Studies on *Lasius flavus* F. (Hymenoptera, Formicidae): I. Population density, biomass, and distribution of nests

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Abstract: On a study area (625 m²) in a Danish tidal meadow the number of *Lasius flavus* nests were 191. The mean area covered by each nest was 0.39 m²; 11.6 % of the ground area were ant nests. The above ground volume of the nests variated from 1.2 to 115 liters with a mean of 36.8 liters. The distribution of the ants in the nests was studied by taking sectors of the nests at different compass directions. The number of ants in the nests was determined by handsorting of seven whole nests, three half nests, and one fourth nest.

The number of ants in the nests can be described by

$$y = 303 + 609x \qquad (r = 0.96)$$

where y = number of ants in the nest

x = above ground volume in liters

The mean number of ants in the nests was 22100 ± 760; outside the nest was the density 230 ants per m². The mean territory of each nest was 3.28 m², which gives a density of ants for the whole area of 7290 ± 815 ants per m² or 2435 ± 270 mg d.wt. per m².

Introduction

On many localities, especially on meadows and tidal meadows, the nests of *Lasius flavus* F. occur in high density. The ants collect all their food in the ground, and they are rarely seen aboveground; however, the conspicuous nest domes attest to their presence. In the work presented here, we have investigated the distribution of the nests and the population density of *Lasius flavus* in tidal meadows of Denmark.

Lasius flavus has been intensively studied in England where Pickles (1936, 1937, 1938, 1940), and Carey and Diver (1937) investigated the territories and biomasses of this ant species. The distribution of *Lasius flavus* was studied by Waloff and Blackith (1962), Gallé (1972), and Elmes (1974), and competition between *Lasius flavus* and *Lasius niger* (L.) by Pontin (1957, 1961, 1963). Pontin (1960) investigated the colony foundation by *Lasius flavus* and Odum and Pontin (1961) determined the population density on a calcareous grassland.

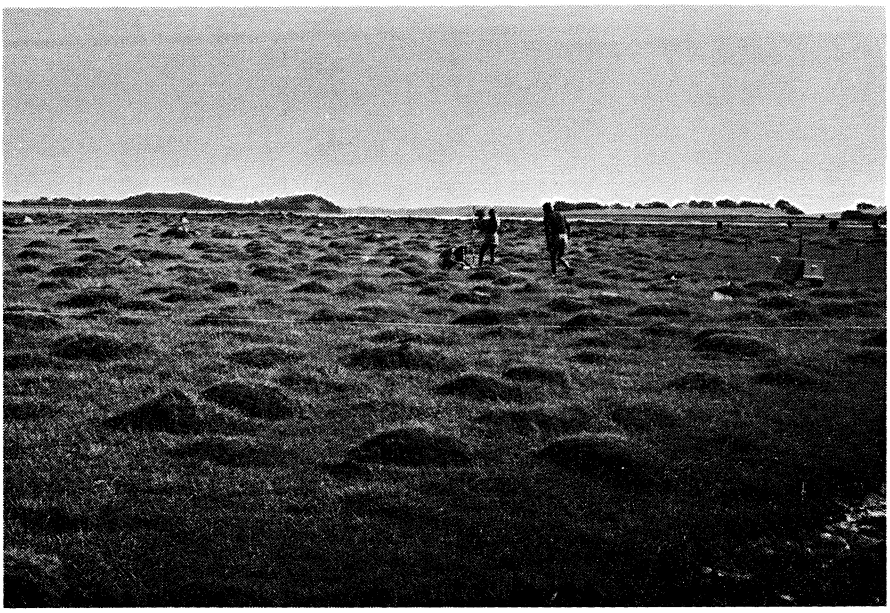

Fig. 1. The study area at the tidal meadow near Stavns Fjord, Samsø, showing the conspicuous nests of *Lasius flavus*.

Study area

The investigations were carried out in summer and early fall, 1975, at Stavns Fjord on the island of Samsø, and on the neighbouring island Hjortholm, Denmark. Fig. 1 shows the study area at Stavns Fjord. This area is inundated by exceptionally high tides a few times per year. The vegetation on the area, which is grazed by cattle, is dominated by *Festuca rubra* L. and *Agrostis tenuis* Sibth. Besides the two dominant species the following plants were found: *Phragmites communis* Trin., *Juncus gerardi* Lois, *Armeria maritima* (Mill.) Willd., *Sieglingia decumbens* (L.) Bernh., and *Carex extensa* Good. One species of reindeer moss, *Cladonia rangeformis* Hoffm.. was found in the area between the ant nests.

The vegetation on the anthill had a higher diversity than the surroundings, but the two dominant grass species, *Festuca rubra* and *Agrostis tenuis*, were the same. In addition the following plant species were found on the anthills, *Armeria maritima* (Mill.) Willd., *Cochlearia danica* L., *Plantago maritima* L., *Empetrum nigrum* L., *Sagina procumbens* L., *Sagina maritima* Don, *Cerastium* sp., *Deschampsia flexuosa* (L.) Trin., and *Stellaria media* (L.) Vill.

