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COMPARISON OF THE USEFULNESS OF AN ENTOMOLOGICAL NET, PHOTO-ECLECTOR AND BIOCENOMETER FOR INVESTIGATION OF ENTOMOCENOSES*

Comparison was made of quantitative estimates of entomocenoses obtained in grassy and cultivated habitats by means of three different sampling techniques: an entomological net, a photo-eclector and a biocenometer combined with a suckingapparatus. The best results in ascertaining the abundance of insects are obtained by means of a biocenometer, but it was found that when the latter is combined with the entomological net sampling technique the scope of ecological investigations of insects is greatly extended.

The aim of this study is to compare estimates of the abundance of insects obtained by means of three different sampling techniques: an entomological net, biocenometer and photoeclector, and to ascertain which of them is the most suitable for estimating the numbers of insects in meadow habitats and agrocenoses.

The question of adequate estimation of the numbers of insects in meadow habitats and agrocenoses has been dealt with in numerous studies (Chauvin 1956/1957, 1965; Balogh 1958, Andrzejewska 1965, Andrzejewska and Kajak 1966), but none of the techniques hitherto proposed has been unconditionally accepted.

In addition there are no trying for standardisation of the various methods which define the way and scope of application of individual techniques.

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Standardization of sampling techniquest is of particular importance. Research on entomocenoses, especially investigations of the fluctuations in numbers of insects over the whole growth cycle, involves a whole group of technical and elaborating workers, is very laborious and in consequence very expensive. Data published should be comparable both in the same and between different habitats. At present, however, it is only possible to compare quantitative relations or tendencies contained in figures published. Direct comparison of abundance or densites is usually difficult on account of this lack of standardization of capture techniques. The difficulties encountered today will probably be, even greater in the future. The International Biological Programme presents research workers on quantitative evaluation techniques with especially important tasks. Investigations of the ecological and energy production of grassland and agrocenoses make it necessary to obtain particularly precise data on evaluation of densities of the animals living in a defined unit of surface of plant biomass, and maximum comparability of the data obtained in different geographical regions. In the present study special stress has been laid on the accuracy of quantitative evaluations.

I. STUDY AREA, SAMPLING TECHNIQUES AND MATERIAL

The investigations were made from 1963–1964 at the Agroecological Station at Turew in artificial habitats which could not be unequivocally classified from the phytosociological aspect:

1. An unmown meadow 0.25 ha in area, growing on marshy ground, becoming very wet in spring, situated in the immediate vicinity of a pond and covered with luxuriant vegetation.
2. A meadow mown for hay, about 1 ha in area, far drier than the preceding meadow, not becoming very wet in spring.
3. The grass layer of a shelter belt composed of two rows of trees, about 4 m in width, a dry, poor habitat.
4. A potato field.
5. An alfalfa field.

From the spring of 1965 continuous investigations were carried out using an entomological net and biocenometer in the entomocenoses of rye and potato fields and the grass layer of a shelter belt, the results of which were not directly used in the present elaboration, but will from the subject of a separate study.

The sampling instruments were made in our own workshop. The accepted sampling technique was adhered to in all the samples taken, with the exception of those in which a different way of collection data was used for the purposes of evaluating the usefulness of the method. A note of such changes is given when discussing results.

1. The entomological net is one of the most popular and simultaneously

one of the most criticised instruments used in investigations of entomocenoses (Balogh 1958). The instrument we used consisted of a metal ring to which a linen bag and a wooden handle were attaches. This folding ring or hoop, roughly 30 cm in diameter, of ϕ 5.5 mm steel wire, ensured the durability of the entomological net even under difficult field conditions. The hoop was connected to a wooden handle about 55 cm long. The replaceable bag was ungular in shape, and about 60 cm in height. Buttons were attached round the mouth of the bag (diameter approx 28 cm) to which rectangular exchangeable bags measuring approx. 15 × 20 cm were attached. These bags had loops sewn round the mouth by means of which they were attached to the net, and a little below this a drawstring by means of which the bag together with the insects it contained could be firmly secured at the end of sampling. When sampling particular attention was paid to maintaining the same way and speed of striking with the net, and for this reason the same person made the net samplings in both study years. Each sample consisted of 25 strokes. The insects caught were secured in the bag, which was placed for several hours in a bottle containing ether after taking it to the laboratory, and the insects after being killed in this way were removed from the bags, identified and entered on the list.

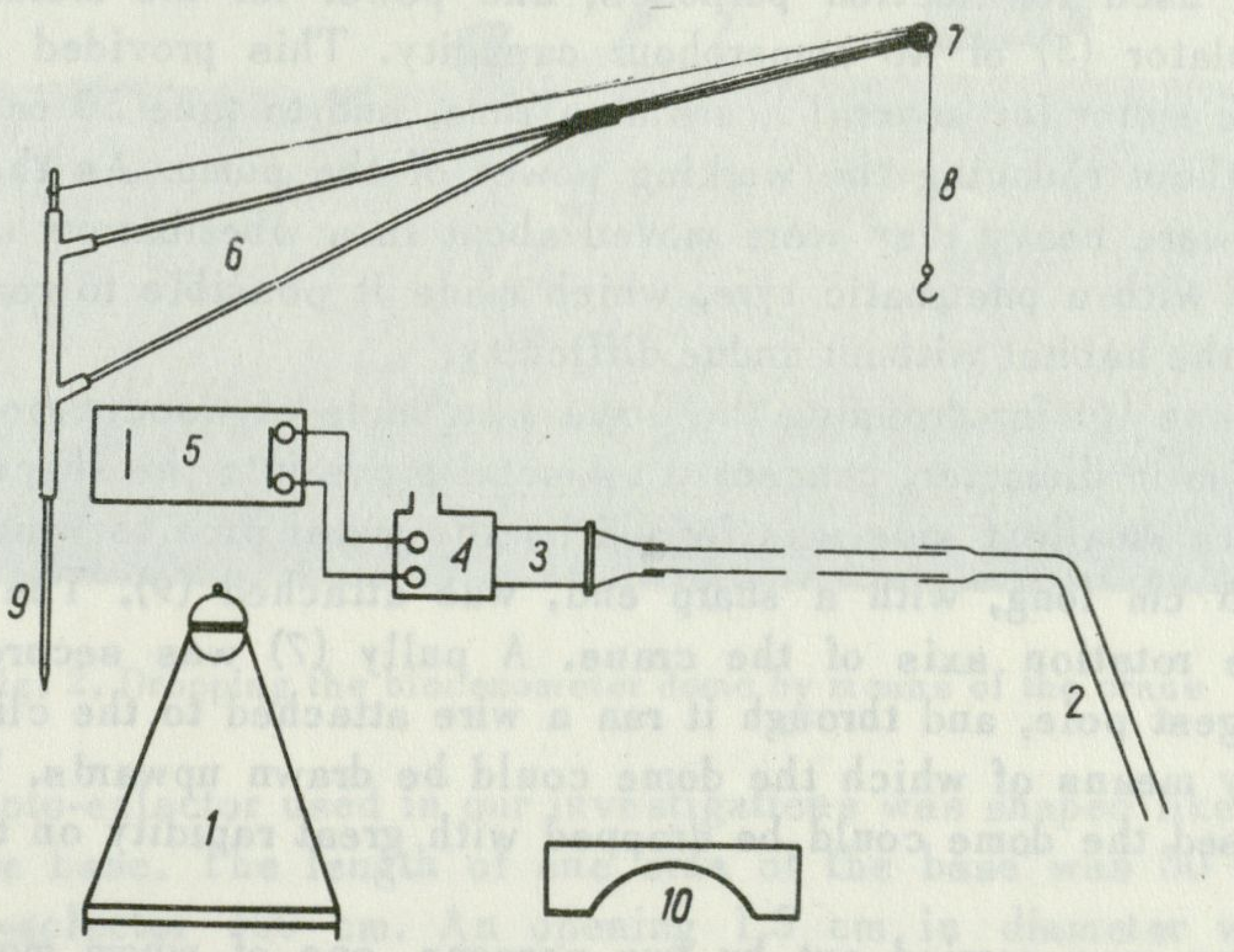

Fig. 1. Diagram of biocenometer

1 – dome, *2* – suction pipe, *3* – chamber with interchangeable bag in which insects are collected, *4* – suction pump, *5* – accumulator, *6* – crane for manipulating dome, *7* – pulley, *8* – wire, *9* – rotation axis of crane, *10* – special base for use in potato field

2. The biocenometer constructed for our investigations consisted of four parts (Fig. 1): a dome to enclose the insects (*1*), electrically driven suckers for collecting the insects (*2*, *3*, *4*), power supply (*5*) and crane for dropping the dome (*6*).

