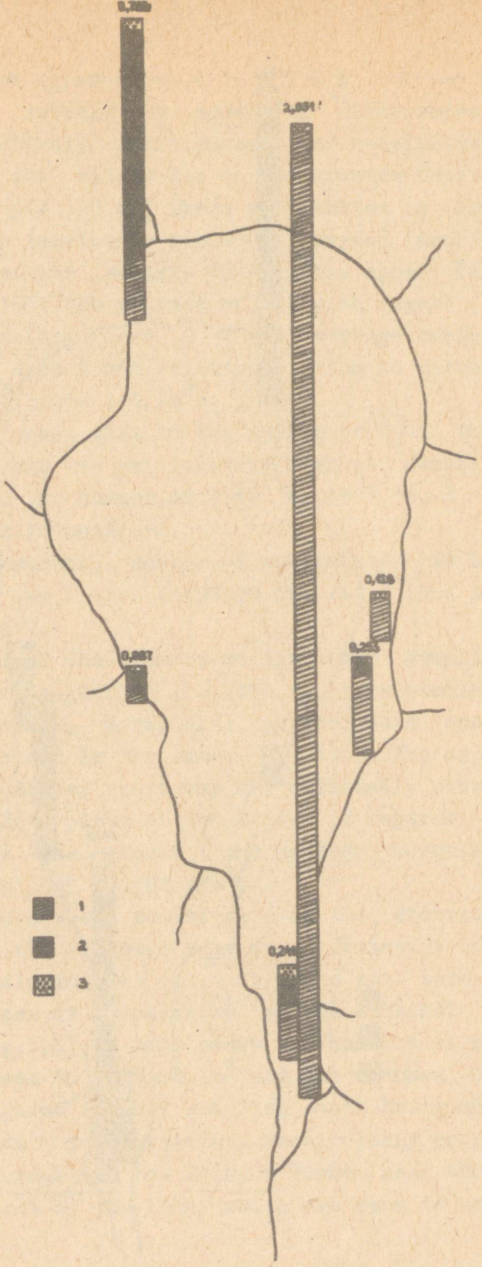

Fig. 8. Biomass (g/m^3) of littoral zooplankton at different sampling spots of L. Võrtsjärv in August-September, 1966. 1 - Cladocera, 2 - Copepoda, 3 - Rotatoria.

and where open-water species (Bosmina coregoni, Chydorus sphaericus, Daphnia cucullata, etc.) often dominate. The southern part of the lake, especially the region eastward of Pähksaar Island, was richer in zooplankton. Several large forms of the littoral zone (Eurycercus lamellatus, Simocephalus vetulus, species of Macrocyclops, etc.) occurred and their number was 175.200 ind./m^3 , while the biomass constituted 2.551 g/m^3. The littoral region to the north of Valma was also comparatively rich in plankton. According to N. Schönberg (Шенберг 1958), plankton of the littoral zone is more abundant at the mouth of the Õhne river.

If one compares the quantitative data reported by N. Schönberg (Шенберг 1958) with our data ,there is wide agreement on the number of plankton while the values of the biomass given in the present paper are, as a rule, greater.

Comparing the summertime numbers of cladocerans and copepods (the most important zooplankters as regards the biomass) of L. Võrtsjärv to those of 77 Estonian lakes, we may infer that L. Võrtsjärv occupies approximately 12th-13th place in this respect. As for the numbers of zooplankton, L. Võrtsjärv is a little poorer (as for the biomass, much poorer) than L. Peipsi (especially L. Pskov), several other eutrophic lakes (Harku, Jõemõisa - Kaiu, Juusa, Kodijärv, Eesjärv at Neeruti) and even some dyseutrophic lakes (Suurjärv at Puhatu, Udujärv, Kautla, Kahala, etc.).Still L. Võrtsjärv should be regarded as a lake rich in zooplankton where the total number of the open-water cladocerans and copepods exceeds 100.000ind./m^3 during the whole summer.

Systematic Survey of Zooplankters in Lake Võrtsjärv

Rotatoria

1. Brachionus angularis Gosse. An open-water and pelagic form. In L. Võrtsjärv it occurred in small numbers in January. Elsewhere, for instance in L. Ülemiste (Schneider 1908), the species is characteristic of the plankton in summertime.
2. Brachionus quadridentatus Hermann. Both an open-water and littoral form. Its occurrence in L. Võrtsjärv (in July) under the synonym Brachionus bakeri O.F.M. is mentioned by K.M. Levander (Mühlen, Schneider 1920).
3. Platyias quadricornis (Ehrenberg). A littoral form . Found in small numbers in the southern corner of L. Võrtsjärv among Scirpus lacustris (Aug. 30, 1966).
4. Keratella cochlearis (Gosse). An open-water form, a very common species. One of the dominant species of L. Võrtsjärv, occurring the whole year round and attain the maximum number at the end of May and at the beginning of June (in some sampling spots exceeding 200,000 ind./m^3). - Cf. Fig. 9.
5. Keratella quadrata (Müller). An open-water form, a very common species. In L. Vortsjarv it could be found throughout the year, attaining its maximum in May.
6. Keratella hiemalis Carlin. An open-water form. A stenotherm thermophobe species (Peiler 1957). In L. Võrtsjärv it occurred from February to June.
7. Notholca squamula (Müller). An open-water form. A stenotherm thermophobe species (Pejler 1957). Occurred in L. Võrtsjärv in small numbers from March till May and in December (at a temperature of the water from 1.5 to 14.6°).
8. Notholca striata (Müller). A thermophobe open-water form. In L. Võrtsjärv it occurred in small numbers from

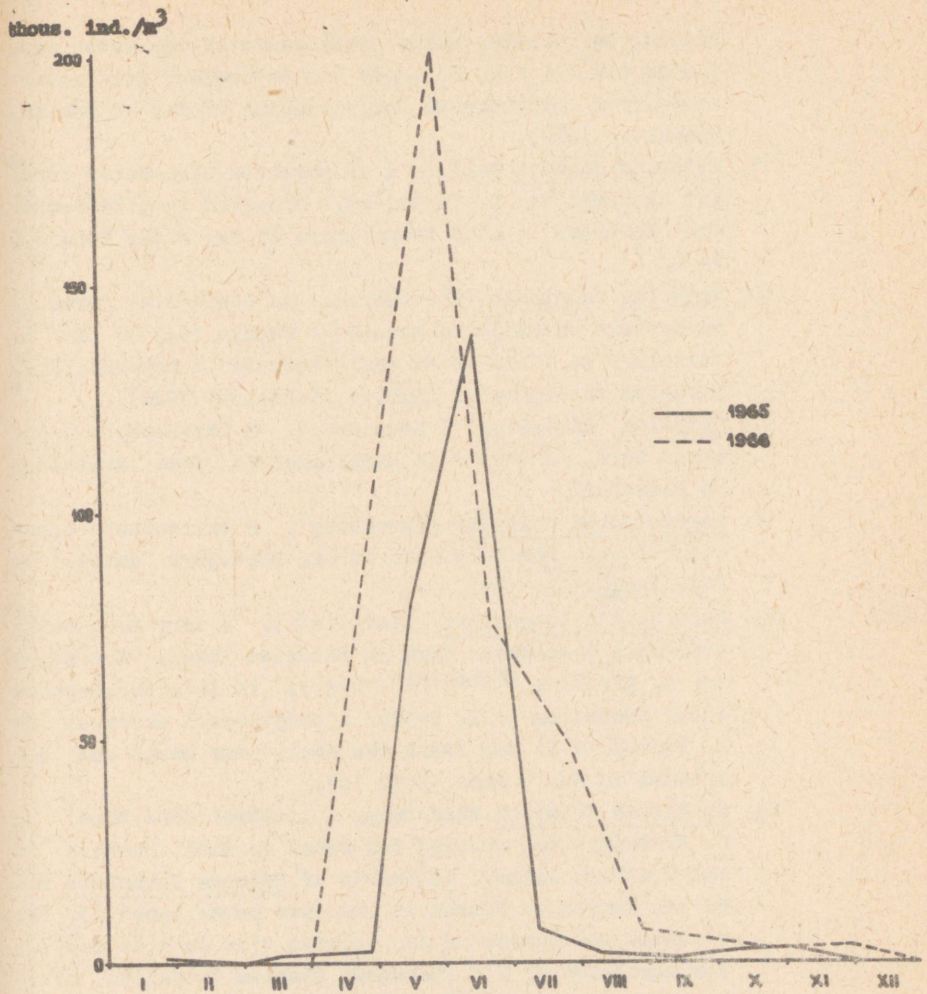

Fig. 9. Seasonal dynamics of the numbers of Keratella cochlearis in L. Võrtsjärv in 1965 and 1966.

October to December (at a temperature of the water from 1.0 to 8.6°). K.M. Levander has determined its occurrence from February to the beginning of May (Mühlen, Schneider 1920).

9. Notholca caudata Carlin. A thermophobe open-water form. Not abundant in L. Võrtsjärv. Occurred from September till November (at a temperature of the water from 5.0 to 9.6°).
10. Notholca acuminata (Ehrenberg). An open-water form. A stenotherm thermophobe species (Carlin 1943). In L. Võrtsjärv we found it in small amounts in October, K.M. Levander in September (Mühlen, Schneider 1920).
11. Notholca limnetica (Levander). A thermophobe open-water form. Occurred in small numbers from September to December.
12. Argonotholca foliacea (Ehrenberg). A thermophobe open-water form. The only find in L. Võrtsjärv dates from June (June 16, 1965).
13. Kellicottia longispina (Kellicott). A very frequently occurring open-water form in Estonian lakes. According to L. Kutikova (Кутикова 1962), it is a thermophobe form, according to B. Pejler a eurythermal species. In L. Võrtsjärv it was found the whole year round and dominated in May - June (Fig. 10).
14. Euchlanis dilatata Ehrenberg. A litteral zone form. In L. Võrtsjärv the species was found in small numbers in the southern corner, in bushes of Scirpus lacustris and in the region of Jõesuu in the open water (spot 1). The frequent occurrence of the species from June to September mentioned by K.M. Levander (Mühlen,Schneider) obviously applies to E. lucksiana, which is considered to be a separate species in the present paper.
15. Euchlanis parva Rousselet. A litteral zone form. Rather numerous in the vegetation of the southern part of the lake.It also occurred in the open water in the vicinity of the eastuary of the Rõngu river.

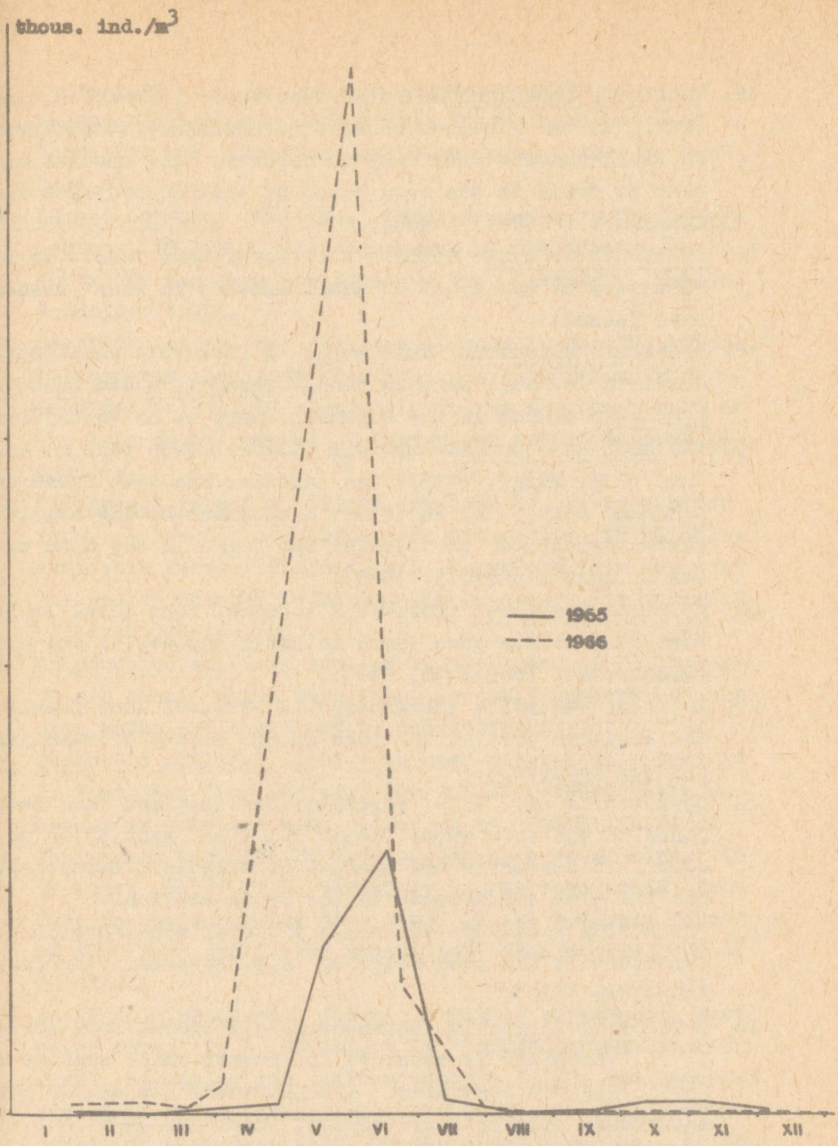

Fig. 10. Seasonal dynamics of the numbers of Kelliocottia longispina in L. Võrtsjärv in 1965 and 1966.

16. Euchlanis lucksiana Hauer. An open water form which also occurs in the littoral zone. In L. Võrtsjärv it occurred in small numbers from July to October. The species can also be found in the open water of the lakes Pskow and Lämmijärv (Мяэметс 1966).
17. Euchlanis deflexa Gosse. A littoral zone form. In L. Võrtsjärv it was found in small amounts in reed bushes near Vehendi.
18. Euchlanis triquetra Ehrenberg. A littoral zone form. Occurred in small numbers among Phragmites and Scirpus lacustris bushes in the southern part of L. Võrtsjärv.
19. (?) Euchlanis proxima Myers. A littoral zone form. According to M. Voigt (1957) the species has been found in Sphagnum only. In L. Võrtsjärv a specimen having similar characteristics of the species was found in the open water at spot 4 (Oct. 5, 1965).
20. Mytilina mucronata (Müller). A littoral zone form. In L. Võrtsjärv it has been found in small numbers in the profundal zone. (Sept. 30, 1966).
21. Mytilina ventralis (Ehrenberg). A littoral zone form. In the southern part of the lake among bushes of reed and Scirpus lacustris.
22. Lophocharis sp. In L. Võrtsjärv one specimen has been found in the open water (Sept. 30, 1966, spot 5). In general, it resembled the species L. salpina (Ehrenberg) but had some differences in the cross-section.
23. Trichotria pocillum (Müller). A littoral zone form. In L. Võrtsjärv it has been found by K.M. Levander (Mühlen, Schneider 1920).
24. Trichotria tetractis (Ehrenberg). A littoral zone form. In L. Võrtsjärv it occurred in rather small amounts in April, May and September. K.M. Levander has stated its occurrence also in July (Mühlen, Schneider 1920).
25. Lecane luna (Müller). More frequent in the littoral zone than in the open water. In L. Võrtsjärv it occurred in the open water in July-August, attaining a maximum of

up to 5,000 ind./m^3 at some sampling spots.

26. Lecane closterocera (Schmarda). In the open water of L. Võrtsjärv one specimen has been found (Aug. 9, 1965, spot 4).

27. Lecane cornuta (Müller). Under the synonym Monostyla cornuta (O.F.M.), the occurrence of the species in L. Võrtsjärv has been mentioned by K.M. Levander (Mühlen, Schneider 1920).

28. Cephalodella sp. One specimen at spot 1 (May 30, 1965).

29. Trichocerca longiseta (Schrank). A littoral zone form. Occurred relatively abundantly in the southern part of the lake among bushes of Phragmites and of Scirpus lacustris.

