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COMPARISON OF SUCTION AND NETTING METHODS IN POPULATION INVESTIGATIONS CONCERNING THE FAUNA OF GRASS LEYS AND CEREAL FIELDS, PARTICULARLY IN THOSE CONCERNING THE LEAFHOPPER, CALLIGYPONA PELLUCIDA (F.)

OSMO HEIKINHEIMO and MIKKO RAATIKAINEN

DEPARTMENT OF PEST INVESTIGATION
AGRICULTURAL RESEARCH CENTRE
TIKKURILA, FINLAND

SELOSTUS

IMU- JA HAAVINTAMENETELMIEN VERTAILU HEINÄ- JA VILJAPELTOJEN ELÄIMISTÖÄ, ETENKIN VILJAKASKASTA, CALLIGYPONA PELLUCIDA (F.), KOSKEVISSA POPULAATIOTUTKIMUKSISSA

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1. Introduction

In investigations concerning the biology and destructiveness of *Calligypona pellucida* (F.) *(Hom., Araeopidae)* (Kanervo et al. 1957), which have been performed in the Department of Pest Investigation since 1956, it was found to be essential to obtain as reliable quantitative data as possible on the occurrence of nymphs and adults of the leafhopper at various times and in various habitats influenced by man. As it was impossible to obtain mutually comparable samples by netting from bare soil and from low vegetation, equipment operating on the suction principle was finally chosen. With the device presented by Johnson et al. (1955) as a model, the first of the present authors designed a suction apparatus with a view to maximum applicability independent of the location of the sampling plots. Practical tests revealed that there seemed to be good possibilities for using a device of this kind even in high vegetation. In the years 1957—1959 the latter of the present authors accordingly carried out experiments concerning the efficiency of the suction apparatus and the comparison of suction and netting sampling.

Tullgren (1925), von Rosen (1956) Kanervo et al. (1957) and Raatikainen and Tinnilä (1959 a, b) have published field studies concerning the biology of the leafhopper *C. pellucida* used in these tests. The sample material for the present investigation was collected from cereal fields and from 1st year timothy leys. This was done for the following reasons. Cereal fields are among the most important propagation habitats of the species. It lays eggs there between the end of June and beginning of August, mainly in cereal stems that have emerged from the sheaths. The species hibernates in the nymphal stages I—IV in the same habitats. Adult eclosion occurs the following year some time between the end of May and beginning of July. The adults are almost exclusively macropterous. They migrate to new cereal fields during the period between the beginning of June and middle of July. Preservation of the nymphs of the species in habitats like these occurs only if a timothy ley is established among the spring cereal by simultaneous sowing with the latter, i.e., if the field is not tilled in the autumn.

2. Review of the suction and netting methods

Hills (1933) was presumably the first to apply the suction apparatus to quantitative sampling and also to pay attention to the factors limiting the suitability of the netting method for quantitative field investigations (influence of temperature on the activity of the insects, wind velocity, state of the vegetation, small size of the plants). However, his suction apparatus was inadequate. The suction principle has later been applied, e.g., by Johnson et al. (1955, 1957), Remane (1958) and Dietrick et al. (1959) in quantitative investigations of the insect fauna of the field stratum, particularly of its *Hemiptera*. In these investigations the authors stress that the composition of the suction sample is independent of the vertical distribution of the species investigated, the height and density of the vegetation (cf. also Linnavuori 1952), the time of day when the sampling is done, and the weather conditions (temperature, wind velocity, humidity). Moreover, the error caused by the sampling time is less than in the case of netting samples (Johnson et al. 1955, 1957; cf. Zubareva 1930).

All the investigators mentioned in the foregoing stress the advantages of the suction method and its possibilities of application, especially in quantitative investigations.

Bremi, in 1846, was the first, to the authors' knowledge, to recommend netting samples for quantitative investigations (Kontkanen 1950, p. 3). Kontkanen (1937, 1950, 1954) has presented a review of the investigations dealing with the netting method. The method has been much used up to date, and in recent times its use has become quite general, particularly in applied entomology. It has been employed in quantitative studies of all arthropod orders of the field stratum, particularly of leafhoppers, bugs and certain beetles (e.g. the recent investigations by Kontkanen 1937, 1950, Linnavuori 1952, Marchand 1953, Schnell 1955, Markkula and Myllymäki 1958, Schober 1959, Skuhravý et al. 1959, Afscharpour 1960 and Markkula and Köppä 1960).

Kontkanen (1950) and Linnavuori (1952) consider the netting method to be the only useful sampling method in quantitative leafhopper investigations. However, they stress the fact that the results are only relative.

3. Equipments and sampling procedures

The suction apparatus was at first designed for hand operation, to be connected to a crank-operated crop duster. A device with petrol engine was built later and has been used since 1957. This makes the sampling operations independent of an electricity supply.

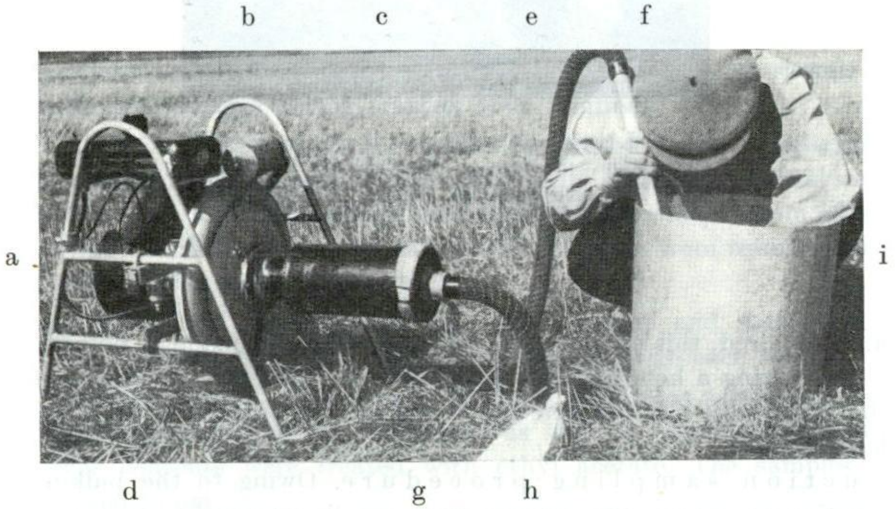

Fig. 1. The suction apparatus in operation. For explanation, see text. — Photo by O. Heikinheimo.

Kuva 1. Imulaite toiminnassa. Valok. O. Heikinheimo.

The suction apparatus (Fig. 1) was powered by a 1.1 HP internal combustion engine (a) with a centrifugal blower (b) mounted directly on its shaft. On the opposite side of the blower an axial sheet metal cylinder (c) of 13 cm diameter and 25 cm length was provided, and this part of the apparatus was supported by a conveniently portable steel tube frame (d). The aggregate weight of these components was about 23 kg. The suction tube consisted of vacuum cleaner tubing (e) fitted with an extension tube (f) bearing a suction head of about 29 mm diameter. Attached to the suction tube was a cover (g) fitting over the end of the cylinder (c), a rubber gasket ring being inserted between the cover and the cylinder edge (Fig. 2). The end of the suction tube opening into the cylinder bore a flared sheet metal cylinder to which the sampling bag (Fig. 1 h) could be attached. This bag was made of thin, fine-mesh nylon fabric. Its size was 17 by 28 cm.