The dome (*1*) was similar in shape to a truncated pyramid with a square base (side of base measured 50 cm, height 100 cm). It was constructed in the following way: the base was made of fairly thick zinc tape 5 cm high, with a sharp bottom edge, and the four iron rods forming the edges of the pyramid were secured by rivets to the tape. The upper ends of the rods were connected by a metal ring 21 cm in diameter. The dome was covered with a fine mesh zinc net which prevented even very small insects from escaping while ensuring good visibility of the inside of the dome. The apex of the dome ended in a sleeve made of fine gauze, to the end of which a rubber ring was attached. This enabled the suckets to be introduced into the interior of the dome and to be manipulated as required without allowing the insects to escape. A wire clip was fastened to the top ring to carry the crane wire. When sampling in the potato field a special metal base (*10*) fitting into the furrows was attached to the lower part of the dome.

The sucker consisted of a plastic pipe from a vacuum cleaner, with a diameter of 3 cm (*2*), connected by means of a flexible hose with the suction pump of the electrically driven blowing engine (*4*). A metal ring was held by a special attachment between the pump and hose, and a cotton bag attached to the ring. The air drawn in from under the dome was filtered through the bag, in which the insects were retained. A pump driven by a 12 V electric motor was used for suction purposes, and power for the motor provided by an accumulator (*5*) of 48 amperohour capacity. This provided enough power to work the motor for several hours at a time, and to take 50 or more samples in turn without reducing the working power of the pump. As the accumulator and pump were heavy they were moved about in a wheelbarrow made of metal tubing and with a pneumatic tyre, which made it possible to reach any place desired in the habitat without undue difficulty.

The crane (*6*) for dropping the dome was made of wooden poles measuring approx. 35 m in diameter, connected by metal pipes into the shape of a triangle (Fig. 1). Its smallest side was formed by the metal pipe to which an iron rod approx. 165 cm long, with a sharp end, was attached (*9*). The pipe and rod formed the rotation axis of the crane. A pully (*7*) was secured to the end of the longest pole, and through it ran a wire attached to the clip of the dome ran (*8*), by means of which the dome could be drawn upwards. When the wire was released the dome could be dropped with great rapidity on to any desired spot.

Sampling was carried out by two persons, one of whom moved the crane and dome to the sampling site while the other moved the accumulator and sucker. The crane was fixed in position by driving the pole trough the pipe into the ground. The dome was then drawn upwards and the crane slowly rotated to the spot from which the sample was to be taken (Fig. 2). Directly the wire was released the dome dropped on to the ground, confining in its interior the insects present within an area of 0.25 m². The rapidity with which the dome was dropped the distance of the person sampling from the sampling site and the openwork construction of the dome, which did not create eddies or draughts as it dropped, formed favourable conditions for capturing even the most wary and rapid insects within the biocenometer. Directly the dome had been dropped the suction pipe was inserted into its interior, passed over the walls of the dome and the plants enclosed in it (Fig. 3). Sampling time formed one of the objects of our investigations. After sampling the person operating the crane moved the dome to another place, while at the same time the second person quickly closed the bag containing insects, and placed an empty bag on the metal ring. The insects captured were treated in the same way as those caught by the entomological net.

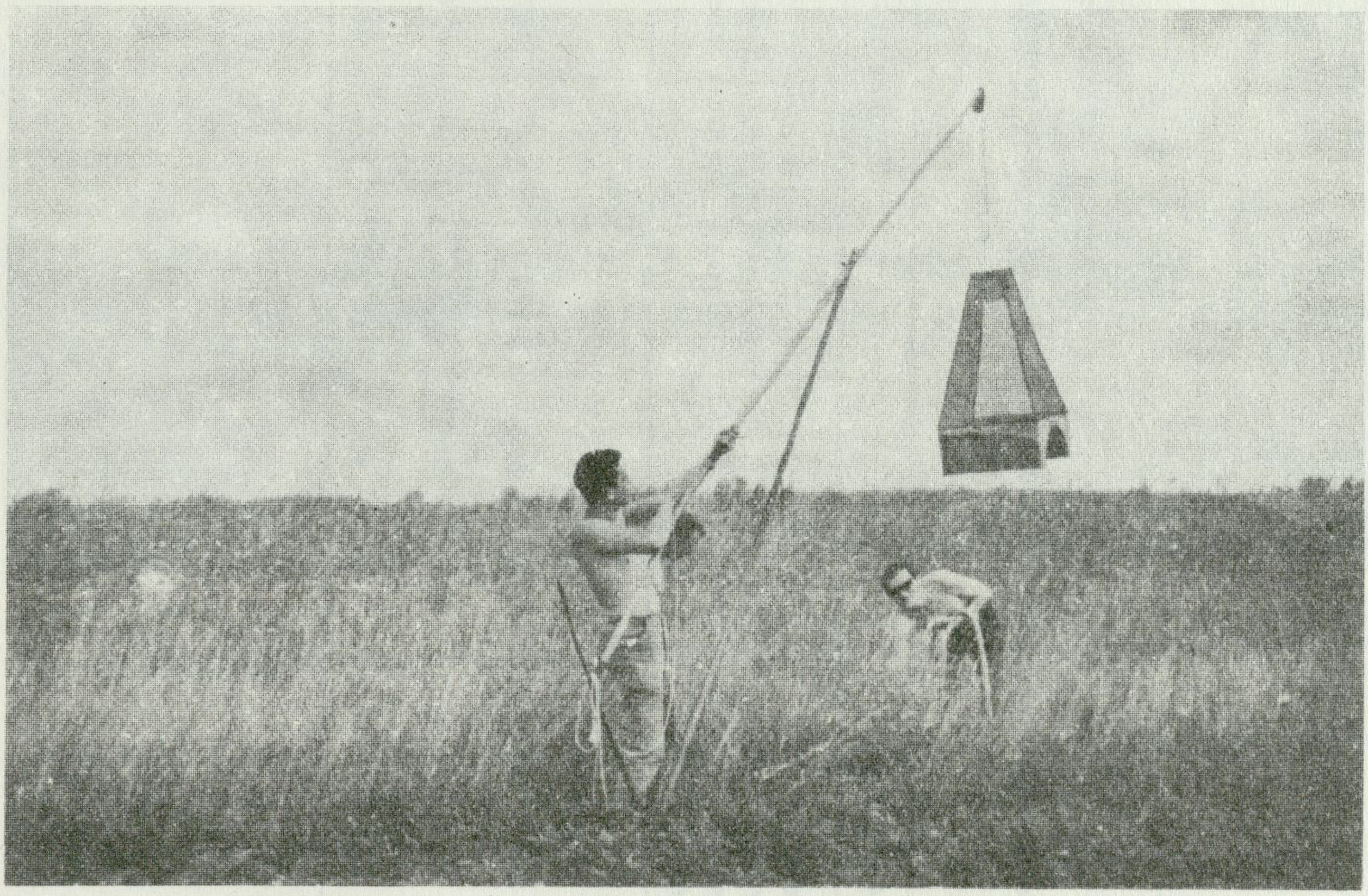

Fig. 2. Dropping the biocenometer dome by means of the crane

3. The photo-eclector used in our investigations was shaped like a pyramid with a square base. The length of one side of the base was 50 cm, height of the photo-eclector 100 cm. An opening 1.5 cm in diameter was drilled below the apex, through which a glass flask was inserted in which the insects imprisoned under the dome were collected. The photo-eclectors were arranged in the study habitats so as to avoid frightening away the insects with rapid flight and which reacted sharply to movement in the habitat. With this aim the person carrying out captures carefully approached the sampling site, stood still and raised the photo-eclector, remained motionless for a moment until the insects in the vicinity had setteled down, then quickly covered part of the grass layer with the dome of the photo-eclector. Two kinds of samples

Tab. I

Comparison of number of samples and insects captured by means of three sampling instruments

Sampling instrument	Number of samples					Number of individuals						
	unmown meadow	mown meadow	herb layer of shelter belt	potato field	alfalfa field	*Diptera*	*Homoptera*	*Coleoptera*	*Heteroptera*	*Hymenoptera*	Others	Total
Entomological net	125	70	30	10	30	5 666	3 374	1 635	907	694	518	12 794
Photo-eclector	45	47	–	–	–	368	214	18	20	101	11	732
Biocenometer	85	39	–	9	–	1 444	1 703	200	283	136	62	3 954

were taken: in the first the insects were taken from the flask five minutes after placing the photo-eclector in position, in the second thirty minutes later.