30. Trichocera capucina (Wierz. et Zach.). An open-water form. A species occurring very frequently in Estonian eutrophic lakes, recorded in L. Võrtsjärv from May till the end of October (a maximum in June-July, it numbered up to 10,000 ind./m^3).

31. Trichocerca sp. Here some small specimens of Trichocerca are meant which were found in small numbers in the open water and could not be indentified.

32. Gastropus stylifer Imhof. An open-water form. Found in L. Võrtsjärv from May till the end of October, more numerous in June (in some places up to 10,000 ind./m^3).

33. Asplanchna herricki De Guerne. An open-water form. In the open water of L. Võrtsjärv it has been found from June to September but also found in the southern corner of the lake and in the vegetation zone of the Bay of Tarvastu.

34. Asplanchna priodonta Gosse. A rather eurythermal open-water form. In L. Võrtsjärv it occurs the whole year round, attaining its maximum numbers in May and October.

35. Synchaeta sp. A thermophobe open water form.The species could not be indentified in the fixed material. It is possible that there are some species of Synchaeta. It was found in L. Võrtsjärv the whole year round except

for July and August. The greatest abundance was observed in December-January and in March-April when the species was dominant.

36. Ploesoma (Bipalpus) hudsoni (Imhof.). An open-water form. In L. Võrtsjärv it occurs from the end of April to the end of October and attains its largest numbers in May and July. According to B. Pejler (1957, 1964), it prefers oligotrophic lakes.

37-43. Polyarthra Ehrenberg. According to the new classification (see Кутикова 1962), the genus is rather rich in species but not all of them could be identified in the fixed material. Therefore no exact survey of all the species occurring in L. Võrtsjärv is available. We managed to indentify the following species: Polyarthra dolichoptera Idelson, P. vulgaris Carlin, P. dissimulans Nipkow, P. luminosa Kutikova, P. minor Voigt and P. remata Skorikov. At least one species remained unidentified. They are open-water forms whose largest numbers occurred at the end of May, in June and July, but which in small numbers could be found the whole year round.

44. Testudinella patina (Hermann). Mainly a littoral zone form. Frequent in Estonian lakes. In L. Võrtsjärv found only among bushes of Phragmites and Scirpus lacustris of the southern part of the lake.

45. Pompholyx sulcata Hudson. An open water form. In Estonia it is characteristic of eutrophic lakes. According to B. Pejler (1957a), this species is an indicator of the eutrophy of a lake. K.M. Levander (Mühlen, Schneider 1920) found the species in L. Võrtsjärv in March. Later the species has not been found in L. Võrtsjärv.

46. Filinia terminalis (Plate). An open water form. In L. Võrtsjärv it occurred in the cold season ; it was found from January to May and in October, in one case in July. The abundance of the species was highest in April and May (up to 9,500 ind./m^3). According to B. Pejler (1957, 1957a), the species is more or less a stenothermal ther-

mophobe form.

47. Filinia longiseta (Ehrenberg). An open water form. According to B. Pejler (1957a), it occurs only in the warm water. K.M. Levander (Mühlen, Schneider) mentions the occurrence of the species in L. Võrtsjärv in the June, August and October of 1912, in 1913 also in April and September. The occurrence of the species in L. Võrtsjärv is still doubtful since the earlier authors did not distinguish between F. longiseta, F. terminalis and F. limnetica.

48. Filinia limnetica Zacharias. An open-water form. Rather frequent in Estonian lakes. In L. Võrtsjärv it occurred from May to November and attained the largest numbers in the period of June to August (the maximum being up to 30,500 ind./m^3).

49. Floscularia sp. K.M. Levander mentions the limited occurrence of the species in June, July and October (Mühlen, Schneider 1920).

50. Conochilus unicornis Rousselet. An open-water form. Very common in Estonian lakes. According to B. Pejler (1957a), it prefers oligotrophic lakes. In L. Võrtsjärv the species was found from February to August and in November (the maximum number in June, at spot 3 - 43,300 ind./m^3).

Copepoda

51. Eudiaptomus gracilis (Sars). An open-water form. A very common eurythermal species in Estonian lakes (Mäemets, 1959). In L. Võrtsjärv it occurs all the year round, attaining the largest numbers in June - see Fig. 11 (in some years it was found to be more numerous in July - see Шенберг 1961). Sexually mature females and males also occurred all the year round while females were somewhat more numerous in October and November, males in June. The number of juveniles was largest from June to September. The maximum number of E. gracilis in L. Võrts-

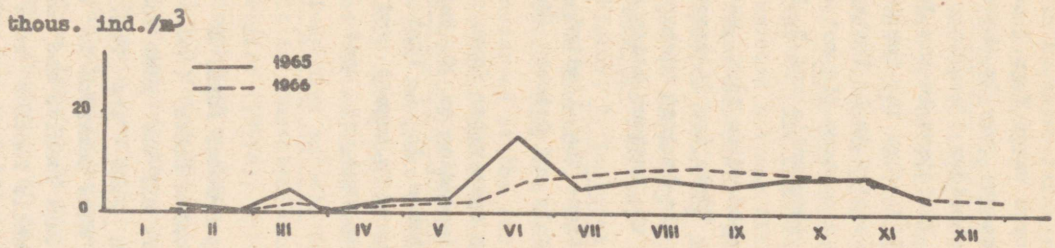

Fig. 11. Seasonal dynamics of the numbers of Eudiaptomus gracilis in L. Võrtsjärv in 1965 and 1966.

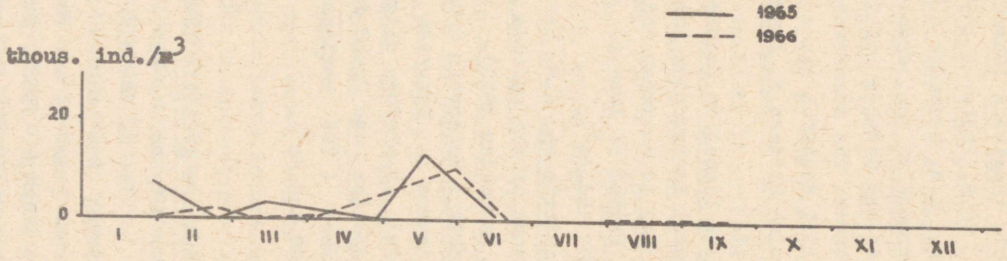

Fig. 12. Seasonal dynamics of the numbers of Cyclops kolensis in L. Võrtsjärv in 1965 and 1966.

järv was attained 15,000 ind./m^3, but as regards the biomass its role was much higher (0.735 g/m^3). According to N. Schönberg (Шенберг 1961), the species is to be found in ice-free regions in winter.

52. Macrocyclops fuscus (Jurine). A littoral zone form. In L. Võrtsjärv it was found in small numbers in the southern corner of the lake, among bushes of Phragmites and Scirpus lacustris.

53. Macrocyclops albidus (Jurine). A littoral zone form. A very common species in Estonian lakes. In L. Võrtsjärv it was found in the southern corner of the lake, in bushes of Phragmites and Scirpus lacustris, also at the mouth of the Nigula rivulet.

54. Eucyclops serrulatus (Fischer). A littoral zone form. Very common in Estonian lakes, in L. Võrtsjärv but a few specimens have been found in the open water in March and May.

55. Eucyclops macruroides (Lilljeborg). A littoral zone form. In L. Võrtsjärv found in small amounts in the southern corner of the lake, in bushes of Scirpus lacustris and at the mouth of the Nigula rivulet.

56. Eucyclops macrurus (Sars). A very common littoral zone form. In L. Võrtsjärv it occurred in the southern corner of the lake, among bushes of Phragmites and Scirpus lacustris.

57. Paracyclops fimbriatus (Fischer). A benthic form. In L. Võrtsjärv one find in the open water (Sept. 30, 1966 , spot 2).

58. Cyclops kolensis Lilljeborg. A thermophobe open-water form. In Estonian eutrophic lakes it occurs rather frequently in winter. In L. Võrtsjärv it can be found almost all the year round, more abundantly in May (at some sampling-spots up to 27,000 ind./m^3) and is practically absent in July (Fig. 12). According to N. Schönberg, the species performs diurnal vertical migrations. In the opinion of the same author the species is more

numerous in the northern part of the lake than in the southern one. C. kolensis is of some importance in the zooplankton of L. Võrtsjärv during the spring period poor in plankton.

59. Acanthocyclops viridis (Jurine). A littoral zone form which can also be found in the profundal zone of the lake. In L. Võrtsjärv the species occurred in small numbers in the open water from March to November and reached its maximum numbers in May (up to some thousand individuals per cubic metre).

60. Microcyclops bicolor Sars. A littoral zone form. In L. Võrtsjärv it was found in small amounts in the southern corner of the lake, among the bushes of Phragmites and Scirpus lacustris, also at the mouth of the Nigula rivulet.

61. Mesocyclops leuckarti Claus. A very common open-water form in Estonian lakes but occurs also in the littoral zone. In L. Võrtsjärv it was found from April to November with the largest number in June to August (at some sampling spots up to 21,000 ind./m^3).

62. Mesocyclops oithonoides Sars. An open-water form. Very common in Estonian eutrophic lakes. In L. Võrtsjärv the species could be found from April to November attaining its maximum numbers in July and August (at some places up to 17,000 ind./m^3).

63. Mesocyclops crassus (Fischer). An open-water form. Occurs mainly in eutrophic lakes. In L. Võrtsjärv it was found in small amounts both in the open water (May 29, 1957) and in bushes of Phragmites and Scirpus lacustris of the southern corner of the lake (Aug. 30, 1966).

64. Ergasilus sieboldi Nordmann. A fish parasite whose juveniles are rather common in the open water of Estonian eutrophic lakes. In L. Võrtsjärv juveniles were found in rather small numbers in the open water (Aug. 13, 1954). In L. Võrtsjärv it is a parasite of the pike-perch, burbot, ruff, perch, whitefish, bream, roach and rudd

(Телль 1958).

65. Canthocamptus staphylinus (Jurine). A thermophobe form with a benthic way of life. In L. Võrtsjärv its subspecies staphylinus has been found in February (Veldre, Mäemets 1956).

Cladocera

66. Sida crystallina (Müller). A common littoral zone form in Estonian lakes. Occurred in all macrophytes of L. Võrtsjärv.

67. Diaphanosoma brachyurum Lieven. Occurs both in the open water and in the littoral zone. Common in Estonian lakes but in L. Võrtsjärv it has been found only in the southern corner of the lake, among bushes of Phragmites and Scirpus lacustris (Aug. 30, 1966) and at the mouth of the Nigula rivulet.

68. Daphnia cucullata Sars. An open-water form. Characteristic of Estonian eutrophic lakes. In L. Võrtsjärv it is one of the dominant species. Occurred here from the end of April till November (Fig. 13), Attaining the largest numbers in July and August (at some sampling spots up to 55,600 ind./m^3). The Daphnia cucullata of L. Võrtsjärv belongs to the race Kahlbergensis Schoedler.

69. Simocephalus vetulus (Müller). A littoral zone form. Frequent in Estonian lakes, in L. Võrtsjärv found only in the southern corner, among bushes of Phragmites and Scirpus lacustris (numbering 1,600 ind./m^3).

70. Ceriodaphnia pulchella Sars. A littoral zone form. Common in Estonian lakes. In macrophytes of the southern part of L. Võrtsjärv it reaches a rather large number at some places (up to 15,200 ind./m^3).

71. Scapholeberis mucronata (Müller). A littoral zone form, inhabitant of the surface layer. Occurs frequently in Estonian lakes but in L. Võrtsjärv it has been found only at the mouths of some rivulets: f. cornuta Schoedler in the Rivulet Nigula Aug., 1956, var. bispinosa De Geer

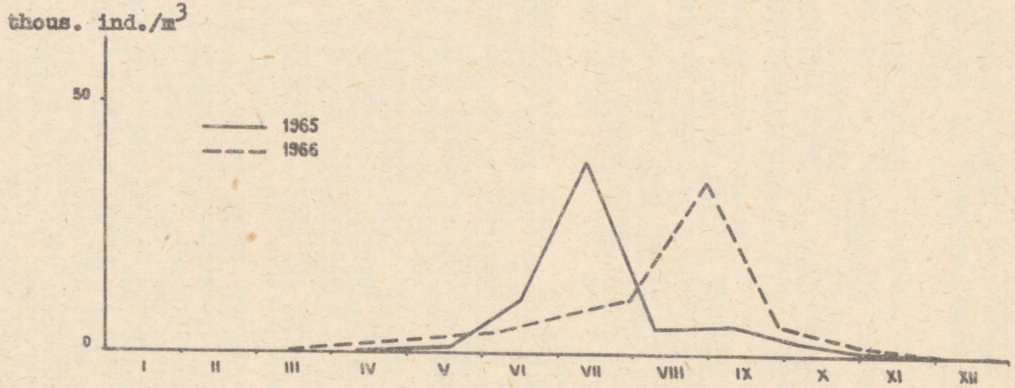

Fig. 13. Seasonal dynamics of the numbers of Daphnia cucullata in L. Võrtsjärv in 1965 and 1966.

in the Rivulet Vaibla (Mühlen, Schneider 1920).

72. Bosmina longirostris (Müller). Occurs both in the open water and in the littoral zone. Common in Estonian lakes. In L. Võrtsjärv, too, it is practically found all the year round (no finds in February) while the abundance of the species was highest in spring (May) and autumn (from September to November - at some sampling spots up to 10,000 ind./m^3). In average numbers it can also be found among macrophytes. The following forms have been found in L. Võrtsjärv: typica Müller, cornuta Jurine, brevicornis Hellich, similis Lilljeborg.

73. Bosmina obtusirostris Sars. Occurs both in the open water and in the littoral zone. Is common in Estonia above all in oligotrophic and dystrophic lakes. In L. Võrtsjärv it (the subspecies obtusirostris Lilljeborg) occurred in small numbers in the open water in April-May and in August to November, being somewhat more numerous in May and October (at some places up to 1,000 ind./m^3). Males occurred in October. At some places the species was also found in bushes of Phragmites and Scirpus lacustris of L. Võrtsjärv (up to 3,200 ind./m^3).

74. Bosmina berolinensis Imhof. An open water form. In some earlier works (e.g. Mühlen, Schneider 1920) it was identified as B. coregoni-longispina Leydig. In fact, it is an independent species requiring much oxygen which in Estonia, besides L. Võrtsjärv, is found in L. Peipsi-Pskow (Мяэметс 1966), in the Narva River and the Storage Reservoir of Narva, in L. Valgjärv near Otepää (Mäemets 1960). In L. Võrtsjärv it occurred in relatively small numbers from April to November, being more numerous in September-October (at some sampling spots up to 3,300 ind./m^3).

75. Bosmina coregoni Baird. An open-water form. Frequent in and characteristic of Estonian eutrophic lakes. In L. Võrtsjärv it is one of dominants species, occurring from April to January (Fig. 14). The number of the species is

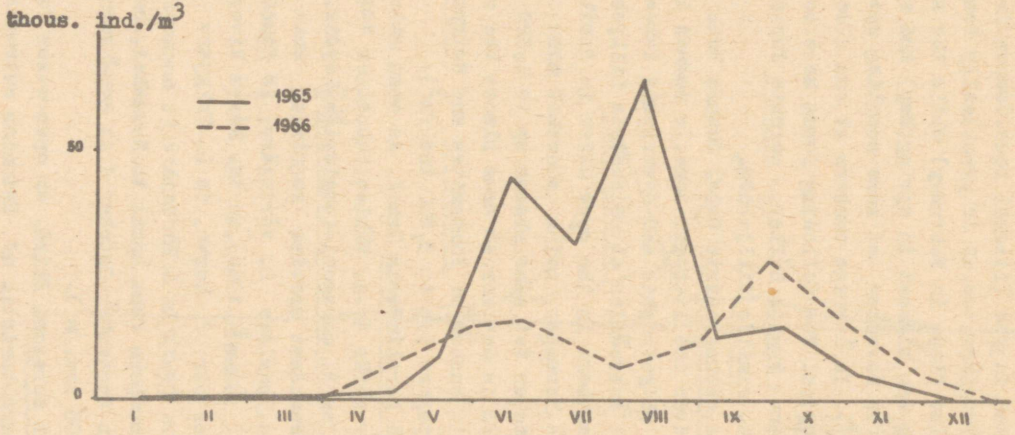

Fig. 14. Seasonal dynamics of the numbers of Bosmina coregoni coregoni in L. Võrtsjärv in 1965 and 1966.

largest in June and in August-September. Males are found from September to December. The species is comparatively numerous even among bushes of Phragmites of the northern and central part of the lake (at some places up to 10,400 ind./m^3).