The sampling plots were circumscribed and isolated with the aid of a sheet metal cylinder (Fig. 1 i) of 36 cm height and 0.10 m^2 cross section

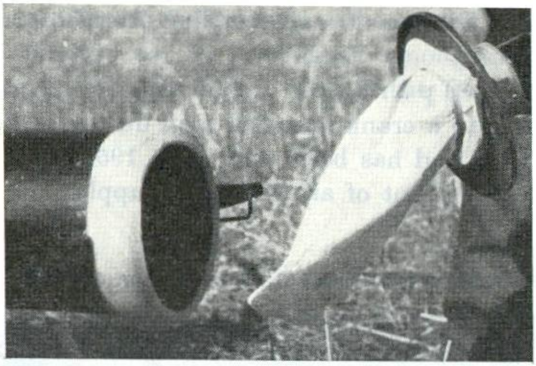

Fig. 2. Location and attachment of the sample bag in the suction apparatus. — Photo by O. Heikinheimo.
Kuva 2. Näytteenottopussin sijainti ja kiinnitys imulaitteessa. Valok. O. Heikinheimo.

area. If required, this cylinder was covered with a lid made of polyethylene film and having a hole for the suction tube at its centre. A taller cylinder of the same cross section area had to be used for sampling on plots with high vegetation.

S u c t i o n s a m p l i n g p r o c e d u r e. Owing to the bulkiness of the suction apparatus, two persons were usually required to transport and to use it. The sampler (always the same person in these tests) chose an intact area, mostly in the upwind direction, and thrust the sample plot cylinder into the soil with a rapid movement. If necessary, for instance when the leafhoppers were moving about actively, the cover was tied in advance to the top of the cylinder with a piece of string. The sampling was done by moving a metal tube, attached to the end of the suction tube, at first at a higher level within the cylinder and later along the soil surface in order to catch the arthropods from the ground. If required, the plants were cut during the sampling; coarser foreign matter was vigorously shaken in the cylinder and removed.

A partial 0.10 m^2 sample was usually taken from each area of 200—1 000 m^2. Two minutes were required to take a partial sample of this kind.

S w e e p n e t. The netting samples were taken with the aid of a circular sweep net, 34 cm in diameter at its mouth; the net had a depth of 60 cm and a diameter of about 10 cm at the bottom. The net handle was 82 cm long.

N e t s a m p l i n g p r o c e d u r e. The strength and height of the sweeps, the sweep angle (about 120°) and the method of sweeping varied somewhat, according to the height, density and type of vegetation. All the sweeping was done by the same person, in order to minimize the errors due to sampler. If a second person participated in the work, an identical procedure was followed as scrupulously as possible. Sampling on plots with low vegetation (e.g., sprouting fields) was done by a slow sweep close to the ground, and in high vegetation a strong sweep at low height was used.

The sweeps were done at intervals of one step. Three partial samples (of 20 sweeps each) were taken from one sampling area and were combined to form a single sample (comprising altogether 60 sweeps). Each sample of this kind was emptied into a linen sample bag of about 14 cm by 25 cm in size. The size and shape of the netting bag as well as of the sample bags were such that escapes during transfer were minimal.

Comparative samples. The material for the comparison fo suction and net sampling was always collected by taking one partial suction sample (0.10 m^2) and one partial netting sample (20 sweeps) from adjacent plots, while the different partial samples (3 samples) were taken from different parts of the same sample area.

Observations on the sampling site, type, height and density of the vegetation, weather, etc., were made in connection with each sample.

Treatment of samples. The bags containing suction or netting samples were brought to the laboratory as soon as possible and together with their contents were treated with ethyl acetate. The samples were then allowed to dry.

In separating the arthropods from the fresh suction samples a modification of the Tullgren apparatus was tried at first. Later this work was accomplished exclusively by picking the arthropods by hand from the dried, ethyl acetate-treated, samples, as Tullgren's method was not found efficient enough for samples kept in storage for varying lengths of time. The earth in the samples caused damage particularly to fragile insects, such as mosquitoes and aphids. The quantity of earth in the suction samples varied between 0 and about 50 g. Various sieves, and in the final stage a binocular dissecting microscope, were employed to aid the separation. When samples containing earth were treated under the microscope it was possible for the arthropods, particularly the smaller ones, to be discarded with the earth. The number of very small arthropods not detected among the earth increased with decreasing grain size and weight and increasing dryness of the soil on the sampling site, and also with increasing quantity of earth in the sample. All samples were inspected by the same person, in order to minimize the effect of personal errors.

Separation of the insects from the netting samples was done in the same manner.

4. Efficiency of the suction method, and its applicability in quantitative population studies

a. General

The usefulness of the suction method in quantitative investigations essentially depends on how great a fraction of the insects present in a given area enclosed by the sample plot cylinder appears in the samples. JOHNSON et al. (1955, 1957) report that the efficiency of the suction apparatus which they employed was usually 90—100 % for different groups of arthropods. It was highest (more than 98 %) in the groups *Collembola*, *Aphidoidea*, *Diptera* (adults), *Heteroptera*, *Isopoda* and *Auchenorrhyncha* and poorest in the groups *Chilopoda* (66.7 %), *Coleoptera* (larvae) (70.3)%, *Diptera* (larvae) (75.5 %) and *Diplopoda* (86.1 %). Concerning the suction method which REMANE (1958) used he says that within a reasonable range of accuracy this method permits absolute quantitative determination of *Heteroptera* and *Homoptera Cicadina* on plant-covered areas.

b. Efficiency of the suction apparatus

Special tests were carried out in 1957—1959 in order to determine the suction efficiency of the apparatus described in this paper. The test insects were adults and nymphal stages III—V of *Calligypona pellucida*. In the tests, 50 individuals at a time were placed in the sample plot cylinder circumscribing an area of 0.10 m² on a timothy ley where no leafhoppers had been observed previously. The cylinder was covered with gauze and the leafhoppers were drawn up again after two hours by the procedure employed in our other investigations, using two minutes for each sample. All the tests were made in the middle of the day, on days with dry, warm weather. The wind velocity was about 2—3 Beauf. and the height of the vegetation was 20—30 cm.

Table 1. Efficiency of the power-driven suction apparatus in catching adults and nymphal stages III—V of *Calligypona pellucida*. 50 experimental insects at the start of each test.

Taulukko 1. Koneimurin teho viljakaskaan aikuisten ja III—V toukka-asteiden imennässä. Koe-eläinmäärä kussakin kokeessa 50 yksilöä.

Stage of development *Kehitysaste*	Number of tests *Kokeita kpl*	Recovery of individuals *Koe-eläimiä saatu takaisin*		Difference *Ero*
		$\bar{x}$ %	Arc sin $\bar{x} \pm s_{\bar{x}}$	
Adults — *Aikuiset*	16	87.5	70.34 ± 1.81	9.60**
Nymphs — *Toukat*	20	74.8	60.74 ± 2.07	

The results are shown in Table 1. It can be seen that adult leafhoppers were recovered at a distinctly higher percentage than nymphs; the difference is highly significant, and the results in both groups are fairly uniform. Two tests with *C. pellucida* adults were also made in an oat field. The efficiency was found to be about the same as on the timothy ley (86 % on an average). For the sake of comparison, a few tests were also performed with a hand-driven suction apparatus, which proved to be clearly less efficient than the power-driven apparatus. The average recovery of adults and nymphs was 68 and 52 %, respectively. These results serve to demonstrate that separate efficiency tests with adults and nymphs are necessary if one intends to use the suction apparatus for quantitative work.