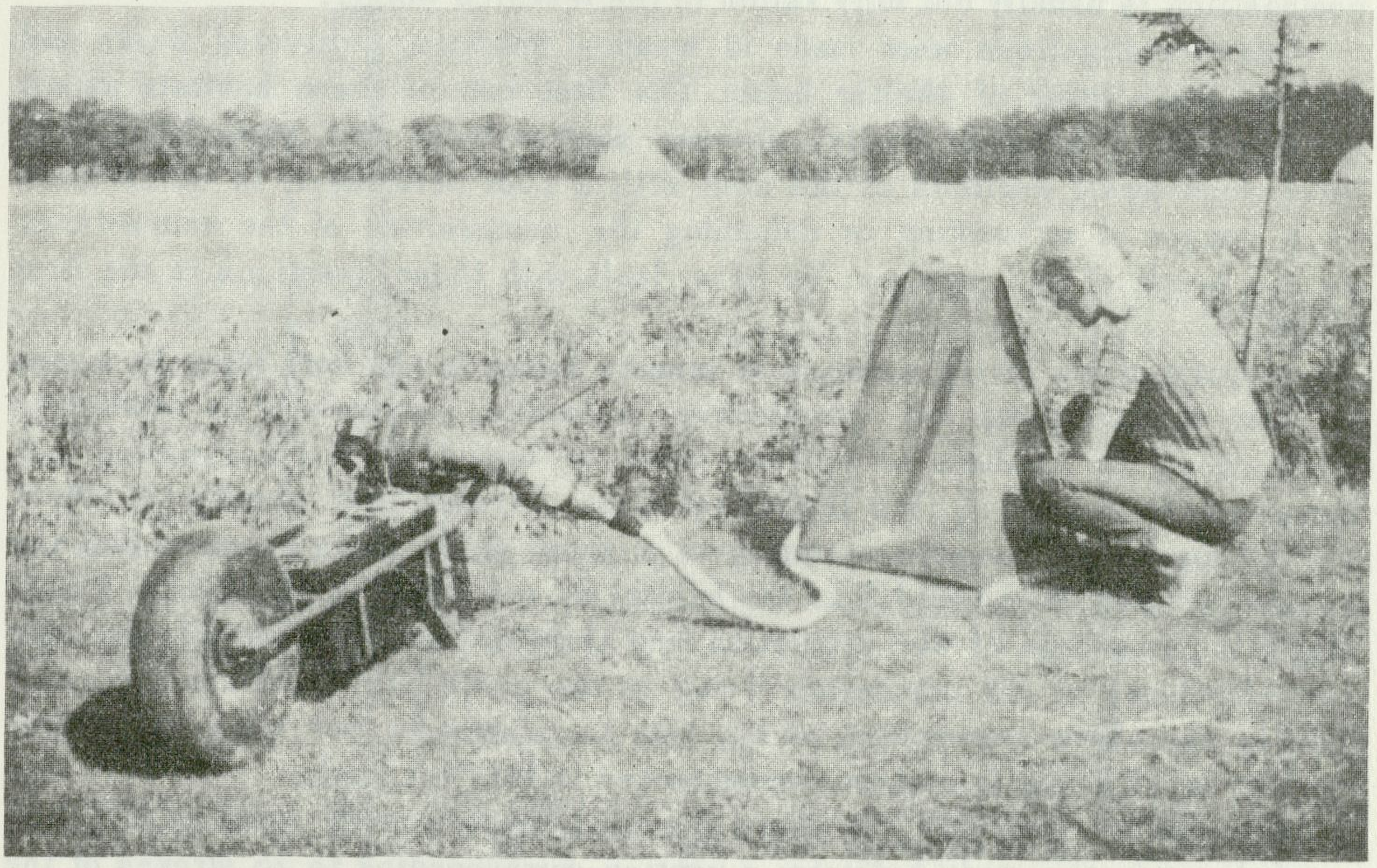

Fig. 3. Catching insects from inside the biocenometer dome by means of suction pipe

Sampling was carried out using all the sampling techniques on sunny days during the midday period.

The material collected is listed separately (Tab. I).

II. RESULTS

1. Entomological net

The usefulness of the entomological net for estimating numbers of insects is very limited; the data obtained may be interpreted only as assessments of numbers (Turnbull 1960). More exact estimates may be obtained by calculating results on the basis of data obtained from the biocenometer (Smalley 1960), or by marking the insects and using the Lincoln coefficient (Andrzejewska, Kajak 1966). Balogh (1958) proposes direct calculation of data per unit of area, recommending even strokes of the net over a defined measurable area. This technique is however difficult to apply correctly under field conditions, and also the fact that a given area is covered by net sweeps does not guarantee that all the insects there are caught. Efforts at using the entomological net for estimating the abundance of definite species combined with the use of supplementary information or techniques hold out hopes for the future, but it is more difficult to ascertain the effectiveness of this technique in relation to a varied entomocenosis, in which the species composition is usually not fully known to the research worker.

Our investigations were made in meadow habitats, cultivated fields and in the grass layer of shelter belts. The first two of these habitats permit of distributing samples freely, whereas shelter belts and grass boundaries often form small sections of the area with a poor herb layer, in which there is a danger of exhausting or deforming the composition of the entomofauna as the result of net captures. We have dealt with these questions in the first place.

Investigations of the numbers of insects living in the herb layer by means of the entomological net quantitative technique, particularly in relation to fluctuations in numbers of insects, must be based on the assumption that sampling by means of this instrument does not have any significant effect on the numbers of insects occurring in a given place. It is assumed that the number of insects removed from the habitat by net sampling forms only a negligible percentage of the population and therefore captures should not alter the abundance of the population living in the given habitat. While not questioning the above assumption, at any rate in relation to rich habitats, it must be born in mind that in certain circumstances it does not apply.

In order to elucidate the above question the following experiments were carried out in the study habitats: a section corresponding to 25 strokes of the net was measured out along a straight line, the ends of the section being marked by stakes. Samples were taken uninterruptedly along this line – each passage corresponded to one sample. Thirty samples each were taken from three different habitats in this way, the first from an unmown, wet meadow (Fig. 4), the second also from a grassy habitat, consisting of the poor dried-up herb layer of a single row shelter belt. The third series of captures were made in an alfalfa field (Fig. 5). The sum total of insects in different samples was used as an index. The numbers for different samples are shown in diagrams. Differences in total numbers can be observed between the habitats examined, being most distinct in the first samples and also differences in the course taken by variations in the numbers of animals in a given place as the result of complete removal by capture.