76. Ilyocryptus sordidus (Lieven). A profundal form. Few finds have been made in Estonian lakes. In L. Võrtsjärv it has been found in small amounts on mud at a depth of 3 m only once (May 19, 1959).

77. Ilyocryptus acutifrons Sars. A profundal form. Few finds in Estonian lakes. In L. Võrtsjärv it has been found in small amounts on mud at a depth of 2.9 and 4.9 m in May and June (with the temperature of the water ranging between 13.9-18°).

78. Lathonura rectirostris (Müller). A littoral zone form. Rather few finds have been made in Estonian lakes. In L. Võrtsjärv it has been found in small amounts in the southern corner of the lake, in bushes of Phragmites and Scirpus lacustris, and at the mouth of the Nigula rivulet.

79. Drepanothrix dentata (Euren). Mainly a littoral zone form. In Estonia it has been found in few, mainly oligotrophic and mesotrophic lakes. In L. Võrtsjärv it occurs in the open water in May and September (with numbers up to 500 ind./m^3). Has been found in the food of the bream and the ruff of L. Võrtsjärv from June to September (Haberman 1964 and unpublished data by Kangur).

80. Eurycercus lamellatus (Müller). A littoral zone form. Occurs frequently in Estonian lakes. In L. Võrtsjärv found in small amounts in the southern corner, in bushes of Phragmites and Scirpus lacustris (Aug. 30, 1966), at the mouth of the Nigula rivulet and in the food of the bream (Haberman 1964).

81. Camptocercus lilljeborgi (Schoedler). A littoral zone form. Comparatively few finds in Estonian lakes. In L. Võrtsjärv it occurs in the southern corner of the lake,

among bushes of Phragmites and Scirpus lacustris (with numbers up to 1,600 ind./m^3), also at the mouth of the Nigula rivulet.

82. Acroperus harpae Baird. A very common littoral zone form. Occurred in all macrophytes of L. Võrtsjärv, at some places up to 4,800 ind./m^3.

83. Acroperus elongata Sars.* A littoral zone form. Frequent in Estonian lakes. Prefers oligotrophic and mesotrophic water bodies. In L. Võrtsjärv it has been found in bushes of Phragmites and Scirpus lacustris near Tamme (Aug. 30, 1966) at the mouth of the Nigula rivulet (Aug. 1956) and in the open water (Mühlen, Schneider 1920).

84. Oxyrella tenuicaudis Sars.* A littoral zone form. Comparatively rare in Estonian lakes. In L. Võrtsjärv it has been found once in the southern corner of the lake, in bushes of Phragmites and Scirpus lacustris (Aug. 30, 1966).

85. Alona guttata Sars. A littoral zone form. Frequent in Estonian lakes. Prefers oligotrophic and mesotrophic lakes. In L. Võrtsjärv some finds have been made in August and September both in the open water and in the littoral zone.

86. Alona costata Sars. A littoral zone form. Frequent in Estonian lakes, preferring mesotrophic and eutrophic lakes. In L. Võrtsjärv it has been found in small amounts in the open water (in September) and in the southern corner of the lake, in bushes of Phragmites and Scirpus lacustris (in August the numbers amounting to 4,800 ind./m^3) and at the mouth of the Nigula rivulet.

87. Alona rectangula Sars. A littoral zone form. Frequent in Estonian lakes. In L. Võrtsjärv it occurs in small amounts from May to October both in the open water and

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*According to N. Smirnov (1966), the species belongs to the Genus Acroperus.

*A. Behning (Бенинг 1941) and E. Manuilova (Мануйлова 1964) consider the species to be a member of the Genus Oxyrella.

in the littoral zone. Males have been found in September and October.

88. Alona quadrangularis (Müller). A benthic form, occurs both in the littoral zone and in the open water. In L. Võrtsjärv it has been found in small amounts in the open water in May, August, October and November and in the food of the ruff also in February (unpublished data by Kangur).

89. Alona affinis Leydig. A benthic form, occurs both in the littoral zone and in the open water, common in Estonian lakes. In L. Võrtsjärv it has been found in small numbers from May to November, occurring also among macrophytes in the southern corner of the lake and steadily in the food of the bream, ruff and other fishes (Haberman 1964 and unpublished data by Kangur).

90. Graptoleberis testudinaria (Fischer). A form frequently occurring in the littoral zone of Estonian lakes. In L. Võrtsjärv it has been found comparatively abundantly (up to 4,800 ind./m^3) among macrophytes of the southern corner of the lake, also at the mouth of the Nigula rivulet.

91. Leydigia leydigii (Schoedler). A profundal form preferring eutrophic lakes. Few finds in Estonian lakes. In L. Võrtsjärv it has been found only once in the stomach of a bream (Haberman 1964).

92. Rhynchotalona falcata (Sars). A littoral zone form, frequently occurring on the sandy bottom. In L. Võrtsjärv it has been found in the littoral zone near Tamme and at the mouth of the Nigula rivulet in August as well as in the open water in October.

93. Alonella rostrata (Koch)*. A littoral zone form which is rather rare in Estonian lakes. In L. Võrtsjärv it has been found in small amounts in the open water in May

*D.G. Frey (1961) considers the species to be a member of the genus Alonella.

and from August to November (males in September).In the food of the bream and the other species it has also been found in June (Haberman 1964).

94. Alonella excisa (Fischer).A frequent littoral zone form in Estonian lakes. In L. Võrtsjärv it occurs rather abundantly in the southern corner, among bushes of Phragmites and Scirpus lacustris, and at the mouth of the Nigula rivulet.

95. Alonella exigua (Lilljeborg).A littoral zone form. Frequent in Estonian lakes. In L. Võrtsjärv it has been found abundantly in macrophytes of the southern corner together with Alonella excisa (Fischer).

96. Alonella nana (Baird). A common littoral zone form in Estonian lakes which also occurs in the open water of shallow lakes.In L.Võrtsjärv it was found in small numbers in the open water from May to January, more abundantly in September-October (males have occurred during same period. It is also found in macrophytes of the littoral zone.

97. Peracantha truncata (Müller). A littoral zone form. Being a common species in Estonian lakes, it has been found among macrophytes of the southern corner of L. Võrtsjärv and at the mouth of the Nigula rivulet (in August). It has also been found in the open water (Mühlen, Schneider 1920).

98. Pleuroxus laevis Sars.A littoral zone form. The species is rather rare in Estonian lakes. Its occurrence in L. Võrtsjärv is mentioned by M. zur Mühlen and G. Schneider (1920).

99. Pleuroxus trigonellus (Müller). A littoral zone form. Rather frequent in Estonian lakes. In L. Võrtsjärv it has been found in small numbers in the open water in September (sampling spot 2). It also occurs in the food of the bream and ruff (in September and August) à (Haberman 1964 and unpublished data by Kangur).

100. Pleuroxus uncinatus Baird. A benthic form occurring mainly in the littoral zone but also met with in the open water. Rare in Estonian lakes. In L. Võrtsjärv it has been found in the food of the bream in September (Haberman 1964), also found in the food of the ruff in July, August and September (the fish were caught near the Limnological Station and near Tamme — data by Kangur).

101. Chydorus gibbus Lilljeborg. Both an open-water and littoral zone form. In Estonia it occurs mostly in larger lakes on the sandy and muddy bottom. In L. Võrtsjärv the species has been found in small numbers near Vehendi in bushes of Phragmites and Scirpus lacustris in August and in the open water in October (sampling-spots 2,5,6).

102. Chydorus piger Sars. Occurs more frequently on the sandy and muddy bottom of the littoral zone but also in the open water of shallow lakes, preferring oligotrophic and mesotrophic water bodies. Not very frequent in Estonian lakes. In L. Võrtsjärv it has been found in small amounts in the open water in July and August, likewise among bushes of Phragmites and Scirpus lacustris near Tamme and Vehendi in August. The species has also been found in the food of the bream, ruff and other fishes (Haberman 1964 and unpublished data by Kangur).

103. Chydorus sphaericus (Müller). Both an open-water and littoral zone form. Occurs very abundantly in the open water of eutrophic lakes only; is very frequent in Estonia. One of the dominant species in L. Võrtsjärv. Here it can be found practically all the year round (Fig. 15) while in maximum numbers it occurs in July (sometimes in June or August). At some sampling spots the number has been found very high (up to 218.000 ind./m^3).

104. Chydorus latus Sars. A littoral zone form which rarely

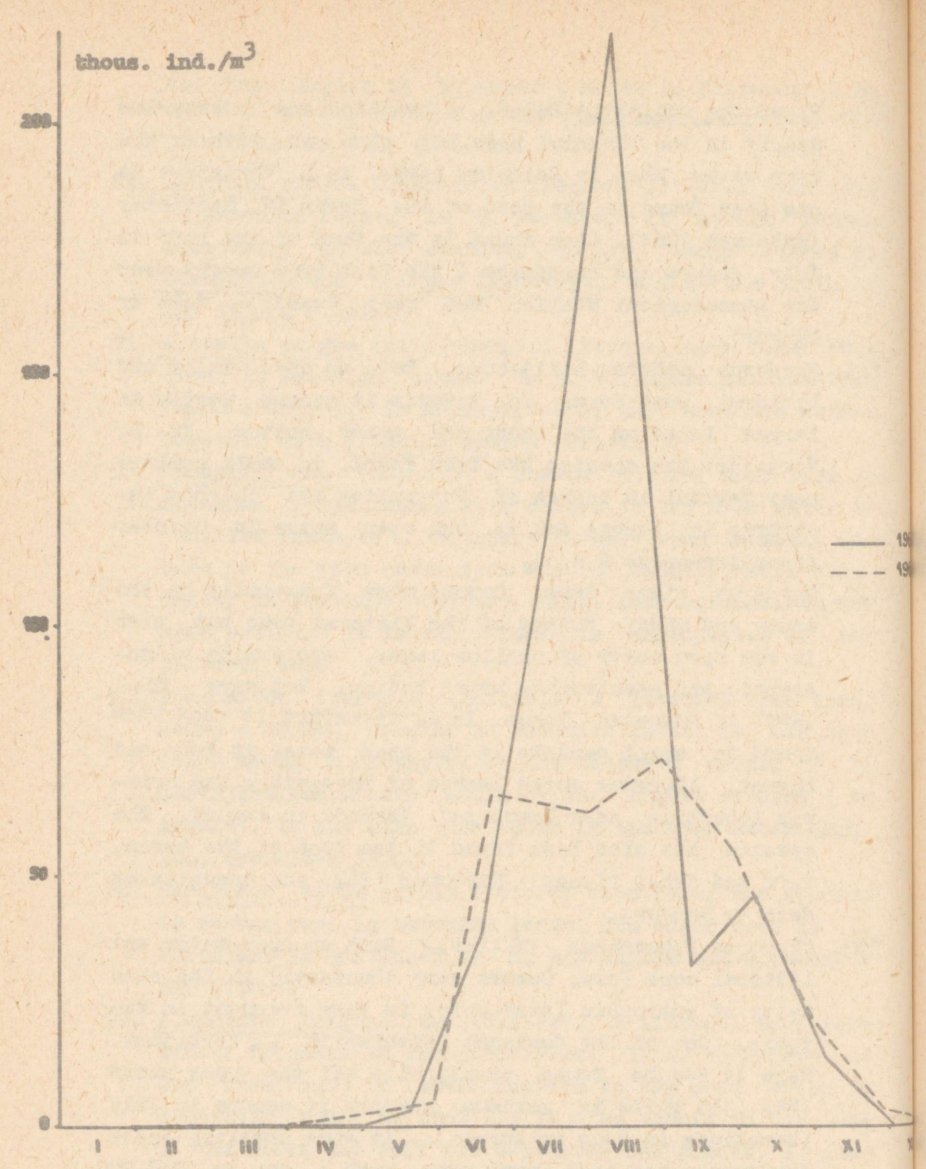

Fig. 15. Seasonal dynamics of the numbers of Chydorus sphaericus in L. Võrtsjärv in 1965 and 1966.

occurs in Estonian lakes. In L. Vôrtsjärv it has been found once in the open water (at sampling spot 2) in September (Sept. 30, 1960).

105. Monospilus dispar Sars. Occurs both in the littoral zone and in the shallow open water but prefers a sandy bottom. Not frequent in Estonian lakes. In L. Vôrtsjärv it has been found in small numbers in the open water in August and October, in the littoral zone near Tamme and Vehendi (Aug. 30, 1966). The species has been found in the food of the bream in May and September (Haberman 1964).

106. Anchistropus emarginatus Sars. A rare littoral zone form in Estonian lakes. In L. Vôrtsjärv it has been found once in small amounts in the southern corner, in bushes of Scirpus lacustris (Aug. 30, 1966).

107. Polyphemus pediculus Linne. Lives both in the littoral zone and in the shallow open water. Frequent in Estonian lakes but prefers oligotrophic and dystrophic lakes. In L. Vôrtsjärv it has been found in large numbers near the pier of the Limnological Station at the end of April (the temperature of the water being 7.8°). According to M. zur Mühlen and Schneider (1920) it has been found only once in the stomach of a perch.

108. Bythotrephes longimanus Leydig. A very rare open-water form in Estonian lakes. In L. Vôrtsjärv one specimen (spot 3; July 30, 1961) was found which was close to the var. brevimanus Lilljeborg. Similar populations of the species are found in the lakes Peipsi-Pskow and Ülemiste. The occurrence of Bythotrephes sp. is mentioned by M. zur Mühlen and G. Schneider (1920).

109. Leptodora kindti (Focke). A very common open-water species in Estonian lakes which is of great importance as food for fish. In the open water of L. Vôrtsjärv the species occurs in small numbers from May to August and is somewhat more numerous in June (at spot 5 even 4.000 ind./m^3). It seems that in comparison with the data of

1953 the numbers of the species in L. Võrtsjärv have noticeably decreased. Due to its large size, Leptodora is a valuable constituent of the food of young pik perches (Erm 1961).

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ON THE PARASITES OF PREDATORY FISHES OF LAKE VÕRTSJÄRV

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L. Võrtsjärv is a large (270 sq km), shallow (the average depth being 2.8 m) lake of a eutrophic character.

Four well-known predatory fishes of industrial importance - pike, perch, pike-perch, burbot - live in the lake. The fishes mentioned begin to kill other fishes at a rather early age, The pike at the age of some months uses the larvae and fries of other fishes, mainly of cyprinid fishes, as its food. The adult pike uses mainly perches and roach for its food. 0 + year-old perches feed on zooplankton and switch over to the predatory way of life in the second year only or still later. At first they feed on the larvae and fries of other perches, later on they also use smelts, ruffs and roach for their food. The fries of the pike-perch start killing those of the smelt at the age of some months already. Afterwards they feed mainly on the smelt and the perch. The burbot feeds on invertebrates during its first life-year and uses small fishes for its food afterwards, especially the ruff and the perch (PIHU 1963, KANGUR 1969 a, KANGUR 1969 b).

Predatory fishes get most of their parasites with their food. It is the food that determines the character of the parasitofauna of these species. During the years 1964, 1962 and 1968, 390 predatory fish (250 perches, 60 pikes, 40 pike-perches and 40 burbots) were studied. The fish were taken from different parts of the lake (northern, central and southern parts). The fish were studied according to the method of ich-

thyoparasitological dissection elaborated by V. A. Dogel. Mostly helminths are studied while the studies on protozoan are rather insufficient. Parasites of each species will be presented in the form of a table where the infection of the organs of the fish species (percentage of the total number of the studied fish) and its intensity will be given.