There may also be differences of the same kind between nymphs of different ages, but this cannot be ascertained from our data. The efficiency of the suction apparatus is further affected by certain changes in weather conditions and by the differences between habitats. For instance, it was noted that when the plants were wet adults and nymphs stuck to them or to the suction tube in considerable numbers, the percentage loss thus increasing. Low efficiency was also recorded for samples taken from litter-covered fields. In order to eliminate the influence of these errors, the samples discussed in the following were only taken during dry weather and the sample areas were chosen so as to include only two kinds of habitats.

On the basis of the efficiency tests on the suction apparatus, fairly accurate estimates can be made of the absolute numbers of the different developmental stages of the investigated species per unit surface area. The following compilation shows the correction coefficients calculated from the results in Table 1 and their 95 % confidence limits for the numbers of adults and nymphs, based on the arc sin-transformed percentages:

Adults:	arc sin	$66.49 < 70.34 < 74.19$
	Retransformed efficiency percentage	$84.1 < 88.7 < 92.6$
	Correction coefficient	$1.19 > 1.13 > 1.08$
Nymphs:	arc sin	$56.41 < 60.74 < 65.07$
	Retransformed efficiency percentage	$69.4 < 76.1 < 82.2$
	Correction coefficient	$1.44 > 1.31 > 1.22$

The correction coefficients relating to the hand-operated suction apparatus were 1.47 and 1.92 for adults and nymphs respectively. Multiplying the frequency values found from the samples by these coefficients will give the best estimates of the true numbers of *C. pellucida* adults and nymphs per unit area.

Summarizing the studies concerning the accuracy of the suction method in absolute quantitative investigations of the fauna in the field stratum, particularly with respect to leafhoppers, it can be said that fairly reliable and comparable results can be achieved with the aid of this device. The absolute accuracy of the results can be improved by means of preliminary investigations concerning the efficiency of action of the suction apparatus with respect to the different stages of development and forms of the species under investigation, possibly even with respect to different habitats.

c. Significance of the size of the sample area and the number of partial samples

In order to determine the influence of variations in sample size and sampling plan, a test was carried out, drawing 32 partial samples, each covering 0.10 m², from an area forming part of a level, underdrained cultivated field in an open area. The size of the sample area was 16 m by 32 m and the partial samples were spaced at intervals of 4 m. The margins of the sample area were about 15 m distant from the edges of a fairly large block of cultivated land. The plant cover was a timothy ley of comparatively uniform quality over the whole sample area. 97 % of the captured *C. pellucida* individuals were nymphs.

According to the variance analysis there were no significant differences between the lines and rows of samples. The standard error of the partial samples, drawn form the entire sample area, was 6.5 %; about half of this was accountable to sources of error involved in the sampling procedure (cf. Table 1), the other half being caused by the non-uniform distribution of the leafhoppers. The effect of variations in the number and size of the sample groups on the standard error and on the confidence limits was studied by dividing the partial samples at random into sample groups of different sizes. The results can be seen in Fig. 3.

A study was then made of the manner in which the number of samples comprising three partial samples and the method of their analysis affect the confidence limits between sample groups consisting of two or three such samples. For the sake of comparison, the average numbers of leafhoppers per m² were calculated from the partial samples without application of correction coefficients. The partial samples to be combined in each sample were chosen at random from the material of the investigation just described above. As for the method of analysis, the mean values of the samples were compared (proceeding as if the partial samples had originally been combined, and not analyzed individually), while, on the other hand, a comparison was made of the mean values obtained for the partial samples (each partial

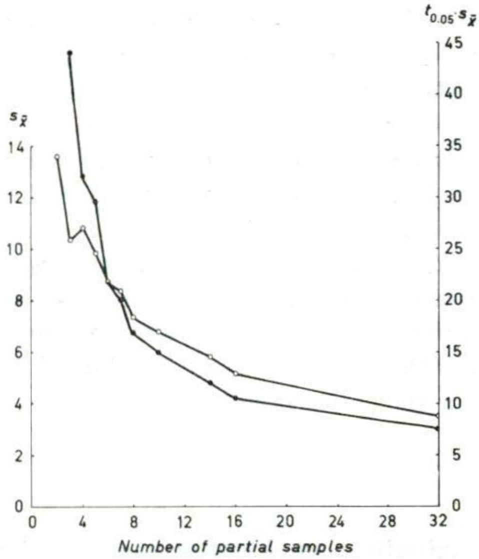

Fig. 3. Standard error, $s_{\bar{x}}$ (—○—) and 95 % confidence limits, $t_{0.05}$ $s_{\bar{x}}$ (—●—) of the partial samples in the suction method, as a function of the number of partial samples n. Mean number of leafhoppers 55.5.

Kuva 3. Osanäytteiden keskivirheen, $s_{\bar{x}}$ (—○—) ja 95 %:n luotettavuusrajojen, $t_{0.05}$ $s_{\bar{x}}$ (—●—) riippuvuus osanäytteiden lukumäärästä (vaakasuoralla akselilla) imumenetelmää käytettäessä. Viljakaskaita keskimäärin 55.5 kpl/osanäyte.

sample being analyzed individually). The following compilation shows the range in which the mean values for the sample groups and the confidence limits between them varied:

Number of sample groups	Size of sample groups	Leaf-hoppers per m² $\bar{x}$	95 % confidence limits between the sample groups for the preceding	$s_{\bar{x}}$ %
5	2 samples (each containing 3 combined partial samples)	535	±517	29.2
3	3 samples (each containing 3 combined partial samples)	546	±181	32.5
5	2 × 3 partial samples, individ.	535	±190	18.7
3	3 × 3 » » »	546	±155	9.2
	Entire series: 32 partial samples ..	555	± 74	

The results of investigation presented in the foregoing reveal that to attain a satisfactory accuracy of the results it is best to analyze each partial sample individually, and that nine partial samples from each site give a much more precise idea of the leafhopper population of a given area than six partial samples. As the size of the samples must be reduced with increasing number of samples, owing to the increasing amount of work involved, 2 × 3 individually treated partial samples can suffice in the investigation of a smallish, homogeneous area of cultivated land.

Investigation of the significance of the choice of sampling area by taking four samples, each consisting of eight partial samples, to represent ¼, ½ or the whole sample area under investigation, resulted in the standard error percentages between individual samples proving to be 7 %, 4 % and 2 % respectively. It follows that the best result is obtained if the partial samples are evenly spaced over the entire sample area.

5. On the quantitativeness of netting samples referred to area

a. Sources of error and their significance

The opinion has frequently been stated that no absolute results can be obtained by the netting method because the sampling cannot be linked with any accurately defined area. This is due to the numerous sources of error involved in the method (cf. e.g. MARCHAND 1953, REMANE 1958). According to statements made by SMITH (1928, p. 492), KROGERUS (1932, p. 23) and TISCHLER (1949, p. 10), however, 50 sweeps usually corresponds to the number of individuals on an area of 1 m^2.