The initial differences observed in the first sample (Fig. 4, 5) are objective in character and supply information on the differences between the habitats examined. Decrease in the numbers of insects in later samples is due to the different effect of the same method on the insect population in a given place. Curves illustrating a decrease in numbers in grassy habitats are similar in character and point to the rapid exhaustion of the entomofauna when sampling is repeated in this habitat. Reduction of the entomofauna after ten consecutive samplings is nearly 95% in these habitats. The curve illus-

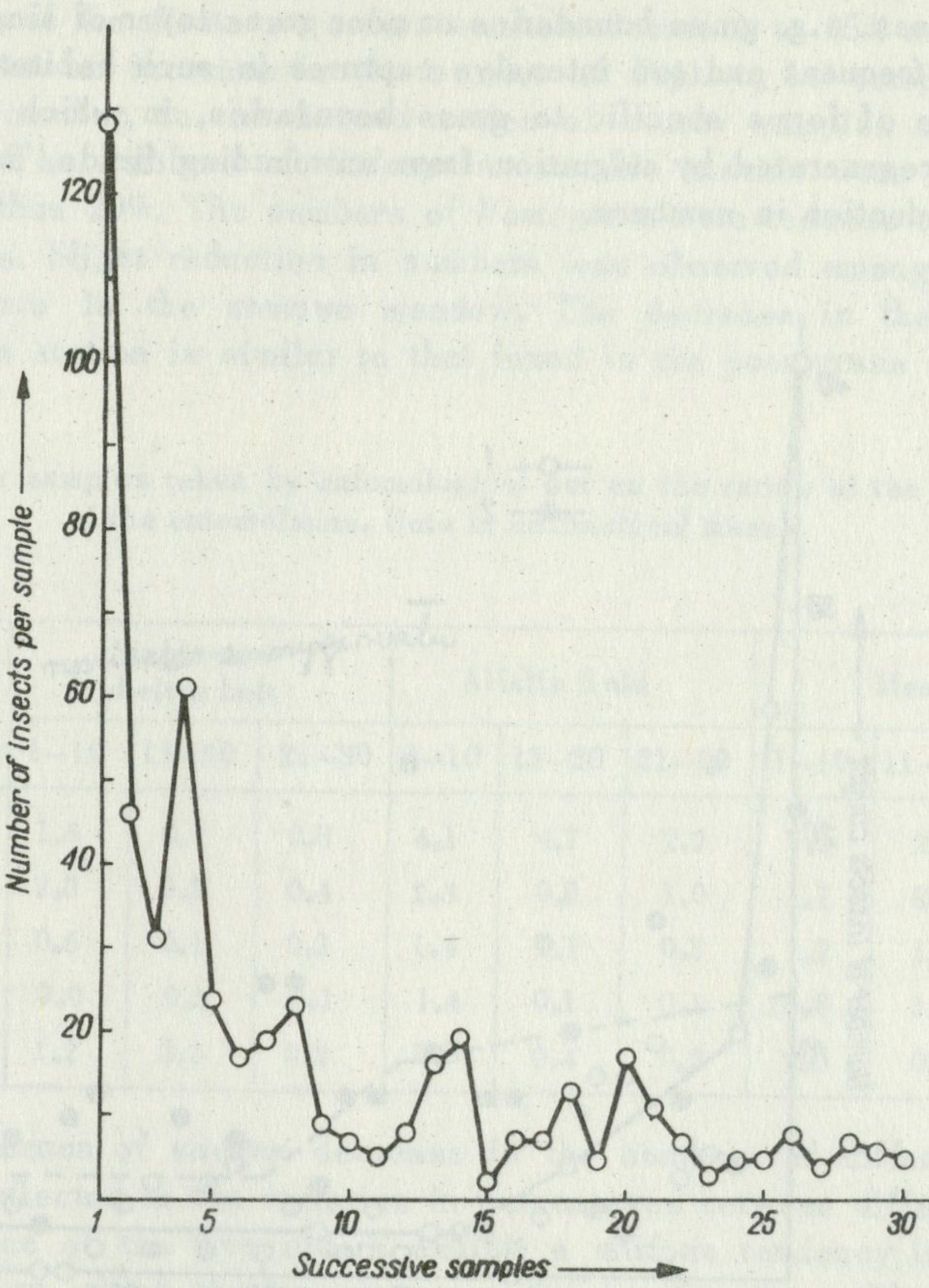

Fig. 4. Decrease in number of insects in successive net samples made in the same habitat

trating this decrease (Fig. 4) exhibits slight fluctuations and fairly regular course. On the alfalfa field (Fig. 5) very considerable dispersion of data is observed, but the decrease in numbers observed in the case of this series of samples is far smaller and is only 17% of the initial numbers after ten samplings have been carried out. It is not until after twenty consecutive captures have been made that a decrease in numbers of 65% of the initial number is observed in this habitat.

In large populations in which the entomofauna removed by net captures can easily be replaced by the migration of other insects, use of an entomological net for quantitative sampling does not involve the risk of exhausting the entomocenosis or disturbing the quantitative relations by one-sided capture of some definite forms. This possibility must however be taken into consideration in the case of such special habitats as are formed in agrocenoses, e.g. grass boundaries or poor grass layer of single-row shelter belts. Too frequent and too intensive captures in such habitats, particularly in the case of forms specific to grass boundaries, in which the population cannot be regenerated by migration from surrounding fields, may cause considerable reduction in numbers.

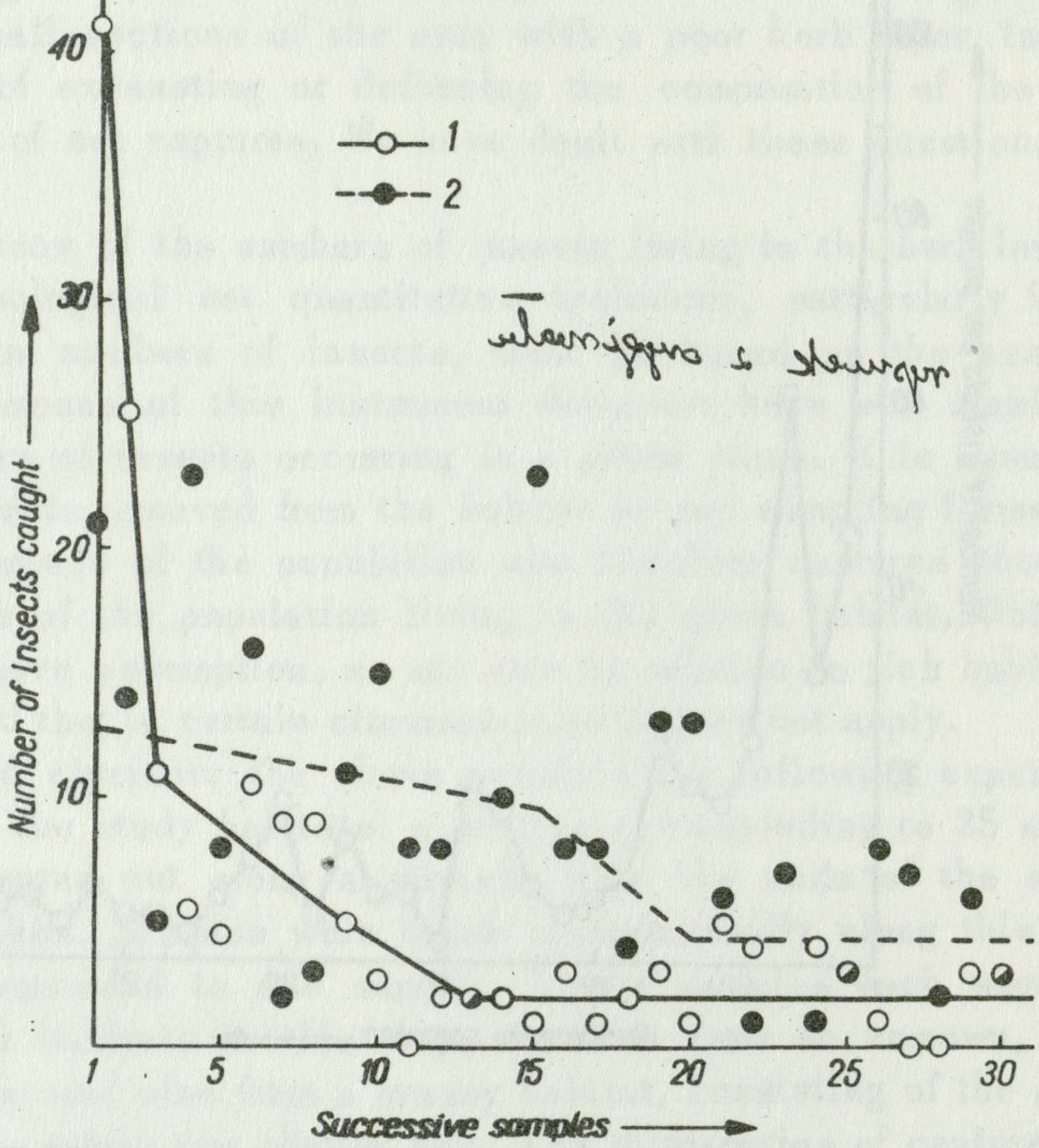

Fig. 5. Decrease in number of insects in successive net samples
1 – in grass layer of single-row shelter belt 2 – in alfalfa field