Pike - Esox-lucius. All in all, 60 pikes were dissected - 15 fish from the northern part of the lake in the May of 1964, 20 fish in the summer and 15 fish in the autumn of 1965 from the central part of the lake and 10 fish from the central part of the lake in the winter of 1968. The studied pikes fell into the following age groups: 0 +, 1 +, 2 +, 3 +, 4 +, 5 +, 6 +.

26 species of fish parasites occurred with the pike of which 10 were dominant: Myxidium lieberkühni, Myxosoma dujardini, Tetraonchus monenteron, Triaenophorus nodulosus, Diphyllobothrium latum, Azygia lucii, Diplostomulum clavatum, Rhaphidascaris acus, Camallanus lacustris and Ergasilus sieboldi.

Dominant species infect the fish with a high infecti on percentage and intensity and they are often specific parasites for one species of fish only. Predatory fish have less specific species of parasites than non-predatory fish, as they mainly feed on the same prey fishes.

The infection of the pike with parasites was different in different age groups. The smallest number of parasites was found on 0 + year-old fish and 1 + year-old fish-13 while the largest number - 22 species of parasites was found in group 3 +. In the first and second age group the pike was highly infected with Myxosoma dujardini. Henneguya psorospermica, Diplostomulum clavatum, Azygia lucii, Phyllodistomum folium, Ergasilus sieboldi.

On 3 + year-old fish some species which were absent in the previous cases were added: Proteocephalus esosis, Acanthocephalus lucii, Camallanus lacustris, Cotylurus pileatus

Table 1

Parasites of the Pike

Name of the Parasite	Organs	Percentage of infection	Intensity of the infection of one fish		
			average	minimum	maximum
Chloromyxum esocinum	gall-bladder urine-bladder	+			
Myxidium lieberkühni	gall-bladder urine-bladder	83	+	+	+
Myxosoma dujardini	gills	41.6	1.6	3	80
Myxobolus mülleri	gills	5	0.2	3	10
Henneguya psorospermica	gills	20	0.7	1	15
Ichthyophthirius multifiliis	skin	+			
Trichodinella sp.	gills	15	0.5	1	9
Tetraonchus monenteron	gills	45	38	1	860
Triaenophorus nodulosus	intestine liver	83.3	22.2	1	110
T. crassus	intestine muscles	8.3	0.15	1	3
Diphyllobothrium latum	internal organs	45	3	1	25
Proteocephalus esocis	intestine	8.3	0.25	1	12
Bucephalus polymorphus	intestine stomach	6.6	0.4	27	46
Bunodera luciopercae	intestine	11.6	0.4	3	25
Azygia lucii	stomach intestine	36.6	1.4	2	13
Phyllodistomum folium	urine-bladder	18.3	2.7	1	94
Diplostomum spathaceum	eyes	3.3	0.015	1	1
Diplostomulum clavatum	eyes	58.3	6.5	1	60
Neascus brevicaudatus	eyes	3.3	0.05	1	2
Cotylurus pileatus	heart and internal organs	6.6	0.15	4	6
Rhaphidascaris acus	intestine	30	2.1	2	39
Camallanus lacustris	intestine	35	1.4	1	12
Acanthocephalus lucii	intestine	8,3	0,62	1	9
Piscicola geometra	skin	3,	0.2	1	1
Ergasilus sieboldi	gills	93.3	34.3	1	150
Argulus foliaceus	gills skin	10	0.16	1	3

and several other rarely occurring and less essential species. The infection with Tetraonchus monenteron, Triaenophorus nodulosus and Rhaphidascaris acus increased. Myxosoma dujardini, Henneguya psorospermica, Diplostomulum clavatum, Azygia lucii, and Ergasilus sieboldi occurred less than in the previous groups.

4 + year-old fish had 17 species of parasites. As compared with the previous group, Diplostomum spathaceum and Neascus brevicaudatus were added while Chloromyxum esocinum, Ichthyophthirius multifiliis, Cotylurus pileatus, Bunodera luciopercae, Phyllodistomum folium, Proteocephalus esocis and Piscicola geometra were absent.

16 species of parasites were found in the age groups 5+ and 6 +. In comparison with the previous group the same dominant species were found while some rarely occurring species were added and some were absent. In general the lower infection could be observed in the last groups.

Perch - Perca fluviatilis. Of the 250 perches studied, 50 ones were taken from the northern part of the lake and analyzed in the autumn of 1964, 25 specimens were taken from the central part of the lake and analyzed in the winter of 1965, another 25 were caught in the same place and analyzed in the spring of 1965. 150 perches were also taken from the central part of the lake and analyzed in the summer of 1968. Both young and adult fish were dissected (1 +, 2 +, 3 +, 4+, 5 +, 6 +, 7 +, 8 +.

26 species of fish parasites were found, of which 9 species were numerous: Triaenophorus nodulosus, Proteocephalus percae, Bunodera luciopercae, Tetracotyle percae-fluviatilis, Diplostomulum clavatum, Diplostomum spathaceum, Camallanus lacustris, Acanthocephalus lucii and Ergasilus sieboldi.

The smallest number of parasites occurred in the first age group (8 species) and the biggest number in group 4 +. (16). There were parasite species dangerous for young fish, there were also species dangerous for adults. In Lake Võrts-

Table 2

Parasites of the Perch

Name of the Parasite	Infection of the organs	Percentage of infection	Intensity of the infection of one fish	
			minimum	maximum
Henneguya psorospermica	gills	0.8	2	9
Trichodina sp.	gills skin	+	+	++
Ancyrocephalus paradoxus	gills	3.2	1	8
Triaenophorus nodulosus	liver	52	1	9
Diphyllobothrium latum larva	muscles	8	1	2
Proteocephalus percae	intestine	32	1	27
Bucephalus polymorphus	intestine	2.4	2	20
Phyllodistomum folium	urine-bladder	1.6	1	3
Azygia lucii	stomach	2.4	1	3
Bunodera luciopercae	intestine	52	3	108
Tetracotyle echinata	heart and internal organs	+	+	+
Tetracotyle percae-fluviatilis	heart and internal organs	92	10	1600
Diplostomulum clavatum	eyes	52	1	720
Diplostomum spathaceum	eyes	80	2	200
Neascus brevicaudatus	eyes	1.6	1	2
Rhaphidascaris acus	intestine	10	1	2
Rhabdochona sp. larva	liver	3.2	1	1
Spiruridae larva	liver	3.2	1	7
Camallanus lacustris	intestine	74	1	60
Camallanus truncatus	intestine	0.8	1	2
Eustrongylides larva	muscles	2.4	1	2
Acanthocephalus lucii	intestine	32	1	40
Piscicola geometra	skin	4	1	2
Ergasilus sieboldi	gills	20	1	7
Achteres percarum	gills	3.2	1	2
Argulus foliaceus	gills skin	6.4	1	10

järv the following parasites were dangerous for young fish: Ancyrocephalus paradoxus on gills, Triaenophorus nodulosus in the liver and Tetracotyle percae-fluviatilis on membranes of internal organs. Proteocephalus percae, Bunodera luciopercae, Camallanus lacustris, Ergasilus sieboldi endangered adult fish (4 years old and older). The infection with the larvae of Trematoda was especially high.

Tetracotyle percae-fluviatilis and Diplostomum spathaceum infected the perches studied in the range of per cent 100 with an intensity till 1000 cysts in the membranes and 160 metacercars in the eyes of one fish. Diplostomulum clavatum (70-80%) also infected the eyes of the fish in a high degres. In the age group 6 + fish were found in whose eyes 600-700 metacercare were established. High infection with the larvae of Trematoda is characteristic of the following age groups as well while the infection with other species of parasites begins to decrease in the group of 5 - 6 year-old specimens.

Pike-perch - Lucioperca lucioperca. All in all 40 pike-perches were studied, of them 15 ones in the summer of 1964, 5 in the autumn of 1965, 15 in the spring of 1968 and 5 in the summer of 1968. All of them were caught in the central part of the lake.

The analyzed pike-perches belonged to the following age groups: 1 +, 3 +, 4 +, 5 +, 7 +, 8 +, 10 +.

15 species of parasites could be found, of which only 4 were dominant: Diplostomulum clavatum, Cotylurus pileatus., Camallanus lacustris, Ergasilus sieboldi.

With most of its parasites the pike-perch is infected via food, all dominant species except for Ergasilus sieboldi included. In the case of the pike-perch it was rather difficult to observe the infection of the fish according to age groups as the number of fish was small (4-6 fish in one group).

Young fish were strongly infected with 5 parasite spe-

Table 3

Parasites of the Pike-Perch

Name of the Parasite	Organs	Percentage of infection	Intensity of the infection of one fish		
			average	minimum	maximum
Myxobolus sp.	muscles	+			
Trichodina sp.	gills skin	+			
Ancyrocephalus paradoxus	gills	12.5	0.35	1	3
Bunodera luciopercae	intestine	15	0.65	3	16
Azygia lucii	stomach	12,5	0.25	1	2
Diplostomum spathaceum	eyes	10	0.25	2	3
Diplostomulum clavatum	eyes	45	4.1	3	23
Tetracotyle percae-fluviatilis	heart and internal organs	+		+	+
Cotylurus pileatus	heart and internal organs	72,5	11.6	10	80
Camallanus lacustris	intestine	52.5	3.4	1	18
Camallanus truncatus	intestine	10	0.27	1	3
Hepaticola petruschewskii	liver	15	0.25	1	12
Acanthocephalus lucii	intestine	5	0.1	1	2
Ergasilus sieboldi	gills	90	14.4	2	40
Argulus foliaceus	skin	2.5	0.025	1	1

cies: Bunodera luciopercae, Cotylurus pileatus, Diplostomulum clavatum, Camallanus lacustris and Ergasilus sieboldi. In group 4 + the weakening of the infection could be noticed as compared with the previous group. Both Camallanus lacustris and Bunodera luciopercae are absent. Ergasilus sieboldi infected as strongly as in the previous group. Smaller changes could be observed in the case of rarely occurring species. In group 5 + the intensity of infection was almost the same as in group 4 +. In the last groups (7 +, 8 +) the general intensity of infection was decreasing.

Burbot - Lota lota. 40 burbots were dissected:10 in the winter of 1964, 15 in the spring of 1965, 5 in the summer and 10 in the autumn of 1965. All of them were caught in the central part of the lake.

The analyzed burbots belonged to five age groups (3+, 4 +, 5 +, 6 +, 7 +).

The burbot had 18 species of parasites, of which 6 had a high percentage of infection and intensity: Myxoboluy cycloides, Eubothrium rugosum, Diphyllobothrium latum, Diplostomum spathaceum, Camallanus lacustris, Ergasilus sieboldi.

As for the dependence of the parasitofauna on the age group of the burbot, the results may be of occasional character as the number of fish in each group was small.

The smallest number of parasites (11) was found in group 3 + and the biggest (14) in group 7 +. In group 4 + there were 12 and in groups 5+, 6+ - 13 species of parasites.

In group 3 + Myxobolus cycloides, Diplostomum spathaceum, Eubothrium rugosum, Diphyllobothrium latum, Camallanus lacustris, Ergasilus sieboldi and Cystobranchus mammillatus had a high percentage of infection and intensity.

Except for Diplostomum spathaceum and Cystobranchus mammillatus, the same parasites could be found in group 4 + as in group 3 +. The two species mentioned were somehow absent in group 4 + but occurred again in the following groups. Myxobolus cycloides and Eubothrium rugosum infected the fish

Table 4

Parasites of the Burbot

Name of the Parasite	Organs	Percentage of infection	Intensity of the infection of one fish		
			average	minimum	maximum
Chloromyxum sp.	gall-bladder	+			
Myxidium sp.	gills	17,5	1,7	3	29
Myxobolus cycloides	gills	40	74,5	3	700
Eubothrium rugosum	intestine	77.5	8	1	60
Diphyllobothrium latum	muscles, internal organs	72.5	14.5	3	42
Phyllodistomum sp.	urine-bladder	7.5	0.09	1	2
Diplostomum spathaceum	eyes	30	3	2	19
Diplostomulum clavatum	eyes	22.2	1.3	1	10
Neascus brevicaudatus	eyes	12.5	0.22	1	8
Cotylurus pileatus	stomach	15	0.9	3	8
Rhaphidascaris acus	intestine	5	0.02	1	1
Camallanus lacustris	intestine	50	4.1	1	40
Eystrongylides sp.	intestine	12.5	0.2	1	3
Acanthocephalus lucii	intestine	15	0.3	1	4
Piscicola geometra	skin	5	0.07	1	3
Cystobranchus mammilatus	gills skin	20	4.4	6	50
Ergasilus sieboldi	gills	72.5	3.6	1	18
Argulus foliaceus	skin	5	0.02	1	1

more weakly than in the previous group while Diplostomulum clavatum and Ergasilus sieboldi occurred more abundantly.

In groups 5 +, 6 + the general tendency was towards a wider infection, the only exception being Myxobolus cycloides, the infection with which was constantly decreasing.

Of the 38 species of parasites observed on the predatory fishes of Lake Võrtsjärv, 17 were ectoparasites and 21 endoparasites.

Ectoparasites infect their host directly from the environment. They mainly reside on the gills, fins and skin of the host. Their development is direct and their occurrence in the water body is largely dependent on the temperature of the water and chemical conditions.

Endoparasites get on their host with food and reside in its internal organs. Their development proceeds via one or several intermediate hosts.

Endoparasites may be divided into species which become sexually mature in the fish and species whose larvae live in the fish.

There were few specific ecto- and endoparasites, characteristic of one certain species of predatory fish only (Table 5).

The pike had four specific ectoparasites, the protozoa Chloromyxum esocinum, Myxidium lieberkühni, Myxosoma dujardini and Monogenea Tetraonchus monenteron. The occurrence of Myxobulus mülleri on the gills of the pike seems to be accidental. In Lake Võrtsjärv it is a parasite of non-predatory fishes, although in our material it occurred on the pike only. Of endoparasites we should mention the Cestoda Triaenophorus nodulosus, to some extent Proteocephalus esocis and Trematoda Phyllodistomum folium. Bucephalus polymorphus may also occur on other predatory fishes, but in Lake Võrtsjärv it was found on the pike only. The abundant occurrence of Triaenophorus nodulosus in the intestine of the pike proves that the pike in Lake Võrtsjärv uses young littoral perches for its food.

It is interesting to note that protozoan gill parasites were completely absent on the perch and pike-perch of Lake Võrtsjärv while the Monogenea Ancyrocephalus paradoxus was represented, although they were rather few in number. It is probably caused by the biochemical unsuitability of tissues with the mentioned groups of parasites. The perch had not a single considerable specific species of parasites. The Nematoda of the liver Hepaticola petruschewskii occurred rather modestly and even these specimens were often almost degenerated in the cyst. Well - known specific parasites Protozoa Myxobolus cycloides and the Cestoda Eubothrium rugosum occurred abundantly on the burbot.

Predatory fishes of Lake Võrtsjärv had several common dominant endoparasites which still had a certain specific inclination towards one or another species (Table 5). The common ectoparasite Ergasilus sieboldi strongly infected all predatory fishes except for the perch. It may be explained by the fact that Ergasilus sieboldi is an open-water parasite which keeps aloof from areas covered with vegetation and in our analyses no distinction was made between the littoral and pelagic perch. On the other hand, the biochemical unsuitability of the gill tissue of the perch for Ergasilus sieboldi may be another reason for it.