The possibility of using the netting method in absolute quantitative studies can be investigated by taking parallel and simultaneous suction samples as well as netting samples, and comparing the frequency figures from the latter with the corresponding corrected frequencies referred to unit area, which are derived from the suction samples and which, as demonstrated in the preceding section, can be considered sufficiently reliable estimates of the absolute frequencies. A comparison of this kind was carried out with respect to the different stages of development of *C. pellucida*, calculating the correction factors for the frequency values from the suction samples. This comparative material was collected during the period 1. VII—8. VIII in 1957 and 1958 from fields under spring cereals (19 pairs of samples), and during the period 20. V—16. VII in 1958 and 1959 from 1st year timothy leys (28 pairs of samples), in the manner described on p. 9. All except nine netting samples from the timothy leys were taken by the same person. Variance analysis, applied separately to the samples from timothy and spring cereal fields, was employed to investigate the effect of stage of development and sex of the leafhopper, height of vegetation, and sampler on the relationship between the frequency values furnished by the pairs of suction and netting samples.

Table 2. Numbers of the different developmental stages of *Calligypona pellucida* in netting samples from timothy leys, as percentages of the sums derived from corresponding pairs of suction and netting samples. 24 pairs of samples investigated. ° = Significant at $F_{0.25}$

Taulukko 2. Viljakaskaan eri kehitysasteiden lukumäärät timoteinurmista otetuissa haavintanäytteissä prosentteina imu- ja haavintanäyteparien vastaavien lukumäärien summista. Tutkittuja näytepareja oli 24. ° = $F > F_{0.25}$

Sources of variation *Variaation laji*	Degrees of freedom *Vapaita asteita*	Mean squares *Varianssien estimaatit*	F	n	$\bar{x}$ %
Nymphs-adults — *Toukat-aikuiset*	1	10 172.43	25.39***	32—40	53.1—77.0
Nymphs III-(IV + V) — *Toukat III-(IV + V)*	1	688.45	1.72°	4—28	40.9—
Nymphs IV-V — *Toukat IV-V*	1	2.11	0.005	6—22	55.4—54.7
Adults ♂-♀ — *Aikuiset* ♂-♀	1	46.87	0.117	20—20	76.0—78.1
Effect of height of vegetation [1]) — *Kasvuston korkeuden vaikutus* [1])	(9)				
Nymphs V — *Toukat V*	3	569.40	1.42°	8—9—3—2	63.3—44.9—63.5—51.6
♂	3	175.00	0.44	6—9—3—2	81.9—73.2—79.2—65.7
♀	3	242.78	0.61	6—9—3—2	80.2—72.6—89.6—79.6
Pairs of samples — *Näyteparit*	58	400.61			
Total — *Yhteensä*	71				

[1]) Height groupings: 15—20, 25—30, 35—40 and over 45 cm.
[1]) *Korkeusluokat: 15—20, 25—30, 35—40 ja 45— cm.*

Analysis of the samples from timothy leys (Table 2) shows that there is a highly significant difference between the frequency ratios for nymphs and adults. The suction method yields a relatively much higher number of nymphs than the netting method. The yield of nymphs of stage III in the netting method seems to be slightly poorer on a relative basis than the yields of nymphs of stages IV and V, between which no difference was observed. The two sexes occur in the suction and netting samples in about equal proportions. The height of the vegetation may exert an influence on the yield of nymphs of stage V. However, linear proportionality appears to be quite poor, according to the table. The numbers of nymphs of stages II and IV are too small to allow any inferences to be drawn with regard to the influence of the height of vegetation.

The main reason why relatively fewer nymphs than adults were caught by the netting method on timothy leys as compared with the corresponding

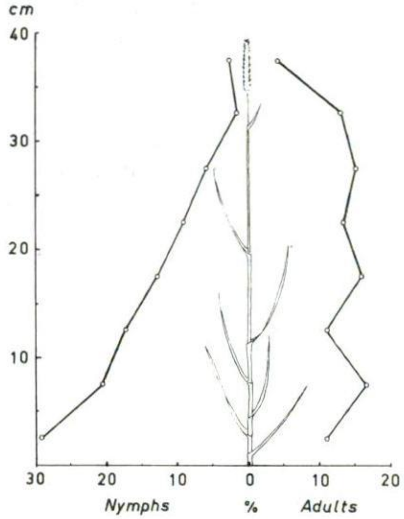

Fig. 4. Vertical distribution of nymphal stages IV and V and adults of *Calligypona pellucida* in timothy at the beginning of July, 1957. The observations were made on enclosed test plots of 60 cm × 60 cm. The total number of nymphs and adults was 79 and 119 respectively. Ordinates: height of the plant cover; abscissae: occurrence of the stages of development as percentages.

Kuva 4. Viljakaskaan IV—V toukka-asteiden ja aikuisten pystysuora jakaantuminen timoteissa heinäkuun alussa v. 1957. Havainnot tehty 60 × 60 cm²:n suuruisista aidatuista koeruuduista. Toukkien kokonaismäärä oli 79 ja aikuisten 119. Pystysuoralla akselilla kasvuston korkeus, vaakasuoralla toukat ja aikuiset.

suction samples, was the different vertical distribution of nymphs and adults (Fig. 4). According to a test that was carried out, more than half of the nymphs remain at a height of less than 10 cm when the vegetation is 40 cm high, while only about 27 % of the adults were encountered in this stratum. In the upper parts of the plants, at a height of 25—40 cm 11 % of the nymphs and 32 % of the adults were found. Only a small fraction of the leafhoppers in the lowest stratum are caught in the netting samples. In the suction samples leafhoppers are caught almost equally well from the upper and lower parts of the plant cover.

It follows that when comparing the frequencies of *C. pellucida* as found by the suction method and by netting, the nymphal stages and the adults have to be dealt with separately.

In the same manner, 19 pairs of samples taken from stands of spring cereal were studied. As such pairs of samples had been taken from an oat field and from a spring wheat field, there was also an opportunity to study whether the species of cereal affected the results. The analysis revealed no difference between the frequency relationships of the pairs from different cereal stands. No significant influence of the height of vegetation was established ($F = 0.033$), nor was there any difference in yield of males and females ($F = 0.53$). On the other hand, there was a significant difference with respect to the frequency relationship between healthy and parasitized adults (mainly *Elenchus tenuicornis* Kirby, but also *Dicondylus lindbergi* Heikinh.) in the pairs of samples ($F = 4.32 > F_{0.05} = 4.08$). A result pointing in the same direction, but with an even higher degree of significance, was obtained

Table 3. Comparison of suction and netting samples as regards the proportion of parasitized adults among all adults and the proportion of males among all healthy adults, presented separately for pairs of samples from timothy leys and from spring cereal fields.

Taulukko 3. Vertailu loisisten %:sesta osuudesta aikuisten kokonaismääristä sekä koiraiden %:sesta osuudesta terveistä aikuisista imu- ja haavintanäytteiden välillä erikseen timoteinurmista ja kevätviljoista otetuissa näytepareissa.