The second question to which attention was directed in the experiments discussed above on exhaustion of the entomocenosis by means of intensive net sampling is the change in the percentage of different groups of insects during the course of consecutive samples. For purposes of comparison examination was made of the relations observed in three successive tens of samples. From the eight orders of insects found in these samples the five most numerously represented in our material were taken for comparison. Considerable differences can be observed in the effect of the captures made by entomological net on the various orders of insects in the three study habitats (Tab. II). In the poorest habitat formed by the grass layer of the dry shelter belt the numbers of *Homoptera* and *Hymenoptera* decrease more markedly than in the case of *Diptera*, the numbers of which decrease only by half, whereas in the case of the first two orders numbers decrease to 25% or even less. There was even an increase in the number of *Diptera*, in comparison with their initial number, in the second series of twenty samples taken in the alfalfa field. The numbers of *Coleoptera* on this station were reduced by slightly more than 20%. The numbers of *Homoptera* were reduces to 7% of the initial numbers. Slight reduction in numbers was observed among *Coleoptera* and *Hymenoptera* in the unmown meadow. The decrease in the number of *Diptera* on this station is similar to that found in the poor grass layer of the shelter belt.

Effect of number samples taken by entomological net on the ratios of the chief groups of the entomofauna. Data in arithmetical means

Tab. II

Order	Single-row shelter belt			Alfalfa field			Meadow		
	1–10	11–20	21–30	1–10	11–20	21–30	1–10	11–20	21–30
Diptera	1.6	0.7	0.8	4.1	4.7	2.2	5.1	2.4	2.2
Hymenoptera	2.8	0.2	0.4	2.3	0.8	1.0	1.1	0.8	0.7
Coleoptera	0.6	0.1	0.3	1.4	1.1	0.3	1.2	1.1	0.5
Homoptera	8.0	0.5	0.1	1.4	0.1	0.1	23.0	3.4	2.3
Heteroptera	1.2	0.3	0.3	0.8	0.4	0.2	2.3	0.1	0.1

The phenomenon of uneven decrease in the numbers of different groups of insects is reflected in the variation in percentages between different orders (Tab. III). Three of the five orders exhibit a uniform tendency irrespective of the station on which the samples were taken. Together with exhaustion of the entomofauna we observe a constant increase in the percentage of *Diptera* and *Hymenoptera* in 10–20 and 20–30 consecutive samples. *Homoptera* exibits a systematic decrease in the percentage present in consecutive samples (Tab. III). The percentage of the numbers of *Coleoptera* and *Heteroptera* does not fluctuate so much and the direction taken by such variations is not uniform in the study habitats. The differences observed in the percentage of different groups point to increase in the percentage of active forms. This phenomenon may also occur in cases other than exhaustive sampling of the habitat. The reaction of escape of the active forms is not always definitely in the opposite direction from the sampling site, as the insects may escape into the upper from the lower parts of the herb layer; this reaction causes increase in the percentage of such insects in the samples obtained by entomological net.

The risk of selective exhaustive sampling of a given habitat makes it necessary to reduce samples to the smallest possible size. In investigations made in Poland the proposed standardisation of net capture technique is often accepted (Tarwid 1955), according the which 25 strokes with the net constitute one sample. Series of captures were made in meadow habitats using 5, 10 and 25 sweeps per sample. The captures were made parallel to each other in the same habitat and time so that the person operating the net took samples in turn consisting of an increasing number of strokes. Detailed data examined for *Diptera* present additional difficulty in regard to the interpretation of numbers obtained by using the quantitative net sampling method.

Percentages between chief orders of insects in successive tens of samples obtained by entomological net

Tab. III

Order	Shelterbelt			Alfalfa			Meadow		
	1–10	11–20	21–30	31–10	11–20	21–30	1–10	11–20	21–30
Diptera	11.19	38.89	42.11	35.34	49.47	50.00	14.66	30.77	36.07
Hymenoptera	19.58	11.11	21.05	19.83	8.42	22.72	3.16	10.26	11.48
Coleoptera	4.20	5.55	15.79	12.07	11.58	6.82	3.45	14.10	8.20
Homoptera	55.94	27.77	5.26	12.07	1.05	2.27	66.09	43.59	37.70
Heteroptera	8.39	16.67	15.79	6.90	4.21	4.55	6.61	1.28	1.63

Effect of number of strokes with entomological net on the number of species and numbers of meadow *Diptera* July 7 th 1964

Tab. IV

Number	Species			Individuals per sample		
Strokes with net	5	10	25	5	10	25
Unmown meadow 7.07.1964	21	24	24	15.9	20.5	21.3
Mown meadow 7.07.1964	28	27	46	6.7	10.1	20.7
Unmown meadow 7.07.1964	30	37	27	41.8	24.3	80.9

The degree to which the samples were representative was determined by means of the number of species and mean numbers of *Diptera* in samples (Tab. IV). The number of species in the series of samples consisting of 25 strokes in the three cases examined is either equal or greater or lesser than in samples consisting of 10 strokes with the net. The smallest sample contains in two cases a smaller and in one case a greater number of species than samples twice or five times greater. For the purpose of obtaining the highest degree of representativeness it is desiderable to increase the number of strokes per sample. Numbers exhibit more complicated relations (Tab. IV).

It would seem that increase in the number of strokes with the net should proportionally increase the number of insects caught, but in no case in our material was such an assumption confirmed; with a large number of strokes the number of *Diptera* caught is far smaller than might be supposed from the difference in the number of strokes with the net. A situation of this kind makes it impossible to interpred the data obtained by net sampling in relation to estimate of the numbers and density of the insects.

Comparison of the percentage of biological groups of *Diptera* using different numbers of strokes (Tab. V) shows that samples composed of 5 and 25 strokes give a truer picture of the percentage of different biological groups than the 10-stroke sample. The reasons for this difference are not clear, and the application of the entomological net technique to estimation of numbers and structure of the entomocenosis would appear unsuitable. We shall return to this question later.

Effect of number of strokes with entomological net on the percentages between main biological groups of *Diptera*

Tab. V

Habitat	Meadow			Unmown			Mown meadow		
Date	7.07.64			24.07.1964			24.07.1964		
Biological- group / number of strokes	5	10	25	5	10	25	5	10	25
Phytophaga	77.30	56.59	79.81	86.12	72.02	83.66	38.80	51.49	53.14
Saprophaga	0.63	1.95	0.84	4.31	5.35	2.23	20.90	9.90	9.66
Parasitica	0.63	1.95	0.84	1.91	5.35	2.47	10.44	22.70	21.74
Aphidophaga	3.14	1.95	0.84	0.48	2.47	0.37	3.00	4.95	6.28
Carnivora imago	17.61	36.59	17.39	6.70	14.40	11.00	26.80	9.90	7.25
Species alienae	0.63	0.97	0.28	0.48	0.41	0.37	0.00	0.99	1.93

2. Biocenometer combined with a suction apparatus

Suction apparatures were first applied to quantitative investigations of insects in 1950, and were constructed mainly for the purpose of estimating the number of flying insects, and on this account the intake end of the first apparatus of this type (Jackson 1950) was direct upwards. Chauvin (1956/1957) described the model of the apparatus used in his investigations, the intake of which was directed downwards. The action of suction apparatus has today been established as undoubtedly selective (Chauvin 1965) and the application of a manually operate handle (Southwood and Pleasance 1962) of a suction pipe to suck in insects from the herb layer, in the same way as American researchers do with a vacuum cleaner, also frightens away the rapid fly by moving insects and does not lessen the selective character of the way in which the suction apparatus works.

The factor determining the value of the results is not only the way in which the instrument is located, the through flow of air etc. The size of the sample is determined by the sampling time, and the figures obtained are therefore relative in character and cannot be referred to area, volume or mass.