There were seasonal regularities in the infection of predatory fishes with dominant parasites. It was especially clear in the case of sexually mature endoparasites and rather indistinct in the case of the larvae of endoparasites which do not become sexually mature in fish. Predatory fishes were most strongly infected in the spring and least of all in the early summer. In general, the infection constantly increases from the second half of the summer till spring when it culminates. It highly decreases at the beginning of summer. The process continues till the second half of summer when the opposite process starts again. It is caused by the yearly development dynamics of endoparasites. The yearly development dynamics was fixed in the case of Cestoda Triaenophorus nodulosus, Eubothrium rugosum, Trematoda Bunodera

Table 5

Infection of Predatory Fishes with Specific and Non-Specific Ecto- and Endoparasites

Name of the Fish	Ectoparasites	Percentage of infection	Endoparasites			
			Sexually mature	Percentage of inf.	Larvae	Percentage of inf.
1	2	3	4	5	6	7
Esox lucius	Chloromyxum esocinum	+	Triaenophorus nodulosus	83.3		
	Myxidium lieberkühni	83	Triaenophorus crassus	8.3		
	Myxosoma dujardini	41.6	Proteocephalus esocis	8.3		
	(Myxobolus mülleri)*	5	Phyllodistomum folium	18.3		
	Tetraonchus monenteron	45	(Bucephalus polymorphus)	6.6		
Perca fluviatilis	Achteres percarum	3.2	Proteocephalus percae	32	Tetracotyle percae-fluviatilis	92
Lucioperca lucioperca	Myxobolus sp.		Hepaticola petruschewskii	15		

Table 5 continued

Lota lota	Chloromyxum sp. Myxidium sp. Myxobolus cycloides Cystobranchus mammillatus	+ 17.5 40 20	Eubothrium rugosum Phyllodistomum sp.	77.5 7.5		
E. lucius P. fluviatilis	Henneguya psorospermica	E -20 P - 0.8			(Triaenophorus nodulosus)	P -52 E - 6
L. lucioperca P. fluviatilis	Ancyrocephalus paradoxus	Lu-12.5 P - 1.2	Camallanus truncatus	P - 0.8 Lu-10		
E. lucius L. lota			Rhaphidascaris acus	E -30 Lo- 5		
L. lota P. fluviatilis					Eustrongylides sp	P - 2.4 Lo-12.5
E. lucius P. fluviatilis L. lucioperca	(Ichthyphthrius multifiliis) (Trichodina sp)	E + P + Lu+ E + P + Lu+	Bunodera lucioperca Axygia lucii	P -52 E -11.6 Lu-15 E -36.6 P -2.4 Lu-12.5		

Table 5 continued

1	2	3	4	5	6	7
L. lota E. lucius P. fluviatilis					Diphyllobothrium latum Neascus brevicaudatus	Lo-72.5 E -45 P - 8 E - 3.3 P - 1.6 Lo-12.5
E. lucius P. fluviatilis L. lucioperca L. lota	(Piscicola geometra	E - 3.3 P - 4 Lu + Lo- 5	Camallanus lacustris	P -74 E -35 Lu-52 Lo-50	(Diplostomum spathaceum)	P -80 Lu-10 E - 3.3 Lo -30
	(Ergasilus sieboldi)	E -93.3 Lu-90 P -20 Lo-72.5	Acanthocephalus lucii	P -32 E -48.3 Lu- 5 Lo-15	(Diplostomulum clavatum)	E -58.3 P -52 Lu-45 Lo-22.2
	(Argulus foliaceus)	E -10 P - 6.4 Lu- 2.5 Lo- 5			(Cotylurus pileatus	E - 6.6 P + Lu-72.5 Lo-15

* The species mentioned in brackets also occur with some other kinds of fish of Lake Võrtsjärv.

luciopercae, Azygia lucii, Phyllodistomum folium and Nematoda Rhaphidascaris acus. In the spring (the end of April and the beginning of May) the above-mentioned parasites ac uired their maximum size and their abdominal cavity was filled with ova. At that time the percentage and intensity of the infection of fish was high. At the end of May and beginning of June parasites disappeared from the fish. In the following period began a gradual infection of the fish with the young parasites developed from the ova. At the end of June and beginning of July the precentage and intensity of the infection of fish were very low. Alongside of the growth of parasites the intensity of infection also grew till the next spring. The larvae of endoparasites which do not become sexually mature in fish infected the fish with a uniform precentage and intensity the whole year round. Neither were any development changes observed.

In case of strong infection certain parasites may cause diseases and death of fish. The larvae of endoparasites cause several diseases of fish.

Diplostomosis - an eye-disease of fish. It is caused by metacercars of the Terematoda Diplostomum spathaceum and metacercars Diplostomulum clavatum whose adult from is not known. In Lake Võrtsjärv the larvae of Diplostomum spathaceum infected up to 80% of the eyes of the perch. The parasite got on the perch with food (i. e. fishes feeding on benthos, in the present case the ruff). Diplostomulum clavatum occurred abundantly in the eyes of the pike, perch and pike-perch. The way of this parasite to its host in partially the same as the above-mentioned one, another part of parasites intrudes into fish independently. Data from the literatum reveal that cercars of the Trematoda leaving the mollusc after the end of a certain stage of development, are able to actively intrude into blood-vessels of fish through the skin and get afterwards into the eyes, which become their places of. In order to become sexually mature, they must get into the intestinaltract of waterfowl. It seems that in the

eye of the fish they remain in the same stage of development for a long time. We have had no case of finding a dead or degenerated parasite in the eye of the fish.

Tetracotylosis. A disease of the mesentery, pericardium of heart, sexual organs and other internal organs of fish. In cases of strong infection the generator of the diseases was found in the brain and eyes of the fish (ruff), in easier cases it was located in membranes of internal organs and on pericardium of the heart. Opinions exist that the waste-products of metabolism on the parasite have a toxic effect on certain species of fish. The metacercar Tetracotyle variegata of the Trematoda Cotylurus pileatus and the metacercar Tetracotyle percae-fluviatilis occurred in the role of the generators of the disease. Both species could be found in the connective tissue cyst of the membrane of the fish. Tetracotyle percae-fluviatilis infected strongly the perch and Tetracotyle variegata the pike-perch. Both parasites get on the fish with food, i.e. fishes which feed on benthos. Some cercars intrude into the fish independently. A peculiar feature is the frequent occurrence of Tetracotyle in the intestine of the burbot. The specimens found probably got into the intestine of the burbot with food (fish) where the connective tissue cyst surrounding the larva was digesting. The larva was very vital and as regards its internal construction similar to Tetracotyle variegata. As for the size it was bigger than the metacercar of cyst Tetracotyle variegata. The latter has not been found on the membrane of the internal organs of the burbot.

Triaenophorosis. A disease of the intestine and liver of predatory fishes. Sexually mature parasites cause the constipation of the pike. The hooks of scolex harm the internal tissue of the intestine, where the inflammation may arise. Still more dangerous are the larvae in the liver of young fish where they damage the tissue and reserve substances of the liver, cause disturbances of metabolism and even death. The generator of the disease, Cestoda Triaenopho-

rus nodulosus infected the pike of Lake Võrtsjärv in the range of 83 per cent, its larvae had the same effect on the liver of the perch in the range of 52 per cent, on that of the pike in the range of 6.6 and on the liver of the burbot in the range of 1 per cent. The livers of the young fish were more strongly infected than those of the adult fish. The area of the liver of young perches damaged by the cysts of the parasite formed a half to two thirds of the total. One- and two-year-old perches were infected with the larvae of Triaenophorus nodulosus most of all, 80 and 70 per cent respectively. Most of the plerocercoids were vital. Among 3-year-old perches the infection of the liver decreased and so did the number of vital plerocercoids in the liver. The livers of young pikes were rarely infected with plerocercoids. The rare cases occurred in the late summer and in the autumn when Triaenophorus nodulosus residing in the intestine had not groun up yet. In the liver of the burbot plerocercoids were found very rarely and even these were weakly developed in the cyst or dead.

The procercoids of Triaenophorus nodulosus grow in copepodae. Therefore it is understandable why namely one- and two-year-old perches who feed on plankton are strongly infected with the parasite. Pikes, feeding in their turn on young perches, get thus infected. The plerocercoid gets free from the liver of the perch during the digestion of the liver tissue, grows in the intestine of the pike and becomes sexually mature.

The burbot which also uses the young perch for its food and the ruff (young ruffs got infected with the plerocercoids of the parasite almost as highly as perches) was not infected with Triaenophorus nodulosus. Obviously the digestion enzymes and the digestion activity of the burbot are different from those of the pike. In the intestine of the burbot the plerocercoids is digesting together with the liver. It is possible that the burbot has a certain immunity towards the parasite or the fact may be explained by the biochemical un-

suitability of tissues with each other. The organism of the burbot is able to damage the tetracotyles and the larvae of Diphyllobothrium lutum more than other fishes.

Diphyllobothriosis. The predatory fishes of Lake Võrtsjärv the burbot, the pike and the perch spread a dangerous invasion disease of the man and domestic animals diphyllobothriosis when the fishes are used for food in the raw or half-raw form. The plerocercoids of the Cestoda Diphyllobothrium latum infected the burbot in the range of 72.5%, the pike in the range of 45% and the perch in the range of 8%. It is interesting to note that during the years 1952-1954 the analyzed burbot and pike were more highly infected, 91 and 72 per cent respectively.

Predatory fishes got infected with the larvae of the Diphyllobothrium latum via prey-fishes who feed on plankton.

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RELATIONSHIP BETWEEN RHEUMATISM AND METEOROLOGICAL AGENTS IN CONDITIONS OF THE MARITIME CLIMATE

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The information about the relations of rheumatism and climate, particularly about the mutual connection between contraction of rheumatism and meteorological agents is contradictory. L. TRAUNER (5), T. J. O'REILLY (3), T. N. NIKONOVA (II), D. ASSMANN (I), D. GROSS (2) and B. G. HAIKINA with co-authors (I3) assure that meteorological factors play a substantial part in the development and the clinical course of rheumatism. Some of the authors consider those factors to be second-rate /A. I. NESTEROV and J. A. SIGIDIN (IO), J. A. GORYAYEV (7)/ or even deny the connections with meteorological agents /L. I. VILENSKI with co-authors (6), D. TSERENGIN (I4)/.

Contraction of rheumatism and exacerbation are more often connected with the increase of the relative humidity of the air (5,IO) and with the variation of the air pressure, especially in spring and autumn (5), with the instability of temperature (II), seldom with variation in solar radiation and atmospheric electricity, the velocity of the wind, the abundance of precipitation and the pressure of water vapour (I2).

As the majority of the researches of this kind have been

carried out in regions of the continental climate (above all those which deny the importance of the meteorological agents) (7,I4), there is still little information about the influence of the above-mentioned agents in the regions where the maritime climate obtains.

The complex effect of the disadvantageous meteorological agents is closely connected with colds. Catching cold is first of all due to the variation of the above-mentioned meteorological agents, especially the instability of subnormal temperature (8,9,I5). A.I.NESTEROV and J.A.SIGIDIN (IO) discuss chill as a nonspecific irritating agent, as a provocative moment in the formation of the relapses of rheumatism.

The present paper deals with the contraction of rheumatism in a district which according to A.RAIK (4) belongs to the sphere of the maritime climate.

The climatic conditions of the largest islands of the Estonian S.S.R. (the islands of Saaremaa, Hiiumaa and Muhu) in many respects differ from the conditions obtaining on the continent. The biggest differences become evident in the seasons and the mean temperature of the year and in the number of frosty and warm days. Thus the mean annual temperature on the island of Vilsandi reaches +6.0°C, the mean temperature in February is -3.2°C. In winter it is 3 to 5°C warmer on the island of Saaremaa than in the east of Estonia. Spring comes about two weeks later than in the east of Estonia. In summer there are appreciably fewer hot days, but autumn lasts longer and is warmer. On the whole, the climate is more homogeneous.

In the years of I963-I968 all the rheumatic cases in the districts of Kingissepa and Hiiumaa, altogether 566 adults and children, were recorded and were continuously observed. In the same period information was collected about the contraction of angina, catarrh of the upper respiratory tract, influenza and scarlet fever. The data of the meteorological stations situated on the above-

mentioned islands, and actinometric observations that are carried out in the Estonian S.S.R. were collated during the same years.

Rheumatic attacks were more often preceded by angina and chronic tonsillitis (61%) and seldom by influenza and the catarrh of the upper respiratory tract (24%).

It became evident that contraction of rheumatism was dependent on the seasons, cases of rheumatism became more frequent in March, April and October. For example, 63% of the total number of the rheumatic attacks on the island of Hiiumaa occurred in March, April and October.

In spring, contraction of rheumatism becomes more frequent in periods when the extensive instability of atmospheric temperature fluctuates in the range of subnormal temperature (+10...-10°C) and the relative humidity increases, the actual duration of sunshine becomes shorter than the potential duration and total radiation decreases. In autumn the number of rheumatic attacks increases with the rise of the relative humidity, atmospheric pressure decreases, but the instability of atmospheric pressure is high, while the actual duration of sunshine is shorter than the potential one.

We calculated the amount of relapses and contraction of rheumatism and the correlative dependence between individual meteorological indices (η) by months.

The correlative connection is high and contrary to the mean air temperature (η =-0.89...-0.95), the actual duration of sunshine in per cent (η =-0.72..-0.84) and the total amount of radiation (η =-0.70..-0.85). The correlative connection is noticeable and contrary to the quantity of precipitation (η =-0.60..-0.90) and the pressure of the mean water vapour (η =-0.60...-0.80). The above-mentioned connection is moderate and contrary to the mean speed of the wind (η =-0.33...-0.85).

The correlative connection is noticeable and not contrary to the mean relative humidity of the air (η =0.62..

0,74), the mean air pressure (η =0,60...0,91), the instability of the amplitude of the air pressure (η =0,66...1,0) and the minimal air pressure (η =0,67...0,86). All the correlative connections are completely plausible.

The results of the calculations show us that contraction of rheumatism has an obvious correlative relationship to meteorological agents. In periods when we notice the rise of a great number of cases and relapses, the following agents are typical: extensive instability of air temperature in the range of a subnormal temperature with noticeable deviations for the mean annual temperature, an increased mean relative humidity of the air, a low mean air pressure together with extensive instabilities, a considerable shortening of the actual duration of sunshine as compared with the potential duration and the decrease of total radiation from the mean of many years.

It is understandable that the meteorological agents have a complex effect while the importance of one or the other agent may vary. It can be presumed that the importance of meteorological agents in the spread of rheumatism is of a different type in the regions of a different climate. On a territory with a maritime climate the relationship between cases of rheumatism and climate is strongly expressed.

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ON LIPID METABOLISM IN ESTONIAN POPULATION DEPENDING ON SEASON AND DIET

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In the whole of nature rhythmical changes take place in accordance with the change of the seasons. Metabolism, lipid metabolism included, is subordinated to rhythmical fluctuations as well. Of the environmental factors climato-geographical conditions (temperature, solar radiation, changeability of weather etc.), food intake and other specific features exercise an influence.

The present work characterizes lipid metabolism and nutrition of some population-groups of the Estonian SSR during autumn and spring. An attempt is being made to find connexions between nutrition and the content of lipids in serum.

Material and Methods

In the autumn and the spring of 1966-69 in 118 adult members of fishermen's families, in 105 mental workers and in 51 undergraduates (average age 43, 38 and 21 respectively) a number of indices of lipid metabolism in serum were determi-

ned: total cholesterol and phospholipids by Blure's method, cholesterol fractions by the digitonin method according to Balakhovski and lipoprotein fractions by the paper-electrophoretic method according to Baumann (13). Relations of indices of lipid metabolism are expressed by the esterification coefficient of cholesterol (EC), which is the ratio of an esterified fraction of cholesterol to its total content, and by the ratio of phospholipids to cholesterol (P/C). The normal values of lipids in serum are estimated after A.A. Pokrovski (1969): total cholesterol at the age 18-30 = 150-200 mg%, at the age of 30-60 = 150-250 mg%, free cholesterol = 40-70 mg%, cholesterol esters = 90-135 mg%, phospholipids = 150-250 mg% and beta-lipoproteins = 65-70% (9).

The nutrition of the same individuals was studied by a questionnaire-weighing method (11, 13), which has been worked out at the Academy of Medical Sciences of the USSR - Institute for Nutrition, and is widely used in the USSR and Socialist countries for the study of the factual nutrition of the population. In the course of ten days 190 dietary cards were filled in; every day the amount of food consumed by the family was marked on the card. On the basis of coefficients, which take into consideration the character of work, age and sex of the family members, an average amount of foodstuffs per person a day was found. Proceeding from this, the caloricity of daily food and the content of protein, fat and carbohydrates were calculated with the help of food composition tables (7, 15). Data on the nutrition of undergraduates have been taken from the analysis of diploma-theses by R. Vee (1967) and A. Vernik (1968) from 150 study-cards of nutrition.