Series — *Aineisto*	$\bar{x} \pm s_{\bar{x}}$, %	Number of leafhoppers *Kaskaita kpl*	Number of samples *Näytteitä kpl*	P %
Timothy leys — *Timoteinurmet*				
Parasitized adults in suction samples — *Loisisia aikuisia imunäytteissä*	17.3 ± 4.8	76	12	84.1
Parasitized adults in netting samples — *Loisisia aikuisia haavintanäytteissä*	16.0 ± 3.8	120	12	
Males in suction samples — *Koiraita imunäytteissä*	58.6 ± 3.1	163	19	18.1
Males in netting samples — *Koiraita haavintanäytteissä*	52.2 ± 3.5	581	19	
Spring cereal fields — *Kevätviljat*				
Parasitized adults in suction samples — *Loisisia aikuisia imunäytteissä*	24.5 ± 3.8	58	15	1.9
Parasitized adults in suction samples — *Loisisia aikuisia haavintanäytteissä*	42.2 ± 6.0	1 453	15	
Males in suction samples — *Koiraita imunäytteissä*	49.9 ± 3.9	117	17	32.4
Males in netting samples — *Koiraita haavintanäytteissä*	55.3 ± 4.0	1 105	17	

by means of another method of analysis. These results are shown in Table 3. Attention is specially drawn to the fact that the proportions of parasitized individuals in the suction and netting samples are different for the timothy leys and the spring cereal fields.

This is thought to be attributable to the fact that the percentages of parasitized adults in the different strata of timothy leys are roughly equal, so that both sampling methods yield parasitized and healthy adults in approximately equal proportions. Conditions are different in spring cereals. At the beginning of oviposition, in the first half of July, the females, and with them the males, move into the lower parts of the plant, where the stem serving oviposition surface is first exposed. Parasitized adults, on the other hand, seem to be fairly uniformly distributed over the whole plant. The conditions resemble those of the vertical distribution of nymphs and adults in timothy. In netting samples the catch of parasitized insects in the upper part of the plant cover is better than the catch of healthy leafhoppers in the lower stratum. Consideration of this circumstance is important when the data from netting samples are used in studies concerning the abundance of parasitized leafhoppers. It is possible that a netting sample taken from a sample area with low plant cover is more representative of the true parasite percentage of the leafhoppers than a similar sample from a habitat with tall plants.

Correlation analysis applied to pairs of samples from a timothy ley from which netting samples had been taken by two persons, revealed that there was no significant difference between the correlation coefficients accountable to the sampler (the percentage values for P were 28.8 and 37.8 for adult leafhoppers and for nymphs respectively). It is thus established that the errors introduced by trained persons taking netting samples of the leafhopper population by an identical procedure, did not exceed the errors caused by other factors, e.g., by the vegetation and weather, in our tests. According to KONTKANEN (1937, p. 8), different samplers obtained widely differing results in experiments carried out by ZUBAREVA (1930). However, ZUBAREVA observes that the samplers obtained more closely similar results with respect to the *Nematocera* and *Auchenorrhyncha* groups than in experiments relating to the *Brachycera* group.

b. Computation of absolute quantitative figures from netting samples

It has been shown in the foregoing that nymphs of *C. pellucida* appear in a different proportion than adults in the netting samples. It has also been found that the ratio of parasitized and healthy adults netted from spring cereals differs from the ratio indicated by suction samples. Using as a basis of comparison the numbers of leafhoppers per m^2 calculated from the suction samples and corrected by the appropriate coefficients, we may calculate the number of sweeps that would have been needed in the various instances to obtain the same absolute frequency values, expressed per m^2.

The formula employed in this calculation is

$$n = k \frac{60}{0.30} \frac{a}{b}$$

where

n = number of sweeps yielding the number of leafhoppers corresponding to the population of 1 m^2,

k = average coefficient of efficiency of the suction apparatus,

a = number of leafhoppers caught in the suction sample from an area of $3 \times 0.10\ m^2$,

b = number of leafhoppers caught with 3×20 sweeps by the netting method.

Inserting the coefficients given earlier in this work (p. 11), we obtain the following formulae:

$$\text{for nymphs} \quad n = 262 \frac{a;}{b;} \quad \text{for adults} \quad n = 226 \frac{a}{b}.$$

In this manner the following values have been obtained from the pairs of samples which had already been used for comparison of the suction and netting methods:

Habitat, and type of *C. pellucida* leafhoppers	Average number of leafhoppers in samples *a*	*b*	Number of pairs of samples	$\bar{n} \pm s_{\bar{n}}$	$s_{\bar{n}}$, %
Timothy; nymphs	66.0	87.8	25	396.2 ± 80.4	20.3
» adults	17.9	64.2	21	86.0 ± 18.8	21.9
Spring cereals; healthy adults ..	12.2	105.2	18	50.7 ± 11.8	23.4
» » parasitized adults	3.9	93.1	15	39.5 ± 15.5	39.2

The high percentages of the standard errors of the n values, particularly in the case of the parasitized adults, are worthy of attention. They are thought to be due to the fact that the suction and netting samples were taken at various times over a lengthy period (1. VII—8. VIII) and on various sites, thus making it possible for a number of sources of error associated with weather conditions, varying type of vegetation, etc., to affect the sampling procedure of the netting method. In the absence of such factors the result would no doubt have been less irregular, as the sampling was done by trained persons. This is suggested, for instance, by the results obtained by Kontkanen (1950) in his experiments concerning the number of sweeps. From Table 1 presented by Kontkanen, the standard error percentage of 20 samples is for example found to be 6.8 % for *Doratura stylata* and 13.0 % for *Verdanus abdominalis*. The first-mentioned figure is quite close to the result of our corresponding investigation concerning the number of suction samples, which was 6.5 % (p. 12).

According to Tischler (1949, p. 10), the results from netting samples can to some extent be regarded as absolute. The results reported in the foregoing show that the absolute reliability of netting samples can be considerably improved. This implies that in the preliminary investigations, in which the suction method is used to find the best estimates for the absolute, coefficient-corrected frequency values per unit area separately with respect to each form type (nymph, adult, brachypterous, macropterous, etc.) of the species under investigation, the effects of the vertical distribution of the different stages of development and of the parasitized individuals as well as the effects of habitat, etc., on the results produced by the netting method have to be determined. There are some further sources of error affecting the results in a manner that has been stressed by numerous investigators, but which it is not thought possible to eliminate or diminish in calculating the results from netting samples. In consequence, even elaborate preliminary investigations are no help towards obtaining a fully accurate idea of the absolute numbers of insects such as leafhoppers in the areas investigated.

Taking into consideration the great amount of work involved in the preliminary investigations, the netting samples can only be used to a limited extent in synecologic studies where the interest centres on the numerical proportions of individuals between the species. Investigations of this kind gain from information concerning the vertical distribution of different species, or even of the different stages of development and the parasitized individuals of the same species, and the consequent influence on the relative numbers found in netting samples (cf. LINNAVUORI 1952 and REMANE 1958).

6. Comparison of suction and netting samples

In the foregoing the efficiency of the suction apparatus was found to differ with respect to adults and nymphs of *C. pellucida*. In regard to the netting method, again, it was observed that in spring cereal fields nymphs are caught in different proportions from adults, and parasitized adults in different proportions from healthy adults, as compared with the corresponding frequency ratios found by the suction method. The qualitative differences between these two methods are naturally even greater when different species or orders of insects differing greatly in their mode of life, size and shape are concerned. For instance, JOHNSON et al. (1957) state that the frequency ratios obtained for the larvae and adults of the bug species *Nabis limbatus* and for the adults of certain other bug species are altogether different depending on the sampling method. KONTKANEN (1937, p. 21) also points out that more than one coordination value is probably needed when the results derived from the netting method are compared with those obtained by some method based on definite areas.