The principle operating in biocenometer sampling consisting in enclosing a defined area together with the vegetation growing on it under the dome, and then capturing the animals within the dome, has led to this instrument being considered as the most suitable for use in all the known techniques of quantitative sampling of insects (Andrzejewska and Kajak 1966). The relatively small popularity of biocenometers for investigations of entomocenoses is due to two causes; the sampling time is considerably longer than in the case of sampling by means of an entomological net; biocenometers so far constructed are difficult to use with the field work system, since no light portable biocenometer has as yet been constructed, but the need for standardisation of results and relation of data to area or plant biomass forms an argument in favour of the use of domes of the biocenometer type.

Combination of the advantages of the two techniques i.e. adherence to a system of reference with the highest degree of comparability in investigations of entomocenoses such as is formed by a unit of area or capacity of the biocenometer dome with simultaneous rapid sampling facilitated by using pneumatic suction apparatus would appear most desirable. It must be emphasised here that the use of a dome to which a suction pipe is attached in a fixed position, such as that used by Chauvin (1956/1957) does not meet such requirements, as the insects living in the part of the herb layer nearest the ground, and also exhibiting a negative reaction to air movement, can shelter and will not be drawn in to the suction pipe.

A standard biocenometer should comply with the following requirements:

1. Sampling surface 0.25 m^2. There are several reasons why this size is most suitable. Increase in sampling area to 1 m^2 (Remane 1958) or even greater does make it possible, it is true, to estimate the numbers of insects dispersed over the area more exactly, but limits the possibility of obtaining larger series of samples, which is essential in estimating density distribution. A small surface of 0.045 m^2 (Johnson, Southwood, Entwistle 1957) or 0.01m^2 (Heikinheimo, Raatikanen 1962) may seriously deform the relations between different components, particularly when cylinders open at the top are used. The sampling area of 0.25 m^2 used in our investigations and those made by Andrzejewska and Kajak (1966) is correct for estimating the chief component elements of entomocenoses of meadow habitats and agrocenoses (*Homoptera* and *Diptera*), but is not sufficient for estimating the numbers of *Orthoptera*.

2. The structure of the dome should be as open as possible in order to prevent the formation of air eddies when dropped on to the ground. Only mesh-covered biocenometers are suitable for this purpose, as biocenometers

of cylindrical shape closed at the top (B a l o g h 1958) cause a column of air to strike the sampling surface and may frighten some of the insects away, whereas cylinders open at the top, which are closed after dropping them on the sampling area, while not causing air eddies allow some of the fauna to escape. Biocenometers with completely closed sides are not suitable for catching insects alive.

3. Suction pipes. When biocenometer domes measuring 0.25 m^2 are used suction pipes equal in diameter to the area sampled cannot be used (D i e t r i c k, S c h i l i n g e r, B o s c h 1959, D i e t r i c k 1961). It would appear to be most desirable to use 2–3 cm diametre pipes and to provide an appliance for regulating the through flow of air, making it possible to adjust it as required to sampling conditions. In our opinion the optimum through flow of air is one which is sufficient to suck in insects without at the same time drawing in grains of sand. Samples obtained with this air flow contain very little litter and are therefore easier to sort.

If the above standards are adhered to in biocenometer sampling the instrument then becomes very suitable for quantitative investigations of entomocenoses. The results obtained show that it is usufel for estimating both density and the percentage of different groups of insects.

Capture of *Diptera* in successive minutes using a biocenometer combined with suction pipe

Tab. VI

Successive minute of capture time		0.5	1	2	3	4	5	Remaining under dome
No	of individuals in given minute	84	27	25	17	6	7	3
	of individuals within minutes	84	111	136	153	159	166	
%	of individuals in given minute	49.70	15.98	14.79	10.06	3.55	4.14	1.78
	of individuals within minutes	49.70	65.68	80.47	90.53	94.08	98.22	

The effectiveness of the suction pipe was tested by making captures of the insects under the dome over a period of successive minutes. The totalled results for *Diptera* (Tab. VI) show that half the insects are caught under the dome within half a minute. The percentage of captured *Diptera* increases considerably during the next two minutes of sampling, but during the next three minutes numbers increase by only 5%. During the five minutes of sampling, when the insects were frightend away from plants, over 95% of *Diptera* were caught. In all samples jointly taken after completion of the

Capture of *Homoptera – Auchenorrhyncha* in successive minutes using a biocenometer combined with suction pipe

Tab. VII

Successive minute of capture	0.5		1		2		3		4		5		Remaining under doms		Number of all individuals
Species	number of individuals	%	number of individuals	%	number of individuals	%	number of individuals	%	number of individuals	%	number of individuals	%	number of individuals	%	
Cicadoidea															
Philaenus spumarius (L.)	4	23	4	23	6	35	9	53	13	76	14	82	3	17	17
Megophthalmus scanius (Fall).			2	25	2	25	6	75	6	75	7	87	1	12	8
Eupteryx vittata (L.)	8	19	10.	24	20	49	31	75	34	82	40	97	1	2	41
Allygus mixtus (F.)									1				1		1
Larvae	3	13	4	17	8	34	12	52	12	52	13	56	10	43	23
Fulgororoidea	3	8	11	29	17	44	27	71	30	79	33	87	5	13	38

five-minute period of capture by suction pipe only 8 individuals of *Diptera* were collected by hand from the sampling area. The situation is the same when capturing *Homoptera – Auchenorrhyncha* from under the dome (Tab. VII). The total percentage of invividuals caught in our experiments for the imagines of the three most numerous species was 92.4%. Heikinheimo and Raatikanen (1962) give a slightly lower figure. The population of *Auchenorrhyncha* was found however to be distributed in layers (Andrzejewska 1965), and as a result part of the individuals shelter in the litter and cannot be caught by means of the capture techniques examined. The percentage of larvae caught by means of the suction pipe also points to the fact that great difficulty is encountered in estimating the numbers of *Auchenorrhyncha* (Tab. VII), since it was found that nearly half the *Auchenorrhyncha* larvae living chiefly in the litter are not caught by means of the biocenometer. This situation is far better in the case of agrocenoses, in which there is no litter layer.

The fact that capture of biologically similar groups is not uniform, as shown by the example of *Auchenorrhyncha*, is even more distinctly shown when analysing *Diptera*, in which biological differences are far more marked (Tab. VIII). A five-minute period of capture by suction pipe of *Diptera* under the biocenometer dome is sufficient to estimate the numbers of parasitic, predatory and phytophagous *Diptera*. Saprophagous *Diptera* are more closely connected with the ground, on which they find dead plant residue, and they cannot therefore all be driven on to the walls of the dome or captured from the surface of plants. The percentage of saprophages omitted in this way from the estimated numbers may be as much as 16%.

Effect of captures made by biocenometer combined with suction pipe on different biological groups of *Diptera*

Tab. VIII

Biological group	Number of individuals		% of individuals	
	5 min.	Remainder	5 min.	Remainder
Phytophaga	192	4	97.96	2.04
Saprophaga	26	5	83.87	16.13
Parasitica	16	0	100.00	0.00
Carnivora (imago)	21	0	100.00	0.00

3. Photo-eclector

Insects were captured by the photo-eclector technique in meadow habitats. Two kinds of samples, five- and thirty- minute, were taken. When the mean numbers of insects in five- and thirty-minute samples (Tab. IX) which were taken from the meadow were compared, we found that the numbers differed very little from each other and the mean values for the thirty-minute samples are only slightly greater. The use of thirty-minute sampling time in this meadow did not significantly alter the percentages found between the different systematic groups. A completely different situation was found in the unmown meadow. The mean numbers of *Diptera* in the five-minute samples, contrary to that was expected, are greater than in the thirty-minute samples. The numbers of *Homoptera*, *Coleoptera* and *Heteroptera* in thirty-minute samples increased by appromiximiately five times. The increase in numbers in all the groups of insects except *Diptera* in the case of thirty-minute samples altered the percentages between these groups in relation to those found for the five-minute samples.