For statistical calculations of the data on lipid metabolism variation calculations and Student's t-test were used. The connexions between nutrition and serum lipids were found by correlation calculations (8). The probability of differences and the existence of correlations was estimated at a probability of 95% ($p \leq 0.05$).

Seasonal Differences in Lipid Metabolism

The average content of serum lipids in studied groups is shown in table 1. It became evident that in fishermen's families the difference in the content of total cholesterol and phospholipids in serum during spring and autumn were of no practical importance ($p > 0.05$), only the content of beta-lipoproteins proved to be authentically higher in spring than in autumn ($p < 0.05$).

In the lipid metabolism of mental workers several changes towards impairement appeared in spring. Thus in mental workers the average content of total cholesterol in serum was higher ($p < 0.01$) than in autumn, exceeding the norm ($p < 0.05$). The rise of total cholesterolemia occurred on account of the free fraction because of which EC dropped by spring ($p < 0.01$). The decline of phospholipidemia was not veracious, but at the same time P/C was lower in spring than in autumn ($p < 0.05$). The level of beta-lipoproteins exceeded the norm at both study periods ($p < 0.05$).

Seasonal changes of serum lipids in undergraduates showed the same tendency, but with a lower probability ($p > 0.05$). But the content of beta-lipoproteins had notably risen by spring. The content of total and free cholesterol exceeded the norm in spring ($p < 0.05$).

Thus in lipid metabolism seasonal changes did occur, which may have been caused by peculiarities of nutrition (10, 16), fluctuations of temperature, intensity of metabolism (5), neuro-humoral changes (14), physical activity and other factors. In the present work they are in the first place associated with the study of nutrition. In the literature available here data on persons of different occupations were absent. As the indices of lipid metabolism in the mental workers studied by us were more subject to seasonal influences than those of physical workers, we came the conclusion that physical work partly helps to normalize the impairment of lipid metabolism in spring that has been caused by other factors.

Table 1

Seasonal differences in lipid metabolism

Index	Group	Fishermen's families		Mental workers		Undergraduates	
	Season	Autumn	Spring	Autumn	Spring	Autumn	Spring
	Month	October	May-June	October	April-May	November	May
		M±m	M±m	M±m	M±m	M±m	M±m
Total cholesterol (mg%)		241±4.4	234±3.7	247±4.1	263±4.4	213±6.9	221±4.7
				$p < 0.01$			
Free cholesterol (mg%)		-	78±6.1	74±3.5	99±3.6	113±5.7	127±7.4
				$p < 0.01$			
Esterified cholesterol (mg%)		-	148±7.0	173±4.6	166±4.7	100±5.8	95±5.9
Coefficient of cholesterol esterification (EC)		-	0.64±0.025	0.68±0.015	0.62±0.012	0.48±0.026	0.44±0.029
				$p < 0.01$			
Phospholipids (mg%)		274±10.6	297±11.2	318±10.5	312±8.5	301±17.1	275±16.5
Ratio of phospholipids to cholesterol (P/C)		1.15±0.045	1.27±0.049	1.32±0.041	1.20±0.033	1.46±0.071	1.27±0.076
				$p < 0.05$		$p < 0.1$	
Alpha-lipoproteins (%)		34.4±0.64	31.0±0.52	27.9±0.65	28.7±0.59	34.0±1.29	27.2±0.64
						$p < 0.01$	
Beta-lipoproteins (%)		65.6±0.64	69.0±0.52	72.1±0.65	71.3±0.65	66.0±1.29	72.8±0.64
		$p < 0.01$				$p < 0.01$	

Nutrition

The results of the study of nutrition are shown in tables 2, 3 and 4.

Table 2

Consumption of foodstuffs (grams per person a day)

	Fishermen's families		Mental workers		Undergraduates		Norm (12)
	Autumn	Spring	Autumn	Spring	Autumn	Spring	
Cereals (calculated on flour)	328	380	357	336	418	442	330
Potatoes	574	506	365	320	453	462	265
Vegetables	113	63	329	165	192	168	400
Fruit, berries	241	40	254	144	261	78	260
Sugar	84	106	113	125	74	80	100
Honey	3	3	6	6	6	3	-
Vegetable oil	4	1	10	7	9	9	20
Margarine	4	8	12	10	-	-	-
Clarified fat	7	7	6	7	13	15	5
Meat and meat products	113	131	195	232	260	248	205
Fish and fish products	174	212	82	82	29	43	50
Butter	32	30	28	33	16	26	15
Milk	618	747	518	551	490	555	450
Milk curd	2	8	51	44	22	39	20
Cream	6	13	27	38	13	21	18
Cheese	4	6	21	23	5	7	18
Eggs	20	32	37	34	29	41	40

From the data of food composition (table 2) a number of common features in the nutrition of all study-groups became evident. The consumption of butter, fat and potatoes was excessive;

an adequate amount of milk, cereals, sugar, meat and meat products was found in the diet. Only in fishermen's families less meat was consumed because of a greater consumption of fish. There was a greater shortage of vegetables, fruit and berries in the diet. Little vegetable oil was used.

Table 3

Caloricity of food, content of protein, fat, cholesterol, carbohydrates (per person a day)

Index	Fishermen's families		Mental workers		Undergraduates		Norm (12)
	Autumn	Spring	Autumn	Spring	Autumn	Spring	
Caloricity (kcal)	3230	3650	3680	3645	3260	3070	3023
Protein (g)	91	106	104	102	91	91	97.6
Fat (g)	106	125	134	146	108	111	96.5
Carbohydrates (g)	457	498	488	456	460	406	420.9
Cholesterol (mg)	635	748	737	798	-	-	-
Protein (caloricity %)	12	12	11	11	11	12	12-14
Fat (caloricity %)	30	32	34	38	31	34	30
Carbohydrates (caloricity %)	58	56	55	51	58	54	56-58

It is seen from table 3 that the food of the persons under observation was of higher calorific value, too rich in fat, cholesterol and carbohydrates; a relative deficiency of protein was evident. The total caloricity was covered by 11-12% of protein, 31-38% by fat and 51-58% by carbohydrates. Disproportions in the weight relation of nutritive matters appeared. In the fishermen's families the ratio of protein, fat, carbohydrates was 1:1.2:4.9 (recommendable 1 : 1 : 4), in men-

tal workers 1 : 1.4 : 4.8 (recommendable 1 : 0.8 : 3) and in undergraduates 1 : 1.2 : 4.8 (recommendable 1 : 0.9 : 4) (12).

As sources of fat and cholesterol the most important in all groups were meat and meat products, butter and milk; in mental workers also cream and cheese played a relatively important part as a source of fat (table 4). Animal fat formed only 86-91% of the total amount. Although the food contained much fat, there was a great shortage of vegetable fat; it formed only 9-14% instead of the recommendable 30% of the total.

Table 4

Sources of Nutritive Matters (% of the total amount in food)

Foodstuff	Fishermen's families		Mental workers		Undergraduates	
	Autumn	Spring	Autumn	Spring	Autumn	Spring
1	2	3	4	5	6	7
Sources of fat in food (% of the total fat content in food)						
Milk	22	22	14	14	14	13
Butter	25	19	16	18	15	17.5
Cream, cheese, milk curd	2	4	14	14	8	10
Meat and meat products	27	29	29	31	46	42.5
Fish and fish products	5	5	3	2	2	2
Eggs	2	3	3	2	3	3.5
Margarine	7	5	7	5	4	2
Vegetable oil	3	0.7	6	5	0.5	2.5
Cereals	8	10	8	10	8	7
Animal fat	89	89	86	86	91	91
Vegetable fat	11	11	14	14	9	9

Table 4 continued

1	2	3	4	5	6	7
Sources of protein in food (% of the total protein content in food)						
Cereals	34	35	33	31	37	35
Meat and meat products	16	15	22	25	28	26
Milk and milk products	20	22	24	25	18	22
Fish and fish products	18	18	9	9	3	4
Potatoes, vegetables and fruit	10	7	9	7	11	9
Eggs	2	3	3	3	3	4
Animal protein	56	58	58	62	52	56
Vegetable protein	44	42	42	38	48	44
Sources of carbohydrates in food (% of the total carbohydrate content in food)						
Cereals	50	53	51	51	54	55
Sugar, honey, jam	20	20	24	28	18	22
Potatoes	17	14	11	10	15	12
Vegetables, fruit	7	6	9	5	8	5.5
Milk and milk products	6	7	5	6	5	5.5
Foodstuffs containing mainly simple saccharides	26	27	29	34	23	27.5
Foodstuffs containing mainly complex saccharides	74	73	71	66	77	72.5

The most prominent protein sources were cereals, meat and milk-products - in the food of fisher families also fish and fish products. In the food of fisher families and mental workers the amount of animal protein was sufficient, i.e. 58-60% of the total. But in the food of undergraduates a

shortage of animal protein appeared - it was 52-56% of the recommendable 60% of the total protein amount of food.

As sources of carbohydrates cereals were prominent. Relatively large was the share of sugar and potatoes, but at the same time the share of vegetable and fruit was insufficient. The ratio of the foodstuffs which contain manly simple and complex saccharides as a source of carbohydrates was 1:1.9-3.0 points to too large a share of simple saccharides in the food.

The composition of food was somewhat varied in the groups under observation. The food of mental workers answered least to the physiological requirements. In the food of undergraduates appeared a shortage of protein, which is especially important to people doing mental work. In the mental workers' group a surplus caloricity in food, excessive consumption of fat, the highest rate of simple saccharides and the lowest rate of polysaccharides in carbohydrates was found. As to the choice of foodstuffs the food of mental workers was varied enough, but at the same time it contained too much fat and sweet foodstuffs. Although the food of fishermen's families proved to be more onesided in the choice, it contained more natural products and fewer chemically refined ones.

The seasonal analysis revealed a number of seasonal differences. The most important were: a larger content of fat, cholesterol and sugar, and a shortage of vegetables and fruit in spring. The food was richer in animal products in spring - mainly meat, clarified fat and milk products. In autumn animal products covered 36-37% of the total caloricity of food, in spring 39-40%, Because of the seasonal differences in the composition of food the proportions of nutritive matters in the energy balance changed. In spring fat constituted 32-38% of the caloricity of food, in autumn 30-34%; carbohydrates in spring 51-56%, in autumn 55-58%. The share of proteins did not vary.

Seasonal changes were somewhat different in the food of workers of different occupations. In the food of fishermen's families the amount of fat, protein and carbohydrates had risen by spring, due to a larger consumption of cereals,

sugar, fish and milk products (milk-curd, cream, cheese). In the food of mental workers a rise in the amount of fat and decline in the total amount of carbohydrates was prevalent by spring. At that only the share of cereals containing polysaccharides, potatoes, vegetabels and fruit declined, and the share of sugar and fatty meat- and milk-products (butter, cream, cheese) rose.

Seasonal changes in nutrition arise from climato-geographical peculiarities of the republic and food habits of the population. The degree of accordance of food to physiological requirements and seasonal differences in study groups is associated with the indices of serum lipids as shown further.

Connexions between Lipid Metabolism and Nutrition

Correlation calculations brought forth a number of connexions between the lipid metabolism of study groups and the average data of factual nutrition during the autumn and spring periods (table 5).

Table 5

Correlations between indices of lipid metabolism and caloricity of food and chemical composition
(correlation coefficients $p<0.05$ are underlined)

Index	Cholesterol (mg%)			Phospho-lipids (mg%)	Beta-lipo-proteins (%)
	total	free	esters		
Caloricity (kcal)	+0,601	-0,854	+0,931	+0,755	+0,239
Protein (g)	-0,623	-0,856	+0,887	+0,668	+0,328
Fat (g)	+0,741	-0,560	+0,914	+0,757	+0,474
Carbohydrates (g)	+0,248	-0,852	+0,644	+0,498	-0,160
Cholesterol (mg)	+0,526	+0,987	+0,134	+0,648	+0,649

The content of total cholesterol in serum had a positive correlation with the total caloricity and fat content of food - and a negative one with the protein content. The content of total cholesterol in serum had an authentic positive correlation with the content of butter ($r=+0.720$), cheese ($r=+0.714$) and sugar ($r=+0.791$) in the food, - and a negative correlation with the amount of cereals ($r=-0.729$).

On grounds of the established correlations and similar data found in the literature(1, 2, 3, 4, 6), there is reason to conclude that the level of total cholesterol is the higher the greater the calorific value, and the richer in fat and sugar and the poorer in protein and polysaccharides the food is. The different effect of carbohydrates on cholesterolemia is also confirmed by the found positive correlation with the percentual part of the total amount of dietary carbohydrates which mainly contain monosaccharides, and the negative correlation with foodstuffs mainly containing polysaccharides ($r=+0.802$, $p < 0.01$).

The content of free cholesterol in serum correlated positively with the cholesterol content in food, and negatively with the amount of proteins and carbohydrates. Meat and meat products as main sources of food-cholesterol gave a positive connexion ($r=+0.739$) with the content of a free cholesterol fraction in serum.

Between the content of the esterified cholesterol fraction and phospholipids in serum a positive correlation with the caloricity, protein and fat amount in food became evident; in esterified cholesterol also with the content of carbohydrates in food. Some foodstuffs had positive correlations with serum cholesterol esters, like butter ($r=+0.718$), cheese ($r=+0.804$) and the amount of sugar ($r=+0.941$); but with phospholipids the amount of cream ($r=+0.640$), cheese ($r=+0.780$) and sugar ($r=+0.715$). Negative correlations became evident between the esterified fraction of cholesterol in serum and the amount of cereals in food ($r=-0.941$), and between the level of phospholipids in serum and the amount of potatoes in food ($r=-0.731$).

Connexions between the protein content in food and the content of lipids in serum can be explained by the participation of proteins in the esterification of cholesterol and the synthesis of phospholipids in the fermentation system as well in the transport of substrata. Dietary fat and carbohydrates appear to be sources of fatty acids as the substrata in serum lipid synthesis.

The different levels of beta-lipoproteinemia in study groups had no authentic connexion with the caloricity and composition of food. Of the foodstuffs only eggs (r=+0.712) and cream (r=+0.610) gave a positive correlation with the content of beta-lipoproteins in serum. In literature we find data on the influence of food on lipoproteinemia (10, 16). We explain the absence of connexions in our research by the fact that lipoproteinemia was probably influenced more by other factors, like nervous tension, physical activity, sex. It is partly explained by the endogenous origin of lipoproteins, in consequence wich food influences them less than other serum lipids.

It is evident from the above that food is one of the most essential factors to influence lipid metabolism. One of the reasons for high cholesterolemia, phospholipidemia and beta-lipoproteinemia in the population of the Estonian SSR is the composition of food: high caloricity, excessive amount of animal fat, cholesterol and sugar in the food, a relative deficiency of protein and vegetable fat. Seasonal changes of lipid metabolism may also be connected with seasonal peculiarities of food: in spring a greater content of fat and cholesterol, and a greater shortage of vegetables and fruit, which are rich in vitamin C. But it is more correct to explain the differences of lipid metabolism in the study groups by the result of a joint influence of many factors; different character of occupation, degree of mental and physical tension, adequacy of food rations to physiological requirements and other factors which have not been investigated by us (heredity, climato-geographical peculiarities and others).

Summary

The seasonal study of lipid metabolism in some population groups of the Estonian SSR showed that the content of lipids in serum was higher in spring than in autumn, i.e. seasonal differences appeared. Thereby the metabolism of metal workers was more influenced by the seasons than that of physical workers.

Seasonal differences in the indices of lipid metabolism were connected with the character of work and the peculiarities of nutrition. Correlation analysis brought forth a number of connexions between the content of serum lipids and the indices of nutrition. High caloricity, disproportions and seasonal differences in diet are some of the main reasons for disturbances in lipid metabolism in the population of Estonia. It is therefore necessary to bring the diet consciously into accordance with physiological requirements of the respective groups of workers and to avoid seasonal deficiencies in nutrition.