As the dependence of the frequency ratios between representatives of different orders of arthropods on the use of suction or netting methods has not been previously investigated, ten pairs of parallel samples were taken in 1957—1959 from 1st year timothy leys, and similarly ten pairs from fields under cereals (oats and spring wheat), by the suction and netting methods. From these samples the numbers of arthropods caught were calculated, taking into account only the adults of *Holometabola* insects, but all mobile stages of other arthropods. The percentages (»the dominance») of the arthropods found in the experiments are shown in Tables 4 and 5.

With regard to the relative numbers (the dominance) of certain groups, rather considerable variation occurred between the different samples, irrespective of the sampling method. In spite of this, however, the observation can be made that certain groups are relatively better represented in the suction than in the netting samples, and the opposite holds true for other

Table 4. Percentages of different groups of arthropods and total number of individuals caught by suction sampling (a) and netting sampling (b) on 1st year timothy leys. — The suction sample area was 3 × 0.10 m² and the netting sample comprised 3 × 20 sweeps. The pairs of samples were taken from different fields. — = no representatives of this group in the sample.

Taulukko 4. Ensimmäisen vuoden timoteinurmista imu- (a) ja haavintanäytteillä (b) saatujen niveljalkaisten prosenttimäärät ja koko yksilömäärä. Imunäyteala oli 3 × 0.10 m² ja haavintanäyte käsitti 3 × 20 haavinvetoa. Näyteparit onotettu eri pelloista. — tarkoittaa, ettei näytteessä ollut kyseisen ryhmän edustajia.

Sample no. *Näyte n:o*	Date of catching *Ottoaika*	*Araneae & Phalangida*	*Acarina*	*Collembola*	*Orthoptera*	*Ephemeroptera*	*Heteroptera*	*Homoptera* *Auchenorrhyncha* *Araeopidae*	Σ	*Psyllina*	*Aphidina*	Σ	*Thysanoptera*	*Lepidoptera*	*Diptera*	*Coleoptera*	*Hymenoptera*	Total no. of individuals *Yhteensä kpl*
1 a	1. VI 1958	3	1	1	—	—	3	72	73	—	—	73	2	—	9	7	1	228
2 a	8. VI 1958	4	26	6	—	—	—	40	43	—	—	43	—	—	14	7	0	249
3 a	12. VI 1958	9	44	21	—	—	3	2	4	—	—	3	2	—	10	6	2	114
4 a	14. VI 1958	14	36	35	—	—	1	9	10	—	—	10	—	—	1	2	1	183
5 a	18. VI 1958	3	12	11	—	—	0	37	39	—	—	39	1	—	28	4	2	358
6 a	23. VI 1957	1	38	16	—	—	1	17	26	—	—	26	4	—	7	2	5	356
7 a	23. VI 1957	2	43	28	—	—	0	6	18	—	—	18	—	—	5	3	1	443
8 a	4. VII 1957	3	18	70	—	—	0	3	3	—	—	3	—	—	4	1	1	425
9 a	4. VII 1957	10	—	27	—	—	—	17	32	—	1	33	9	—	15	2	4	136
10 a	10. VII 1958	8	38	10	—	—	3	10	12	—	—	12	9	1	5	7	7	93
1a—10a	Σ a %	4	25	26	—	—	1	21	26	—	0	26	2	0	10	4	2	
	no. — *kpl*	107	662	670	0	0	22	544	675	0	1	676	44	1	253	93	57	2 585
1 b	1. VI 1958	3	—	—	—	—	1	20	24	0	—	24	6	—	62	3	1	1 337
2 b	8. VI 1958	2	0	1	—	—	1	21	26	0	—	26	13	—	54	2	1	1 329
3 b	12. VI 1958	2	—	6	—	—	4	12	10	0	0	12	5	—	64	2	5	279
4 b	14. VI 1958	1	—	74	0	—	1	12	16	0	0	16	0	—	5	1	2	1 494
5 b	18. VI 1958	0	—	—	—	—	0	8	7	—	—	8	3	—	87	1	1	1 395
6 b	23. VI 1957	1	0	—	—	0	2	8	10	1	1	12	61	0	10	8	6	815
7 b	23. VI 1957	1	0	0	—	—	7	2	5	—	1	7	17	0	34	22	12	386
8 b	4. VII 1957	1	—	12	—	—	0	3	3	—	0	4	54	—	17	3	9	505
9 b	4. VII 1957	0	—	9	—	—	1	4	7	—	0	7	78	—	3	1	1	3 210
10 b	10. VII 1958	0	0	2	—	—	7	0	3	—	0	4	82	—	3	—	2	1 032
1b—10b	Σ b %	1	0	13	0	0	2	9	12	0	0	12	38	0	29	3	2	
	no. — *kpl*	108	9	1 500	1	3	190	1 086	1 434	9	27	1 470	4 501	3	3 452	293	252	11 782

Table 5. Percentages of different groups of arthropods and total number of individuals caught by suction sampling (a) and netting sampling (b) on spring cereal fields. — Sampling procedure as described in caption of Table 4.

Taulukko 5. Kevätviljamaista imu- (a) ja haavintanäytteillä (b) saatujen niveljalkaisten prosenttimäärät ja koko yksilömäärä. Näytteet on otettu kuten taulukossa 4 selostetaan.

Samples No. 12 a, b and 13 a, b from spring wheat; other samples from oats.

Näytteet 12 a ja 12 b sekä 13 a ja 13 b ovat kevätvehnästä, muut kaurasta.

Sample no. *Näyte n:o*	Date of catching *Ottoaika*	*Araneae & Phalangida*	*Acarina*	*Collembola*	*Heteroptera*	*Homoptera* *Auchenorrhyncha* *Araeopidae*	*Homoptera* *Auchenorrhyncha* Σ	*Homoptera* *Psyllina*	*Homoptera* *Aphidina*	*Homoptera* Σ	*Thysanoptera*	*Lepidoptera*	*Diptera*	*Coleoptera*	*Hymenoptera*	Total no. of individuals *Yhteensä kpl*
11 a	1. VII 1958	—	12	12	—	64	64	—	—	64	—	—	12	—	—	17
12 a	3. VII 1958	2	6	2	—	43	48	—	8	56	3	—	26	—	5	61
13 a	4. VII 1957	2	—	11	2	20	20	—	—	20	7	—	22	18	18	45
14 a	4. VII 1958	3	—	13	1	25	28	—	18	46	3	—	15	5	14	103
15 a	10. VII 1958	—	—	—	—	39	44	—	6	50	11	—	22	6	11	18
16 a	10. VII 1958	2	13	—	4	26	28	—	—	28	4	2	41	4	2	53
17 a	15. VII 1957	4	—	14	—	23	24	—	5	30	1	—	32	12	7	74
18 a	17. VII 1957	3	—	27	2	16	16	—	1	17	—	—	33	5	3	63
19 a	22. VII 1958	18	—	—	—	27	37	—	—	37	—	—	9	9	27	11
20 a	8. VIII 1958	5	3	—	4	14	15	—	—	15	2	—	14	7	50	94
11a—20a	Σ a %	3	3	9	2	25	27	—	6	33	3	0	25	6	16	
	Σ a no. — *kpl*	18	16	48	9	136	147	0	30	177	15	1	135	35	85	539
11 b	1. VII 1958	—	—	1	1	50	64	1	3	68	15	—	10	4	1	74
12 b	3. VII 1958	0	—	2	1	58	61	0	7	68	7	0	20	0	3	1 511
13 b	4. VII 1957	0	—	10	0	9	10	0	1	11	8	—	60	1	10	455
14 b	4. VII 1958	1	—	15	1	21	26	1	2	29	21	1	28	3	1	154
15 b	10. VII 1958	—	—	1	0	9	15	1	4	20	55	1	21	1	1	233
16 b	10. VII 1958	1	—	—	1	44	45	—	1	46	29	1	21	0	1	653
17 b	15. VII 1957	0	—	0	0	10	12	0	8	21	26	—	47	1	5	400
18 b	17. VII 1957	0	—	—	1	7	10	0	0	10	11	0	70	1	7	875
19 b	22. VII 1958	0	—	0	1	9	16	—	14	29	49	0	14	0	7	815
20 b	8. VIII 1958	1	—	—	4	10	10	—	10	20	7	—	31	1	36	289
11b—20b	Σ b %	0	—	2	1	27	31	0	6	37	20	0	33	1	6	
	Σ b no. — *kpl*	15	0	98	50	1 496	1 669	11	307	1 987	1 115	13	1 812	33	336	5 459