Comparison of quantitative data obtained by means a photo-eclector

Tab. IX

Station	Mown meadow				Unmown meadow			
Sampling time in minutes	5		30		5		30	
Orders	N	%	N	%	N	%	N	%
Diptera	4.89	45.26	5.62	43.68	3.20	71.77	2.75	34.37
Homoptera	3.46	31.99	4.00	31.06	0.65	14.61	3.00	37.50
Coleoptera	0.20	1.89	0.50	3.88	0.08	1.92	0.37	4.68
Heteroptera	0.25	2.36	0.50	3.88	0.08	1.92	0.37	4.68
Hymenoptera	1.79	16.58	1.87	14.56	0.40	8.97	1.50	18.75
Others	0.02	1.89	0.37	2.91	0.02	0.64	0.00	0.00

Ratios between chief biological groups of meadow *Diptera* calculated on basis of data obtained by photo-eclector

Tab. X

Station	Mown meadow				Unmown meadow			
Sampling time in minutes	5		30		5		30	
Biological group	N	%	N	%	N	%	N	%
Phytophaga	3.65	78.49	3.87	75.50	2.70	91.52	1.87	68.18
Saprophaga	0.25	5.38	0.12	2.50	0.20	6.78	0.50	18.18
Parasitica	0.42	9.14	0.62	12.50	0.02	0.85	0.00	0.00
Aphidophaga	0.22	4.84	0.00	0.00	0.02	0.85	0.00	0.00
Carnivora (imago)	0.10	2.15	0.12	2.50	0.00	0.00	0.25	9.09
Species alienae	0.00	0.00	0.25	5.00	0.00	0.00	0.12	4.55

When considering the percentages in relation to the most numerously represented group, *Diptera*, we find a similar distribution of percentage between the biological groups in both meadows (Tab. X).

Difficulty is encountered in establishing the optimum period for capture by means of the photo-eclector. In the case of the mown meadow the five-minute period would appear sufficient, but it is too short in the case of the unmown meadow. It woult therefore appear that the sampling time for photo-eclector captures must be adapted to the environment.

The experiments made by Baskina and Fridman (1928) showed that the photo-eclector covering an area of 1.000 cm^2 captures all the flying insects under it within five minutes, but both the data given above on length of sampling time and comparison of numbers obtained by photo-eclector with the corresponding figures obtained by biocenometer fail to confirm this conclusion.

The action of the photo-eclector is extremly selective. It is chiefly the most active insects which are caught by means of this instrument (*Diptera*, *Homoptera*, *Hymenoptera*), but even so part of the individuals belonging to these groups remain under the dome of the photo-eclector. On this account the photo-eclector is not, in our opinion, suitable for estimation of the real quantitative relations prevailing in a defined area of the entomocenoses examined.

III. COMPARISON OF RESULTS OBTAINED BY MEANS OF THE THREE CAPTURE TECHNIQUES

The choice of a given capture technique cannot be made only on the strenght of consideration of the operating principles. The effect of the instruments on the habitat and entomocenoses examined is not sufficiently known and does not follow a simple, straightforward pattern. Increase in the number of strokes with the entomological net disproportionately increases the numbers of insects in samples and extension of photo-eclector exposure time does not always increase the number of insects captured. It is only comparison of results with can provide a definite solution.

Data on the number of species, their numbers and percentage have been compared on the basis of data obtained in one place and time by three capture techniques, the basis of comparison being taken as five-minute samples in the case of photo-eclector and biocenometer, and 25-stroke samples in the case of the entomological net; series of samples consisted of 10 repeats. In both cases (Tab. XI) data were obtained from the same unmown meadow.

The degree to which the technique is representative can be ascertained by, inter alia, the number of species occurring in the material. In the case of *Diptera* 55 species were found to occur on the meadow during the series of captures made (Tab. XI). Material obtained by means of one technique did not contain the full list of species. The largest number of species was obtained by quantitative net sweeping, particularly of phytophagous and predatory *Diptera*, whereas the other two techniques revealed a far smaller number of

Tab. XI

Estimated ratics between chief biological groups of *Diptera* obtained by means of three capture techniques

Biological group	Photo-eclector			Biocenometer combined with suction pipe			Entomological net		
	No of species	Mean no. in sample	%	No. of species	Mean no. in samples	%	No of species	Mean no. in samples	%
Phytophaga	12	3.650	78.49	12	6.675	55.98	16	14.625	70.06
Saprophaga	4	0.250	5.38	14	2.925	24.53	10	0.8250	3.95
Parasitica	6	0.425	9.14	9	1.375	11.53	9	4.0250	19.28
Aphidophaga	2	0.225	4.84	2	0.050	0.42	1	0.1000	0.48
Carnivora (imago)	2	0.100	2.15	8	0.575	4.82	12	0.1300	6.25
Species alienae	0	0.000	0.00	2	0.325	2.73	0	0.0000	0.00

these insects. A larger number of saprophagous species were found be means of the biocenometer than by the other two techniques. The number of species obtained by photo-eclector forms about half those represented by means of the other two techniques in all the cases examined, but there was a considerable degree of agreement in the number of species captures between the biocenometer and entomological net.

Estimation of numbers by means of the three techniques reveals further differences. The lowest numbers were obtained in samples taken by photo-eclector. As the photo-eclector and biocenometer we used have the same area of ground covered (0.25 m^2) the samples taken parallel to each other by means of these two instruments are directly comparable. The mean numbers of individuals in the biocenometer samples are greater than in the photo-eclector samples: there are three times as many *Diptera* in the biocenometer samples taken from the mown meadow, about 7 times as many *Homoptera*, 20 times as many *Coleoptera*, about 16 times as many *Heteroptera* and about twice as many *Hymenoptera*. In biocenometer samples taken from the unmown meadow there are twice as many *Diptera*, 11 times as many *Homoptera*, 7 times as many *Coleoptera*, about 22 times as many *Heteroptera* and about 3 times as many *Hymenoptera*.

Comparison of numbers obtained by biocenometer and net can only be made within the biological proups, as the differences between results obtained by means of the two techniques are not uniform (Tab. XI). The numbers of phytophages in data obtained by the net are at least twice as hight as those obtained by biocenometer, and twice smaller in the case of saprophages.

The percentages between the most numerous orders of insects on the mown meadow calculated on the basis of material collected by biocenometer differ from those calculated from samples collected by photo-eclector. In samples obtained by photo-eclector *Diptera* form the decidedly dominating group – 43.68%, then in turn the next most numerous group is *Homoptera* – 31.06%. On the other hand among the insects caught by biocenometer with a suction pipe on this meadow *Homoptera* dominate – 45.74%, while *Diptera* form 29.04%. In the unmown meadow the figures corresponding to the percentages of the groups of insects in the biocenometer samples are similar, in respect of *Diptera*, *Homoptera* and *Coleoptera*, to the corresponding values calculated on the basis of data from the thirty-minute photo-eclector samples. In turn the percentage of *Heteroptera* is greater, and that of *Hymenoptera* smaller, in the biocenometer samples than in those obtained by photo-eclector.

In relation to *Diptera* the percentage of the different biological groups differ greatly for the three capture techniques.

The photo-eclector captures from 80–90% of phytophagous forms in the study habitat, and among *Homoptera* – *Auchenorrhyncha Macrosteles laevis* Rib. dominate (over 70% of individuals). The photo-eclector exhibits the greatest degree of selectivity, and as in the case of the entomological net phytophagous and photophilous insects dominate – chiefly predatory and parasitic *Diptera* living in the upper parts of grasses. Biocenometer samples exhibit a different distribution of percentages – from 55–60% of phytophages and 12–30% of saprophages being found among *Diptera*.

The constancy of percentages between the different components of the entomocenosis, defined by means of the three capture techniques, forms a separate question. The greatest constancy is exhibited by data from the photo-eclector, which instrument is not, however, representative either in respect of the number of species revealed or the percentages of the different groups.

With the entomological net estimates of the percentage of different biological groups differ by even twenty times as much. The maximum constancy is exihibited by data on the percentage of the biological groups obtained by means of biocenometer combined with suction pipe. Insects living in the litter or on the ground, which are omitted from or very insignificantly represented in photo-eclector and net data, are most correctly estimated in the case of saprophagous *Diptera* by the biocenometer, which as a results is the best instrument for investigating the numbers and structure of entomocenoses.