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THE ROLE OF MENTAL STRESS IN THE PATHOGENESIS OF CARDIAC ISCHAEMIA

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Hyperlipemia as one of the basic factors of atherogenesis is generally recognized, whereas the origin of the disturbances of lipid metabolism is still under discussion. The alimentary factor in lipid metabolism has been extensively studied, at the same time the effect of emotional stress has been insufficiently elucidated. In this connection the task of the present investigation was to explain the effect of emotional stress of different intensity and duration on the content of cholesterol, phospho-lipids, beta-lipoproteids and free fatty acids (FFA) in blood serum. As an indicator of emotional stress besides FFA an original fluorimetric method was used to determine the protein-bound catecholamines in plasma, which gives a possibility of adequately estimating the state of the sympatho-adrenal system (SAS). According to our findings an increase of the specific fluorescence of plasma reflects the intensification of SAS activity, and vice versa.

The spontaneous spectrum of blood lipids was studied in various age groups of the population who suffured from mental strain of varying intensity (scientific workers, doctors, students and pupils). We investigated also changes in blood lipid content in acute and subacute psychic stress; for this purpose students and patients with cardiac ischaemia were examined.

Data on the spontaneous content of blood lipids are given in the summary table (Table 1). These data are compared with the corresponding indices of persons who are physically more active (fishermen and members of their families, pupils systematically going in for sports).

It is worth mentioning that scientific workers and doctors have the highest serum lipid content, exceeding the corresponding figures of all the other groups under examination. It is a serious consideration that pupils have a high content of blood lipids, although the average age of this group is only 13. The last-named group may be contrasted with young sportsmen of the same age whose blood lipid content is remarkably lower. It may be presumed that systematical physical training normalizes the content of blood lipids. In this connection it should be mentioned that the high blood lipid content of scientific workers may be the result of their insufficient physical activity and food of high calorific value. On the average the caloric content of a scientific worker's food during a day is 3,660 Kcal, in which fats make up 36% (in a fisherman's family the corresponding figures are 3,440 Kcal and 31%).

Our second task was to elucidate the effect of acute and subacute psychic stress on the content of blood lipids, while all the groups under examination had the same diet and physical activity.

The subjects examined were: 1) third-year students of the Medical Faculty (n= 61), in whom emotional stress was caused by continuous mental burden during the preparation and examination period (subacute emotional stress); 2) patients with ischaemic heart disease (n = 47) in whom psychic excitement was called forth by questioning them about details of their biographies and diseases, and who underwent medical procedures (vein puncture) and psychological tests in order to find out their reaction period and differentiation ability. the venous blood of the students for analysis was taken between examination sessions, during a comparatively tranquil period, and just before entering the examination room (the catecholamine content of plasma was also determined one hour

Table 1

Blood serum lipid content in certain groups of population

Group	Average age	Cholesterol (mg %)			Phospholipids (mg %)			Beta-lipoproteins (%)		
		n	M	± m	n	M	± m	n	M	± m
Fishermen's families	43	217	237	± 2.9	188	285	± 7.8	211	67.5	± 0.40
Pupils-sportsmen	15	83	207	± 3.6	81	294	± 9.9	83	65.8	± 0.54
Scientific workers and doctors	38	199	255	± 3.0	187	315	± 6.7	197	71.1	± 0.44
Students	21	91	217	± 3.9	89	286	±11.9	88	69.8	± 0.73
Pupils	13	63	231	± 5.9	61	273	±11.1	53	69.9	± 1.43
Normal values:		150-200 (18-30) 150-250 (30-60)				150-250			67-70	

after the examination). Blood tests of the ischaemic heart disease patients were made before and after the experimentally induced psychic stress.

In all the students examination stress caused a considerable activation of SAS, which, compared with a tranquil period, was expressed by a higher adrenaline and noradrenaline content in blood plasma by 13% and 26% accordingly. One hour after an examination in 52% of the students the catecholamine content in plasma became lower, but it did not reach the average level of the period without stress. After an examination plasma catecholamine content did not decrease, or was even higher in 48% of the students. SAS activity did not become duly normal chiefly in these students who were not satisfied with examination results, who had a labile nervous system, or who, before their examination, had used drugs stimulating the central nervous system.

In the examination situation a higher content of blood lipids was also observed (statistically significant). The corresponding data are given in Table 2. In the control group were 18 subjects of the same age who were not engaged in mental work. As a contrast to the content of other blood lipid fractions the FFA content in the students' blood serum was lower than in that of the control group and decreased even more during the preparation and examination period. This is in contrast to the previous investigation data confirming a parallel increase of SAS activity and FFA content in blood serum. This obviously holds true of cases of acute stress. In our experiments, however, we deal with prolonged psychic stress which may exhaust the mechanisms regulating FFA content.

Acute psychic stress in patients with ischaemic heart disease caused an increase of catecholamine conditioned specific fluorescence (11.4 ± 0.6 fluorimetric units —— 13.1 ± 0.6 fluorimetric units, p 0.05), and also FFA content was higher (0.52 ± 0.05 mEq/L —— 0.58 ± 0.05 mEq/L, p 0.05). It is to be mentioned that in six patients the mode of emotional stress used in the investigation did not cause an increase of SAS

Table 2

Serum lipid content in students under the influence of subacute emotional stress caused by examination situation

Indices	Control group	Between examination sessions	Immediately before an examination
Cholesterol (mg %)	179 ± 26.5	192.7 ± 8.08	210 ± 8.8
			p 0.05
Phospholipids (mg %)	192.2 ± 14.6	205 ± 11.6	226 ± 2.6
			p 0.05
Beta-lipoproteins (FU)	0.27 ± 0.05	0.34 ± 0.02	0.40 ± 0.03
			p 0.05
FFA (mEq/L)	0.51 ± 0.04	0.49 ± 0.04	0.38 ± 0.03
			p 0.05

activity and the FFA content in blood serum. In patients with ischaemic heart disease, due to emotional stress, the average content of cholesterol, phospholipids and beta-lipoproteids in blood increased (statistically insignificant). A statistically significant increase of all the determined blood lipid fractions was observed in the group of patients (n=16) whose ischaemic heart disease had been caused by at least eight risk factors.

Under the influence of tranquilizers (meprobamat and tiserein) blood lipid content decreased in cardiac ischaemia patients, in certain cases it even normalized. When the adrenergic beta-receptorblocking agent inderal was applied, acute emotional stress did not cause essential changes in lipid metabolism.

The majority of researchers are of the opinion that hyperlipemia is one of the chief pathogenetic mechanisms of ischaemic heart disease. Our investigations, in their turn, prove the fact that disturbances in lipid metabolism are caused, besides the alimentary factor, also by overstrain of the nervous system.

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OCCURRENCE OF CORONARY RISK FACTORS IN MIDDLE-AGED AND ELDERLY ESTONIAN MEN

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Coronary heart disease is one of the most frequent diseases of advanced age in the majority of developed countries Therefore it is essential to explain the factors which have a bearing on the development of the coronary heart disease or so-called coronary risk factors (3,4,12). To date there are no effective methods for the treatment of the coronary heart disease. Establishment of the risk factors and gaining control over them can be the most important stage in the prevention and treatment of the disease (6). The association of the risk factors and the coronary heart disease is based upon results of extensive epidemiologic studies, but the data about the pathogenic role of single risk factors are contradictory (1,7).

R.OLSON (5) divides the risk factors into endogenous and exogenous factors. The endogenous risk factors are: (1) advanced age and male sex; (2) family or genetic predisposition; (3) raised serum cholesterol level; (4) peculiarities of the nervous system; (5) overweight and constitutional peculiarities; (6) related diseases (hypertension, diabetes, etc.). The exogenous factors which have a bearing on the development of the coronary heart disease include: (1) continuous psycho-emotional overstrain; (2) food rich in animal fats and refined carbohydrates; (3) smoking and alcohol intake; (4) physical inactivity.

The present paper deals with the investigation of the coronary risk factors in 105 men aged 31 to 64 years(average age 44.5 years). Group I was made up of 45 men with angina pectoris, examined and treated in the surgical department of the Tartu Municipal Clinical Hospital. Group II consisted of 30 healthy men and group III of 30 men in good health who had had regular physical training from 6 to 10 years.

A standardized questionnaire was used for the establishment of the risk factors. The serum cholesterol level was estimated by BLOOR's method and the beta-lipoproteids in the blood serum by BURSTEIN and SAMAILLE's method. The cholesterol level 200±50 mg % and the beta-lipoproteid level between 350 to 580 mg % were considered as normal. The peculiarities of the nervous system evoking coronary disease were determined by using the questionnaire of M.FRIEDMAN et al. (9).Arterial blood pressure above 150/90 mmHg was considered as hypertension. Overweight was calculated according to BROCA's index (11).

The results were calculated statistically at the Computing Centre of Tartu State University.

The most frequent risk factors in group I were: intensive cigarette smoking (84.4%), hypercholesterolemia (76.7%), continuos psycho-emotional overstrain (60.0%),hyper-betalipoproteidemia (55.6%), overweight (55.5%) and food rich in animal fat (46.6%). The role of the other risk factors was smaller. The main coronary risk factors in group II were hyper-beta-lipoproteidemia (60.0%), overweight (56.5%), cigarette smoking (50.0%) and in group III only smoking (53.3%) and overweight (46.5%).

The average number of risk factors for a patient with angina pectoris in group I was 5.4, in group II 4.2,and in group III 2.3 risk factors per person.

The most frequent combination of risk factors in coronary heart disease patients was: hypercholesterolemia + hyper - beta-lipoproteidemia + intensive cigarette smoking

(35.5 %). In group II the combination hyper-beta-lipoproteidemia + physical inactivity + smoking was highest (30.0%). In group III the most frequent combination of coronary risk factors was: hypercholesterolemia + cigarette smoking+ overweight (13.3%).

By comparing the occurrence of the risk factors in groups I and II, it appeared that among the angina pectoris patients there were more psycho-emotional overstrains ($p < 0.001$), raised serum cholesterol level ($p < 0.05$), intensive smoking ($p < 0.05$) and alcohol intake ($p < 0.05$). The difference between groups I and III was more expressed. Among the patients with coronary heart disease there were more intensive smokers ($p < 0.001$) and drinkers ($p < 0.001$), persons with psycho-emotional overstrain ($p < 0.001$), hypercholesterolemia and hyper-beta-lipoproteidemia ($p < 0.01$). The patients had also a higher systolic and mean blood pressure level ($p < 0.05$) and more peculiarities of the nervous system (type A behaviour pattern according to Friedman) ($p < 0.05$). Statistical differences between groups II and III consisted of a more frequent occurrence of hyper-beta-lipoproteidemia ($p < 0.01$), physical inactivity ($p < 0.001$) and psycho-emotional overstrain ($p < 0.05$) in group II. Statistical differences between angina pectoris patients and healthy men did not exist in the following coronary risk factors: overweight and constitutional peculiarities, family predisposition, food rich in refined carbohydrates, and diastolic blood pressure.

Correlations between the factors which have a bearing on the development of the coronary heart disease were as follows: hypercholesterolemia and A type behaviour pattern ($r = 0.491$), continuous psycho-emotional overstrain and hyper-beta-lipoproteidemia ($r = 0.431$), hypercholesterolemia and hyper-beta-lipoproteidemia ($r = 0.427$), peculiarities of the nervous system and hyper-beta-lipoproteidemia ($r = 0.403$), and food rich in animal fat and overweight ($r = 0.303$). A negative correlation existed between overweight and physi-

cal activity ($r = -0.396$), ($p < 0.05$ when $r \geq 0.273$, $p < 0.01$ when $r \geq 0.354$ and $p < 0.001$ when $r \geq 0.443$).

Analogical results have been obtained by several authors (2,3,8,10).

The present investigation indicates that intensive smoking and psycho-emotional overstrain have, besides the metabolic disturbances of lipids, an important role in the etio-pathogenesis of the coronary heart disease.

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EFFICACY OF THE PARASITES OF THE CABBAGE ROOT FLIES (HYLEMYIA BRASSICAE BOUCHÉ AND HYLEMYIA FLORALIS FALL.) UNDER VARIOUS ECOLOGICAL CONDITIONS

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Hylemyia brassicae Bouché and Hylemyia floralis Fall. are the most dangeruos pests of cruciferous crops in the Estonian SSR. The damage caused by the cabbage root flies may be particularly great and may in economical significance well exceed the damage inflicted by any other insect pest to the above-mentioned crops.

Of the chemical control methods recommended for use in the conditions prevailing in the Estonian SSR and the other Baltic Republics, the most efficient one is the spraying of pest imagos during the peak flight period with 0.1% Bi-58, 0.1% antio, 0.2% chlorofoss (80.5% technical product) or 0.3% trichlorometafoss-3.The use of the two last-named poisonous chemicals kills 70-90% of the maggots of H.brassicae (1,2).

Thus the present-day chemical control methods do not ensure the complete prevention of the damage produced by the cabbage root flies. Due to this circumstance the ascertainment of the natural enemies of these pests and the establishment of the possibilities of their use within the framework of an integrated control (chiefly in combination with the chemical control method) in the conditions prevailing

in the Estonian SSR are of interest. Since the residues of the insecticides chlorofoss and trichlorometafoss-3 completely fade away from the plants sprayed with them within 9 - 13 days (2) and after that they are no longer dangerous to parasitic insects, there exist preconditions for the use of such an integrated control.

Below will be presented the results obtained during the study of the natural enemies of cabbage root flies chiefly in the districts of Tartu, Jõgeva, Põlva and Võru on the basis of materials collected on collective farms as well as in private gardens.

It was established that the chief natural enemies of the cabbage root flies are the parasitic insects Tryblio - grapha rapae Westw. of the Cynipidae, and Aleochara bilineata Gyll. and Aleochara bipustulata L. of the Staphylinidae. The two first-named species occurred most frequently.

T. rapae is characterized by being proovogenic. The egg production of this parasite does not depend on the feeding of the imagos. At the emergence an imago is immediately able to set out in search of hosts and is capable of infecting them. With its eggs T. rapae infects all the three developmental stages of the larvae of the cabbage root flies. The infected larvae still produce a puparium but from it emerges an imago of the parasite. Hibernation occurs in the puparium of the host. The number of the parasite's generations depends on the rate of development of the host; in our climatic conditions it usually produces two generations a year.

The short-winged A. bilineata is characterized by being synovigenic. The maturation of the egg-production of beetles depends on the feeding of imagos. These, however, feed on the eggs of cabbage root flies and their maggots, hence they are predaceous. The larvae of A. bilineata have a parasitic way of life and they develop in the puparia of cabbage root

flies by devouring their content. Thus A.bilineata is characterized by the alternation of a parasitic way of life with the stage of a predaceous insect during the life-cycle of one individual in the course of which this entomophage is able to kill a large number of eggs, larvae and puparia of the cabbage root flies.

It appeared in the course of field work that the number of puparia of the cabbage root flies that were killed by T.rapae and A.bilineata in the fields of cruciferous crops varied greatly on different field plots, ranging from a few per cent to 54% of the hibernating pest population. In connection with that circumstance it was necessary to clear up the factors on which the degree of activity of their entomophages depended and the manner in which the said parasites might be utilized under the present conditionsofagronomical practices.

According to our three-year observations, the mass spring emergence of T.rapae and A.bilineata takes place at least two weeks after the mass flight of the cabbage root flies themselves.Since the period of activity of parasites occurs still later, it is conceivable that their activity should be integrated in time with chemical control,the latter being carried out by spraying the pests during the peak flight period (in the Estonian SSR usually during the second and third decades of May) with chlorofoss and trichlorometafoss-3.The comparatively rapid fading away of the residues of the above-mentioned insecticides from the surfaces of plants would make it possible to save the main lot of the parasites of the cabbage root flies and to use them after the carrying out of the chemical control to reduce the numbers of the pest populations that had survived.