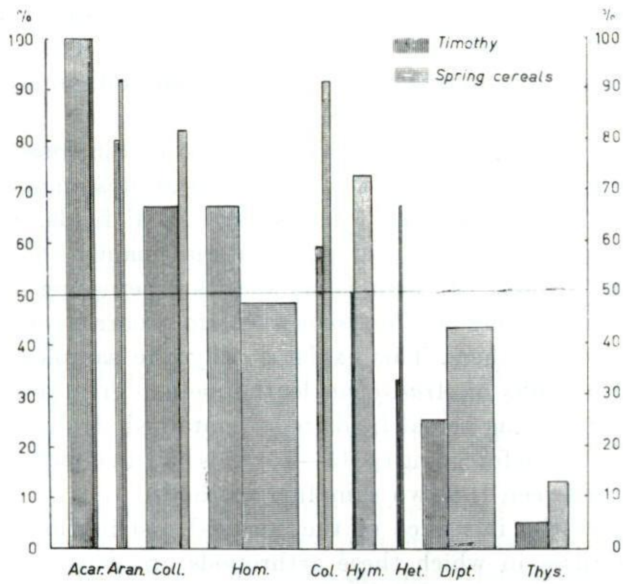

Fig. 5 Relative numbers of the arthropod groups obtained by the suction method, as percentages of the total of relative numbers obtained by the suction and netting samples from timothy leys and spring cereal fields. The width of the columns represents the relative numbers of arthropods.

Kuva 5. Imumenetelmällä saatujen niveljalkaisryhmien suhteelliset lukumäärät prosentteina timoteista (pystysuora viivoitus) ja kevätviljoista (vaakasuora viivoitus) otettujen imu- ja haavintanäytteiden suhteellisten lukumäärien summista. Pylväiden paksuus osoittaa niveljalkaisten suhteellisia lukumääriä.

groups. This is illustrated in Fig. 5, in which the arthropod groups have been arranged according to the degree in which one or the other method appears to be relatively better for catching individuals of the different groups. The results have been given separately for the sampling done on timothy leys and on spring cereal fields. It can be seen that the relative efficiency of the sampling methods is very different for different arthropod groups.

Individuals of groups such as *Araneida*, *Acarina* and *Collembola* are not usually caught in the netting samples, but have been obtained in abundant numbers by the suction method. On the other hand, *Diptera* and *Thysanoptera* are markedly better represented in the netting samples than in the suction samples. The differences are more marked in the samples from timothy leys than in those taken from spring cereal fields. The *Heteroptera* and *Homoptera* groups are better represented in the suction samples from timothy leys than in the netting samples, while the two methods were about equally efficient on spring cereal fields. Representatives of the *Coleoptera*, *Hymenoptera* and *Heteroptera* groups on spring cereal fields were better caught by the suction method than by netting, but from timothy leys *Heteroptera* individuals were relatively better obtained with the net. The yields of *Coleoptera* and *Hymenoptera* were approximately equal, although the numbers were not high.

Particular attention should be paid in Fig. 5 to the considerably different distribution of individuals of the *Homoptera* groups among the different samples taken from timothy leys and spring cereal fields. It can be seen from Tables 4 and 5 that the collected material mainly consists of *Araeopidae* leafhoppers, most of them being species hibernating in the nymphal stages I—IV. Among these *Calligypona pellucida* occurred with much higher frequency than any others. This explains why the samples from timothy leys contained nymphs of *Araeopidae* leafhoppers in great abundance, while the samples from spring cereal fields only contained *Araeopidae* adults. As has been shown in the foregoing (p. 15—16), this had an effect upon the difference observed between the two sampling methods.

Fig. 5 shows the influence of the vertical distribution of arthropods upon the quantities in which these arthropods are caught by the suction method and by netting. Other factors, which were already indicated by JOHNSON et al. (1957), also carry significance in this respect. Slowly moving arthropods living freely on the soil surface or on parts of plants were more quantitatively caught by the suction method, while the netting method was better for thrips hiding between parts of plants and swiftly moving, flying insects. For the same reasons the figures indicating the dominance values, found on the basis of the samples, are only comparable within certain limits.

From the investigations reported in the foregoing the general inference can be drawn that the suction method possesses several important advantages over the netting method. Nevertheless, there are other circumstances limiting its use, or at least affecting it unfavourably. Some advantages of the netting method in comparison with the suction method can be pointed to, but serious disadvantages could also be demonstrated.

The following is a compilation of the most essential advantages and disadvantages of the two methods, together with comments on the observations made by various investigators:

Advantages of the suction method:

1. Samples are obtained from well-defined areas.
2. The arthropods of the different vertical layers in the field stratum and even of the ground level will be fairly equally and well represented in the samples.
3. The representatives of most arthropod groups are caught more quantitatively by this method than by the netting method.

4. Samples can be taken from plots without plant cover or covered by low vegetation.
5. The errors introduced by weather components, time of day, type, density and height of vegetation, and sampler are less than in the netting method.

Disadvantages of the suction method:

1. The sampling devices are comparatively expensive and heavy; their transport over any great distance is therefore a difficult job.
2. The method cannot be applied to the study of species occurring in small numbers.
3. Selective sampling occurs, especially in respect of shape, clinging power, concealment and size. Selection also takes place when the insects are separated from earth that has been sucked up with the sample.
4. The sampling operation is slow and, depending on habitat, the samples may contain foreign admixtures, particularly earth, in greater quantities than are found in the netting samples. The treatment of the samples is therefore time-consuming and expensive.
5. Fragilely built arthropods tend to be damaged in the dried samples, especially by earth clods.
6. There is no satisfactory way of taking samples from plots where the vegetation has lodged, or where there is litter or moss on the ground.

Advantages of the netting method:

1. No expensive and heavy equipment is needed for the sampling.
2. In the case of species occurring in small numbers the samples are, as a rule, more useful than suction samples.
3. Sampling and treatment of samples is usually rapid and inexpensive.
4. Even fragile insects remain fairly intact in the samples.