Ratios between chief biological groups of *Diptera* obtained by means of two capture techniques an potato field

Tab. XII

Biological group	Biocenometer with suction pipe			Entomological net		
	No. of species	No. of individuals per sample	%	No. of species	No. of individuals per samples	%
Phytophaga	4	26.22	67.46	5	30.90	38.34
Saprophaga	9	11.87	30.55	9	47.80	59.30
Parasitica	2	0.22	0.57	1	0.20	0.25
Aphidophaga	0	0.00	0.00	0	0.00	0.00
Carnivora (imago)	1	0.22	0.57	10	1.40	1.74
Species alienae	3	0.33	0.85	2	0.30	0.37

Entomological net captures do not provide reliable information as to numbers and structure of the entomocenosis, but form a very convenient way of investigating differences in the vertical distribution of animals in the habitat when combined with a biocenometer, since results form a far sharper reaction to vertical migrations of insects. As an illustration the quantitative structure of *Diptera* communities in a potato field has been presented (Tab. XII), as according to data obtained by biocenometer plus suction pipe this is constant and contains about 30% of saprophages. Saprophagous *Diptera* are represented in this same habitat in data collected by net, forming only a small percentage in relation to the whole of the fauna. At the end of September data obtained by net on saprophagous *Diptera* showed them to be dominants, as result of their migration to the upper zone of the potato plants. The application of combined techniques appears very promising since it enables the vertical distribution of insects and any variations in it to be examined.

IV. CONCLUSIONS

1. The entomological net exercises a strongly selective influence on the entomocenosis, and samples obtained by this method reveal the greatest number of insects connected with the upper lay of grass and herb vegetation. In the poor habitats formed by shelter belts the use of the net may result in impoverishment or exhaustion of the entomocenosis. Data obtained by this technique are most suitable for estimating the species composition but do not provide any bases for estimating the numbers of the different species.

2. The new biocenometer model used in combination with an apparatus for sucking in insects gives the most reliable information on numbers and structure of entomocenosis. During a sampling period of five minutes over 90% of the insects living in the upper layers of herb vegetation were caught, but not all the representatives of species living in the litter are caught. The number of species captured is similar to that obtained by net sampling.

3. The photo-eclector is not suitable either for estimating numbers or percentage between species. It is chiefly the most active insects which are obtained by this technique, while the number of species and numbers of insects are far smaller than those obtained by the previous methods.

4. The use of combined biocenometer and entomological net techniques in the same habitat increases the possibilities of ecological interpretation of data.

5. None of the techniques investigated is suitable for estimating the numbers of insects permanently connected with plants, e.g. leaf miners, aphids, or greatest insects e.g. grasshoppers.

REFERENCES

1. Andrzejewska, L. 1965 – Stratification and its dynamics in meadow communities of Auchenorrhyncha (*Homoptera*) – Ekol. Pol. A, 13: 685–715.
2. Andrzejewska, L., Kajak, A. 1966 – Metodyka entomologicznych badań ilościowych – Ekol. Pol. B. 12: 241–261.
3. Balogh, J. 1958 – Lebensgemeinschaften der Landtiere – Budapest, 560 pp.
4. Baskina, V., Fridman, G. 1928 – Statističeskoe issledovanie životnogo naselenija dvoch soobščestv Kamskoj pojmy – Trudy biol. nauč. issl. Inst. Perm/Trav. Inst. Rech. biol. Perm. 1: 183–295.
5. Chauvin, R. 1956/1957 – Reflexions sur l'écologie entomologique – Rev. Zool. agric. 1956, 4–6, 7–9; 1957, 1–3, 4–6, 1–79.

6. Chauvin, R. 1965 – Progrès récents de l'écologie des insectes, spécialement dans ses rapports avec l'éthologie – Ann. biol., 4, 11–12: 585–626.

7. Dietrick, E. J. 1961 – An improved backpack motor fan for suction sampling of insect populations – J. econ. Ent., 54: 394–395.

8. Dietrick, E. J., Schilinger, E. I., Bosch, R. 1959 – A new method for sampling arthropods using a sectin collecting machine and modified Berlese funnel separator – J. econ. Ent., 52: V.

9. Heikinheimo, O., Raatikanen, M. 1962 – Comparison of suction and netting methods in population investigations concerning the fauna of grass – and particularity in those cocerning *Calligypona pellucida* – Publ. Finn. State Agric. Res., 191: V.

10. Jackson, G. G. 1950 – A suction trap for small airborne insects, whith automatically segregates the catch in to successive hourly samples – Ann. appl. Biol., 37: 80–91.

11. Johnson, O. G., Southwood, T. R., Entwistle, H. M. 1957 – A new method of extracting arthropods and molluscs from grassland and herbage with a suction apparaturs – Bull. Ent. Res., 48: 211–218.

12. Remane, R. 1958 – Die Besiedlung von Gründlandflächen verschiedener Herkunf durch Wanzen und Zikaden im Weser-Ems-Gebiet – Z. angew. Ent., 42., 353–400.

13. Smalley, A. E. 1960 – Energy flow of a salt marsh grasshopper population – Ecology, 41: 672–678.

14. Southwood, T. R. E, Pleasance, H. J. 1962 – A hand operated suction apparatus for the extraction of arthropods from grassland and similar habitats with notes on other models – Bull. Ent. Res., 53: 124–128.

15. Tarwid, K. 1953 – Instrukcja ilościowego połowu czerpakiem – Biul. Kom. ekol. PAN, 1: 23–24.

16. Turnbull, A. L. 1960 – The spider population of Oak (*Quercus robur*) in Vytham Vood, Berks – England-Can. Ent., 92: 110–124.

PORÓWNANIE PRZYDATNOŚCI CZERPAKA ILOŚCIOWEGO, FOTOEKLEKTORA I BIOCENOMETRU DO BADAŃ ENTOMOCENOZ

Streszczenie

Porównano oceny liczebności oraz stosunków ilościowych między różnymi elementami entomocenoz zbiorowisk trawiastych oraz pól uprawnych uzyskane za pomocą trzech technik odłowu: czerpaka ilościowego, biocenometru i fotoeklektora. Biocenometr zakładano w terenie za pomocą żurawia, aby nie płoszyć owadów, a złowiony materiał wyjmowano spod kołpaka za pomocą ssawki napędzanej elektrycznie.

Zbadano wpływ czerpakowania na wyczerpywanie entomocenozy i wpływ ilości uderzeń czerpakiem na zmianę udziału różnych grup owadów w próbach. Stosowanie czerpaka stwarza niebezpieczeństwo wyczerpania entomocenozy w populacjach małych, gdzie usunięta entomofauna nie może być łatwo uzupełniana na drodze migracji.

Działanie przyrządów na badanie entomocenozy nie układa się według zależności prostych. Zwiększenie liczby uderzeń czerpakiem na próbę od 5 do 10 i 25 nieproporcjonalnie zwiększa liczbę złowionych owadów, zaś przedłużenie czasu odławiania fotoeklektorem z 5 do 30 minut nie powoduje zwiększenia liczby złowionych owadów.

Przeprowadzono porównanie danych uzyskanych w jednym miejscu i czasie trzema technikami połowu. Czerpak ilościowy wykazał najwięcej gatunków, jednak działalność tego przyrządu jest silnie wybiórcza, najwięcej stwierdzono tu owadów związanych z górnymi piętrami roślinności zielnej. Dane uzyskane za pomocą czerpaka

nie dają się przeliczać na jednostkę powierzchni. Najbardziej wiarygodne informacje o liczebności i strukturze biocenoz daje biocenometr o powierzchni 0.25 m^2. W ciągu pięciu minut wyławia on ponad 90% owadów żyjących w górnych warstwach roślinności. Owady żyjące w ściółce np. muchówki saprofagiczne i larwy *Homoptera – Auchenorrhyncha* nie są całkowicie wyławiane, nie wyławiają ich jednak prawie zupełnie również pozostałe metody. Liczba gatunków rejestrowanych przez biocenometr jest podobna jak w przypadku czerpaka ilościowego z zastosowaniem próby z 25 uderzeń.

Fotoeklektor wyławia głównie owady najbardziej ruchliwe. Trafia do niego mała liczba gatunków, liczebność prób jest mniejsza niż przy pozostałych metodach. Przyrząd ten jeszcze silniej zniekształca stosunki ilościowe w entomocenozach niż czerpak ilościowy. Nie nadaje się ani do oceny stosunków ilościowych, ani liczebności.

Znaczne rozszerzenie możliwości wnioskowania i interpretacji ekologicznej danych można uzyskać przez jednoczesne stosowanie biocenometru i czerpaka ilościowego.

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