Three species of reindeer moss were found on the anthills: *Cladonia rangeformis* Hoffm., *C. fimbriata* (L.) Fr., *C. furcata* (Huds.) Schrod., and four genera of moss were present, *Barbula* sp., *Cephaloziella* sp., *Bryum* sp., and *Brachythecium* sp.

On the island Hjortholm, unlike the Stavns Fjord site, the nests occur above the tidal zone. Fig. 2 shows the study area, which is about 10 m above sea level.

Methods

a. Distribution of the nests

At Stavns Fjord the ant nests occur only on the tidal meadow. A typical area of 25×25 m of the tidal meadow was chosen as study area (Fig. 1). The position of each nest within the study area was mapped (Fig. 3). For all nests in the area the greatest and smallest diameter and the height were measured. The elliptic area and the aboveground volume were calculated for each nest.

Fig. 2. The study area at the island Hjortholm in Stavns Fjord. The altitude is 10–15 meters above the tidal zone.

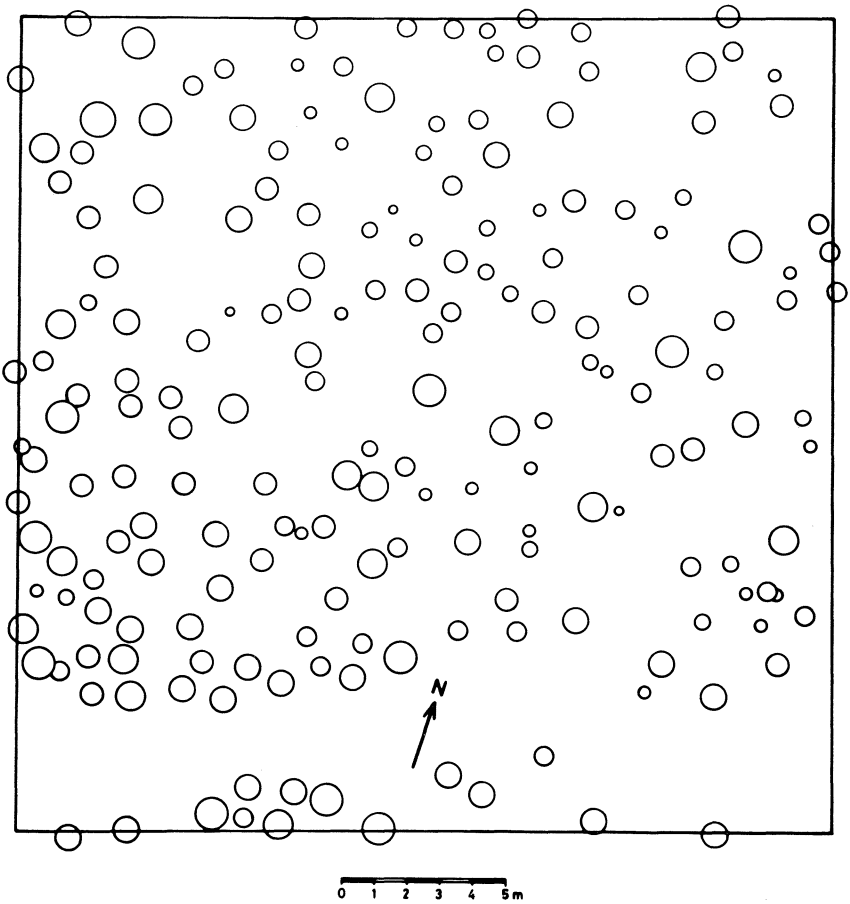

Fig. 3. Distribution of the nests on the study area at the tidal meadow. The band lacking nests at the bottom of the figure corresponds with the lowest and wettest part of the study area.

b. Distribution of the ants in the nest

To determine the distribution of the ants in the nest sectors of 45° of the nest were taken using a triangle shape which could be pressed down through the nest and about 15 cm down into the soil. Each sector could then be taken out separately. A total of 22 sets of samples was taken.

The samples were kept in closed plastic-boxes until the sorting. All samples were handsorted and the ants were sucked from the galleries in the soil. Most of the sand was then sieved from the samples and the rest, mostly

plant material, was placed in heat extraction funnels and the ants were collected in formaldehyde. The sorting methods were very laborious, but the efficiency was high, more than 98 %, measured by carefully repeated sortings.

The number of ants was calculated by weighing, and about 10 % of the ants were counted as control.

Results

a. Density of nests in the study areas

The 625 m^2 study area at Stavns Fjord included 191 nests of *Lasius flavus*. The area covered by the nests ranged from 0.071 to 0.867 m^2 (mean = 0.389; standard deviation = 0.186 m^2). The area covered by ant nests on the experimental site was 72.4 m^2, or 11.6 % of the total area. The aboveground volume of the nests varied from 1.2 to 115.4 liters (mean = 36.8 liters; standard deviation = 28.5 liters).