When studying the degree of activity of parasites in nature;it proved to be essential to ascertain the efficacy of the entomophages under different growing conditions of

cruciferous crops. The evaluation of the efficacy of entomophages was performed on the basis of the following criteria: 1) the percentage of killed pest insects in the hibernating populations by parasites and diseases, 2) the rate of the spring death of seedlings induced by the cabbage root flies, which was determined by means of a four-point scale (1 point - loss of plants up to 10%, 2 points - loss of plants within the range of 10-25%, 3 points - death-rate ranging between 25-50%, 4 points - loss of plants over 50%). When investigating the activity of parasites, chiefly those materials were used which had been obtained from areas where no chemical control measures had been carried out; this was done with the aim of avoiding side-effects. The hibernating puparia of cabbage root flies were analyzed and the results of three years' work were statistically processed altogether in 8.000 individuals.

As a result of the studies performed, it appeared that the degree of activity of entomophages of the cabbage root flies was related to the growing conditions of plants. The activity of parasites was essentially affected by the exposure of fields, the structure of soils, as well as the presence of organic matter and other decomposing substances in the soil. The death rate of the puparia of the cabbage root flies always varied between 30-68% and the spring loss of young plants did not exceed 1 point in these fields where organic fertilizers were used or where there existed other decomposing substances in the soil and where soil structure enabled the parasite imagos to have better facilities of movement in search of hosts and in infecting them. The significance of organic substances can be explained by the fact that in the absence of insect hosts A. bilineata can feed on organic substances.

The death rate of the puparia of the cabbage root flies did not exceed 3-10% and the loss of young plants in spring

Table 1

Death rate of the hibernating puparia of the cabbage root flies in 1966. In fields 6,8,10 no organic fertilizers were used and the soil structure was negligible

Fields	Death rate of puparia (%)
1	60,7 ± 3,2
2	68,4 ± 4,1
3	34,3 ± 9,9
4	34,3 ± 6,5
5	50,7 ± 6,8
6	6,3 ± 1,9
7	38,6 ± 5,9
8	8,3 ± 1,0
9	41,8 ± 8,8
10	10,3 ± 2,9
11	29,7 ± 5,1
12	34,6 ± 4,4

generally varied within the range of 2 points and more in fields where the above-mentioned peculiarities were either completely or partly lacking.

Thus the encouragement of the activity of the parasites of the cabbage root flies may be feasible within the requirements of agronomic practices. Improvement of soil structure, use of organic fertilizers and choice of fields with a better exposition for cruciferous crops (slopes should be orientated towards the south, fields should be protected from northerly winds, etc.) - the improvement of the growing conditions of plants would at the same time be conducive to the parasites of the cabbage root flies. The carrying out of chemical control at an optimum time, i.e. at the peak period

of the spring flight of the imagos of the cabbage root flies, use of chlorofoss or trichlorometafoss-3 for spraying would help to save the natural enemies of these pests and create preconditions for their useful activity in summer.

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ON THE EFFECT OF MICROSPORIDIOSIS ON THE EUROPEAN CABBAGE-WORM PIERIS BRASSICAE L.

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In the natural control of the European cabbage-worm, Pieris brassicae L. various kinds of diseases and parasitic insects play an important role. The parasitic insects also are often spreading diseases in the pest population.

A rather widespread disease affecting P. brassicae is microsporidiosis whose causative agent is Nosema polyvora Blunck (Protozoa, Microsporidia).

The spores of N. polyvora may get into the organism of a butterfly in several ways. Caterpillars may become infected by eating the leaves on which spores of N. polyvora are found. A source of spores may be the excrements of diseased individuals, integuments or dead individuals. The disease may be transmitted to the offspring by eggs, and it may be disseminated by the parasite Apanteles glomeratus L. either by the ovipositor contaminated by spores or by the eggs themselves (1).

N. polyvora is an intracellular parasite. When multiplying in the cells, the cell walls are broken, the spores get into the hemolymph and are carried by the hemolymph all over the organism. Of the parts of the organism, the midgut is infected first of all, then gradually all the rest of the tissues. The disease is chronic by nature. Spores can be found in all the developmental stages of P. brassicae (4).

In the case of a weaker infection, the disease has no

acute external signs. For this reason microsporidiosis may often remain undetected in nature.

In the experiments carried out by us with the aim of studying microsporidiosis, three different concentrations of spores were used ($3.6 \cdot 10^3$, $3.6 \cdot 10^4$ and $3.6 \cdot 10^5$ spores per caterpillar).

Caterpillars were infected immediately on entering the third instar. Rearing proceeded at a temperature of $+21^{\circ}C \pm 1^{\circ}C$ and under illumination of 12 hours per day in batches of ten per one-litre glas jar.

Table 1

Weights of the pupae of P. brassicae

Treatment	Weight (mg)	m(mg)	s	Variability	Number of pupae
Controls	397.6	±5.9	48	326.4...480.4	66
N.polyvora $3.6 \cdot 10^3$	329.0	±12.2	70	196.2...425.0	33
N.polyvora $3.6 \cdot 10^4$	290.0	±11.3	50	181.5...359.7	20
N.polyvora $3.6 \cdot 10^5$	295.2	±9.55	53	208.5...381.9	31

The diseased larvae lost their appetite, their movements were slow, and they developed diarrhoea. A characteristic feature of the disease was the uneven growth and the non-simultaneous moulting of the caterpillars that had been derived from the same egg-cluster. The duration of the larval stage was delayed compared with the controls, being 23-38 and 21-25 days respectively. Several caterpillars underwent additional moulting, which was due to the circumstance similar to a juvenile hormone (2).

Infected caterpillars began to die already 4-5 days after being infected. Mortality was particularly high during moulting and pupation. Due to a decrease in reserve substances caterpillars could not undergo metamorphosis and there often occurred only partial pupation. As it is evident from the data presented in table 3, the best results could be obtained at a concentration of $3.6 \cdot 10^4$ spores per caterpillar. However, a ten times weaker concentration was strong enough to kill caterpillars and the mortality in this treatment was high.

Microsporidiosis produced an unstable diapause. Part of the pupae did not enter any diapause at all (Table 3). The butterflies that had emerged in autumn were killed by frost without producing any offspring. The butterflies at emergence had degenerated wings and were unable to fly.

Table 2

Supercooling points of the diapausing pupae of Pieris brassicae L. November, 1970.

Treatment	$M^{\circ}C \pm m^{\circ}C$	Limits of variability	s	N
Controls	-25.43 ± 0.1	-24.5...-26.6	0.4	15
N.polyvora $3.6 \cdot 10^3$	-23.74 ± 0.38	-20.0...-25.2	1.48	15
N.polyvora $3.6 \cdot 10^4$	-22.00 ± 0.28	-22.0...-26.0	1.08	15
N.polyvora $3.6 \cdot 10^5$	-23.74 ± 0.43	-19.9...-25.2	1.66	15

Microsporidiosis was frequently accompanied by other dis-

Table 3

Death of caterpillars and pupae of P. brassicae as result of nosematosis

Treatment	Number of caterpillars	%	Died as caterpillars	%	Died as pupae	%	Non-diapausing pupae	%	Emergence of butterflies	%
Controls	70	100	10	14.3	12	17.1	-	-	47	67.1
N.polyvora $3.6 \cdot 10^3$	127	100	61	48.0	30	23.6	18	14.2	18	14.2
N.polyvora $3.6 \cdot 10^4$	145	100	113	77.9	22	15.2	3	2.1	7	4.8
N.polyvora $3.6 \cdot 10^5$	148	100	70	47.3	37	25.0	16	10.8	25	16.9

eases since the resistance of the organism to diseases had diminished. Due to an injury to the gut walls saprophytic bacteria of the gut flora got into interior of the body giving rise to an additional infection and in this way accompanying diseases, and not microsporidiosis itself, were the direct cause of death.

The pupae which had been infected with microsporidiosis were considerably smaller in size than the healthy ones (Table 1). Cold-hardiness in the diseased pupae was reduced (Table 2), which caused their death during hibernation. One of the causes of a reduced cold-hardiness could be the lability of the diapause, which was directly indicated by an increased intensity of breathing in the diseased pupae. According to SALT (3) the corpuscles (grain of dust etc.) that have got in the organism, may call forth a drop in the coldhardiness of the organism, being cristallization nuclei. It may be assumed that the spores of protozoa may be cristallization nuclei due to which the supercooling temperature of diseased pupae is higher than that of the healthy ones.

As the microscopical analyses of the caterpillars collected in the nature show, microsporidiosis is very widespread in Estonia. Thus 54% of the total caterpillars collected in the field near Tartu in 1970. were diseased.

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THE MICROSPORIDIAN PLISTOPHORA SCHUBERGI ZWÖLFER AS A PARASITE OF NOCTUIDAE

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Very little is known as yet about the diseases of night-moths. According to NILOVA (7) the protozoan Plistophora schubergi Zwölfer is known to be able to infect night-moths under natural conditions.

The diseases caused by protozoa in the conditions prevalent in the Estonian SSR have not been studied at all. For this reason the author of the present paper set herself the aim of investigating possibilities for infecting some species of the Noctuidae with P. schubergi under laboratory conditions. In the course of the experiments the author studied the effect of the induced disease on the mortality of these species of night - moths.The investigation was carried out at the Institute of Zoology and Botany, Tartu, Estonian SSR, in the years 1968-1969.Some of the data obtained will briefly be discussed in the present article.

The initial material of the microsporidian P. schubergi used in our experiments was obtained from the Laboratory of Microbiology of the All - Union Institute of Plant Protection. The material was multiplied on Agrotis exclamationis, which proved to be very susceptible to infection. The infected tissues were separated from the dead larvae, crushed and mixed with distilled water. The resulting suspension was filtrated and the filtrate was centrifuged 2 - 3 times for the cleaning of the spores

The concentration of the spore suspension was first de-

termined by means of the Goryayev counting -chamber and then diluted with distilled water down to the required concentration. The following spore concentrations were used: 1×10^4, 1×10^5, 1×10^6, and 1×10^7 spores per ml of water. The necessary amount of spores was smeared on the leaves of food plants and was fed to the larvae of night - moths which had been previously starved for 6 - 8 hours. To obtain a homogeneous experimental material, third - instar larvae were used that had moulted on the same day. The controls were fed leaves that had been smeared with distilled water. Experiments were carried out with the following species of Noctuidae: Agrotis exclamationis L., Barathra brassicae L., Mamestra persicariae L., Mamestra pisi L., Mamestra dissimilis Kn. and Mamestra oleraceae L. Caterpillars were brought up at a temperature of $+22^\circ \pm 1^\circ$ and at the day length of 12,5 hours. All the dead larvae were analyzed microscopically with the aim of identifying the cause of death. As is known, bacteria develop very quickly on dead larvae and so the real cause of death may often be disguised by the bacteria. To obviate this we analyzed the dead larvae as quickly as possible.

The disease induced by protozoa often has no external symptoms. For this reason microsporidiosis, in spite of being widespread in nature, may often go unnoticed and the death may be attributed to some other causes (1, 2, 6).

Nevertheless, a significant characteristic of the larvae that have molted from the same egg - cluster is the fact that they differ in size. This could often be noticed at the larvae infected by us. Dark spots appeared on the integument, and the hind legs of some larvae became black. The feet and the wings of the imagos that had developed from infected larvae were deformed. Diseased larvae became sluggish and their appetite diminished and before their death they ceased eating. Due to a decreased turgor of the hemolymph, the skin of these larvae became wrinkled and the abdomen turned inwards in the shape of a telescope. At

Table 1

Mortality rate of caterpillars infected by P.schubergi

Species	Treatment (amount of spores per larva)	Number of larvae	Mortality of larvae infected by: P.sch.	%	Bacteria	%	Viruses	%
Agrotis exclamationis	Controls	60	-	-	3	5	-	-
	1.7×10^4	60	23	38.3	7	11.6	-	-
	1.7×10^5	60	39	65	-	-	1	1.7
	1.7×10^6	60	60	100	-	-	-	-
	1.7×10^7	45	45	100	-	-	-	-
Barathra brassicae	Controls	80	-	-	4	5	-	-
	1×10^4	32	9	28.1	5	15.6	-	-
	1×10^5	34	25	73.6	-	-	-	-
	1×10^6	77	51	66.2	3	3.8	2	2.5
	2×10^7	86	79	91.8	5	5.8	2	2.3
Mamestra dissimilis	Controls	50	-	-	8	16	1	2
	1×10^4	40	3	7.5	2	5	3	7.5
	1×10^5	40	13	32.5	1	2.5	-	-
	1×10^6	40	21	52.5	7	17.5	2	5
	1×10^7	40	40	100	-	-	-	-
Mamestra persicariae	Controls	82	-	-	2	2.4	1	1.2
	1×10^5	104	13	12.5	3	2.8	2	1.9
	1×10^6	123	20	16.2	15	12.1	3	2.4
	1×10^7	73	41	56.1	15	20.5	-	-
Mamestra pisi	Controls	160	-	-	20	12.5	20	12.5
	1×10^5	40	-	-	10	25.0	9	22.5
	1×10^6	160	44	27.5	38	23.7	16	10.0
	1×10^7	100	71	71	25	25.0	5	5.0
Mamestra oleracea	Controls	80	-	-	2	2.5	1	1.2
	1×10^5	60	-	-	-	-	-	-
	1×10^6	80	1	1.2	3	3.7	6	7.5
	1×10^7	80	5	6.2	2	2.5	1	1.2

the final stage of the disease their excrements became fluid.

Several authors have reported that the efficiency of infections depends greatly on the number of ingested spores, the particular instar and the place of infection. According to NILOVA (7) and ISSI (5), the second and third instar have turned out to be the most suitable times for infection. Bearing that in mind, the larvae of the night-moths under study were infected in their third instar. It is also known that P. schubergi infects only the epithelium of the midgut of its hosts. Due to that circumstance, the said microsporidian has proved to be rather pathogenic and the larvae die after 6 to 7 days after infection.

The comparison of the doses of spores used according to different species (Table 1) points to the fact that 1×10^7 spores per larva proved to be lethal to the majority of the sp. studied. Mamestra persicariae and Mamestra pisi turned out to be most resistant to that dose. The individuals of Mamestra persicariae passed through the larval stage but died mostly in the pupal stage. In a few cases the imagos that had developed either proved to be sterile or the larvae that hatched from their eggs laid by them died at their first instars. We did not succeed in infecting Mamestra oleraceae with P. schubergi. Weaker doses of spores proved to be of little efficacy in nearly all the species. However, they increased the mortality of the offspring next year. Agrotis exclamationis turned out to be the most susceptible to P. schubergi and even smaller doses of spores exercised a strong effect. The mortality of the infected larvae also increased due to bacterial and virus diseases. It has also been reported that microsporidia may cause the transition of latent bacterial and virus diseases into acute ones (3, 4). We could often see cases when all these diseases had affected an individual. In such cases the larvae died in a much shorter period of time than otherwise. In the case of a mixed infection the death of the host insect results much sooner compared with the cases when these

diseases occur separetely. As can be seen from Table 1, a certain number of controls also died from bacterial and virus diseases. We tried to prevent the spread of these diseases by sterilizing the jars in which the infected larvae and the controls were reared. When avarage doses of spores were used, mortality from bacterial and virus diseases increased. In the case of strong doses mortality from microsporidiosis increased.

Conclusions

The following conclusions can be drawn from the data obtained:

(1) Under laboratory conditions it was possible to infect the following species of night - moths with the protozoan P. schubergi: Agrotis exclamationis, Barathra brassicae, Mamestra dissimilis, Mamestra pisi and Mamestra persicariae. Attempt at infecting the larvae of Mamestra oleraceae failed.

(2) From the point of view of mortality, the doses of 1×10^6 and 1×10^7 spores proved to be more efficient in the species studied. In other variants the precentage of survivals was higher.

(3) P. schubergi contributed to the outbreak of bacterial and virus diseases that had been latent before.

(4) The protozoan P. schubergi reduced the number of the host also in the succeeding generations.

(5) Considering the above mentioned characteristics, P. schubergi can be regarded as a promising microbiological agent when establishing the possibilities of biological control.

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