Disadvantages of the netting method:

1. The samples cannot be referred to clearly defined areas.
2. The samples are better representative of the fauna in the upper part of the plant cover than of that in the lower strata. Differences in the vertical distribution of the arthropods will therefore produce errors in the samples.
3. No samples can be taken from plots lacking plant cover.
4. The errors caused by type, height and density of vegetation and by time of sampling are higher than in the suction method.
5. The greater part of the arthropods evades capture.

The present study shows that the suction and netting methods are not equally suited for quantitative and qualitative studies. In particular, the netting method may be considered more appropriate than the suction method in sampling work with the *Thysanoptera* and *Diptera*, and possibly with the *Lepidoptera* too. There are also certain groups for which neither method can be said to be satisfactory, for instance, numerous aphid species and coccids, larvae of *Diptera* and of some thrips, and all species or stages of development living in the interior of plants and characterized by a concealed mode of life or varying ability to cling to plant surfaces.

In general, it can be said that in ecological work netting samples render good service in preleminary studies while suction samples suit more precise investigations. Neither method in itself is ideally suited for application in synecological investigations. However, information gained with the aid of several different methods, including methods not commented upon in this paper, can be expected to give good overall results, one method compensating the disadvantages of another.

7. Summary

In this investigation a suction apparatus driven by a petrol engine and provided with suction fan, cylinder with sampling bag, and suction tube, was employed. A metal cylinder covering an area of 0.10 m^2 was used to circumscribe the area from which each partial sample was derived. The netting samples were taken with the aid of a sweep net having a circular inlet aperture. The habitats investigated in this work were 1st year timothy leys and spring cereal fields.

Investigation of the efficiency of our suction apparatus with *Calligypona pellucida* (F.) as an experimental subject revealed a statistically higlhy significant difference in this respect between the capture of adults and nymphs (87.5 and 74.8 % efficiency respectively).

The number of partial samples required in order to achieve satisfactory accuracy in absolute quantitative investigations was found to be at least six, and preferably nine. The number of animals should be counted separately for each partial sample. The plots where partial samples are taken should be evenly spaced over the entire sampling area.

The absolute quantitativeness of netting samples was investigated by comparing their results with the corresponding findings from suction samples. The test subject was *C. pellucida*. Stage of development and parasitization of the adults (*Strepsiptera* and *Dryinidae*) were found to affect the absolute quantitativeness of the netting samples; the variation in vertical distribution of the leafhoppers was found to be responsible for this effect. The error introduced by the sampler was not significant in the present work, nor could any significant influence on the absolute quantitativeness of the netting samples be observed to arise from the sex of the

leafhoppers, the differences in height of vegetation or the different species of cereals. On the basis of the present results, a calculation has been made of the numbers of sweeps of the net that will produce a number of nymphs, healthy adults or parasitized adults of *C. pellucida* equivalent to the population of 1 m^2 in timothy leys and spring cereal fields. These figures show considerable dispersion, which is indicative of the fact that external factors, such as weather conditions and differences of vegetation, combine to constitute a noteworthy source of error. The experiments suggest that preliminary studies with the aid of suction and netting sampling can be usefully applied to achieve considerably increased accuracy of the results derived by calculation from the netting samples.

In the present samples great differences, accountable to the sampling method, were observed between the numbers of individuals of different arthropod groups. These groups have been arranged in a series on the basis of the calculated frequency ratios shown in Fig. 5.

A compilation has been made of the advantages and disadvantages of the suction method as well as of the netting method.

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Selostus

Imu- ja haavintamenetelmien vertailu heinä- ja viljapeltojen eläimistöä, etenkin viljakaskasta, *Calligypona pellucida* (F.), koskevissa populaatiotutkimuksissa

OSMO HEIKINHEIMO ja MIKKO RAATIKAINEN

Maatalouden tutkimuskeskus
Tuhoeläintutkimuslaitos, Tikkurila

Viljakaskaan, *Calligypona pellucida* (F.), runsautta timoteinurmessa ja kevätviljoissa selvittävissä tutkimuksissa käytettiin Tuhoeläintutkimuslaitoksella imuperiaatteella toimivaa laitetta (kuvat 1 ja 2). Imulaite oli polttomoottorikäyttöinen. Näytealan rajauksessa käytettiin 36 cm korkeaa ja pohjapinta-alataan 0.10 m^2:n suuruista lieriötä. Imentäaika lieriöstä oli 2 min.

Samanaikaisesti imunäytteiden kanssa otettiin myös haavintanäytteitä tavallisella kenttähaavilla.

Imulaitteen tehokkuutta tutkittiin asettamalla harsolla peitettyyn lieriöön 50 viljakaskaan toukkaa tai aikuista ja imemällä ne sieltä 2 tunnin kuluttua. Toukista saatin keskimäärin 74.8 % ja aikuisista 87.5 % (taulukko 1).

Näytteiden suuruuden selvittämiseksi otettiin tasaiselta salaojitetulta pellolta tasavälein 32 0.10 m^2:n osanäytettä. Matemaattinen tarkastelu osoittaa, että kultakin näytealueelta otetun näytteen olisi sisällettävä vähintään 6, mieluimmin 9 osanäytettä, ja ne olisi käsiteltävä erikseen (kuva 3).

Imu- ja haavintamenetelmien vertailukokeissa otettiin samalta pellolta imunäytteen osanäyte ja haavintahäytteen osanäyte (20 haavinvetoa) vierekkäisistä paikoista. Molempia osanäytteitä otettiin 3 ja ne yhdistettiin yhdeksi näytteeksi. Tulokset (taulukko 2) osoittavat, että imumenetelmällä saadaan timoteista toukkia suhteellisesti paljon enemmän kuin haavintamenetelmällä. Syynä tähän on toukkien ja aikuisten erilainen jakaantuminen kasvustossa (kuva 4). Kevätviljasta saatiin imumenetelmällä (taulukko 3) suhteellisesti enemmän terveitä kuin loisisia aikuisia. Syynä tähänkin näyttää olevan näiden erilainen jakaantuminen kasvustossa. Todettiin, että imumenetelmällä saadut tulokset ovat oikeampia kuin haavintamenetelmällä saadut.

Timoteista olisi pitänyt ottaa 396 ± 80 haavinvetoa yhtä m^2:ä vastaavan toukkamäärän ja 86 ± 19 vetoa vastaavan aikuismäärän saamiseksi. Kevätviljasta olisi pitänyt vastaavasti ottaa 51 ± 12 vetoa terveiden aikuisten ja 40 ± 16 vetoa loisisten aikuisten saamiseksi.

Imu- ja haavintamenetelmillä saadaan hyvin eri määriä eri eläinryhmien edustajia (vrt. taulukot 4 ja 5). Kuvasta 5 ilmenee, että kaksisiipiset ja ripsiäiset ovat huomattavasti paremmin edustettuina haavintanäytteissä kuin imunäytteissä. Hämähäkit, punkit ja hyppyhäntäiset ovat taas paremmin edustettuina imunäytteissä. Tämän vuoksi on tulkittava erittäin varovaisesti esim. haavintamenetelmällä saatuja ja niistä laskettuja ryhmien välisiä suhteita, ns. dominansseja. Ne eivät edusta läheskään aina luonnossa vallitsevia todellisia lukumääräsuhteita, dominansseja.

Haavintanäytteet näyttävät soveltuvan ekologisissa tutkimuksissa hyvin orientoiviin, imunäytteet taas tarkennettuihin tutkimuksiin. Kummallakin menetelmällä on omat etunsa ja haittansa.