On the study area at the island Hjortholm, the density of the nests was only 92 nests per 625 m^2. The mean area of the nests was 0.45 m^2, so 6.6 % of the total area were covered by ant nests. The mean aboveground volume for the nests was 40.45 liters, which does not differ significantly from the tidal meadow.

b. Distribution of the ants in the nests

Fig. 4 shows the distribution of ants in sectors of the nest at the different compass directions. The number of ants is expressed as number per liter of

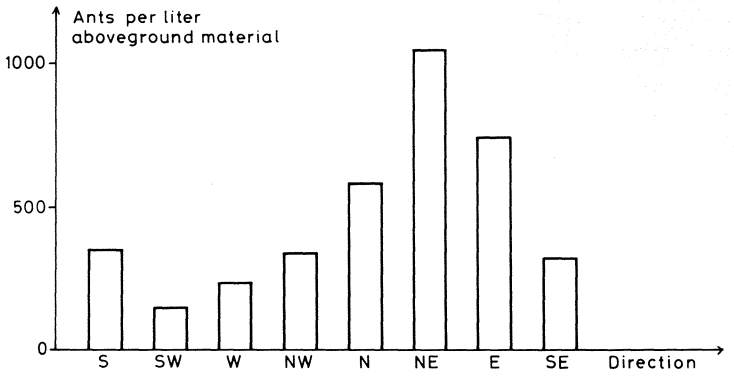

Fig. 4. Number of ants in each 45°-sector of a *Lasius flavus* nest. The values are expressed as number of ants per liter aboveground nest materials.

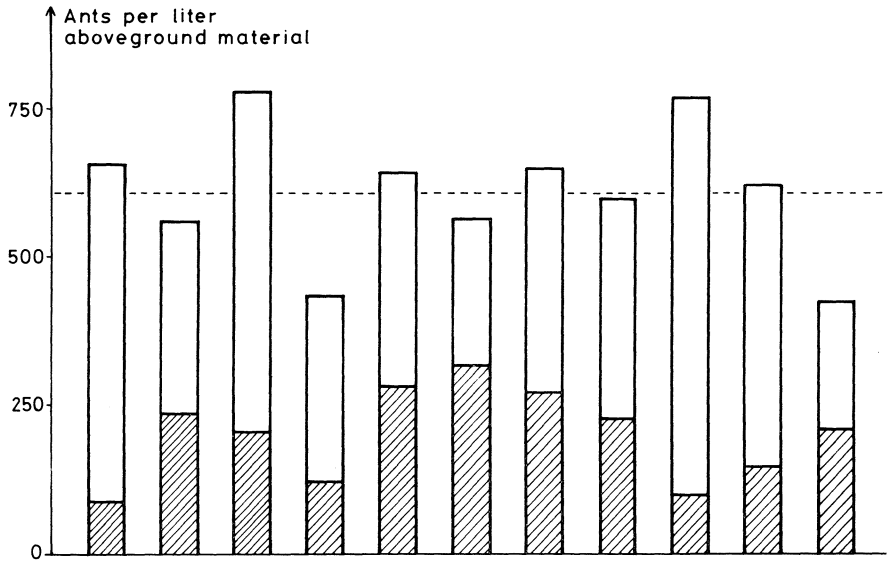

Fig. 5. The number of ants in paired samples taken in opposite directions. The values are expressed as number of ants per liter aboveground nest materials.

aboveground nest material. The highest value is more than seven times higher than the lowest; indicating that the ants were not uniformly distributed within the nest. Rather, there was a distinct tendency for ants to be concentrated in the northeast and neighbouring sectors, with much lower densities in the opposite (SW) sector.

For all samples taken as sectors the number of ants per liter aboveground nest material were calculated. The mean for these samples was 610 and the standard deviation was 310 or 51 % of the mean.

In Fig. 5 the samples are lumped so the opposite sections are added. In this case the mean was the same but the standard deviation was only 115 or 19 % of the mean.

c. Number of ants in the nests

To determine the population density of workers in nests of different size, a number of nests were dug up and the ants were sorted out.

The nests were selected so that greatest variation in size was obtained. Because of the laborious hand sortings, only seven whole nests, three half nests (45°-sectors were taken in the direction N, S, E, and W) and one fourth nest, sectors taken N and S, could be analyzed.

The number of ants in each nest was correlated with the aboveground volume of the nest (Fig. 6). The equation of the regression line is:

$$y = 303 + 609\,x$$

($r = 0.96$ and the 95 % confidence limits were $\pm$ 760)

where y is number of ants in the nest
x aboveground volume in liters

The mean population density in the nests at the study area on the tidal meadow, estimated from nest volume and the regression equation, was 22100 $\pm$ 760 ranging from 1035 to 70500.

d. Density of ants outside the nest

Samples taken with a circular soil core of 177 cm^2 were used to determine the density of ants at different distances from the nests. The samples were taken 0–15, 15–30, and >30 cm from the nests and the means $\pm$ one standard deviation were 25.1 $\pm$ 34.9 (n = 14), 21.0 $\pm$ 12.6 (n = 8), and 4.0 $\pm$ 3.1 (n = 13) ants per sample, respectively. The ants were aggregated and therefore the standard deviations for these samples are high and

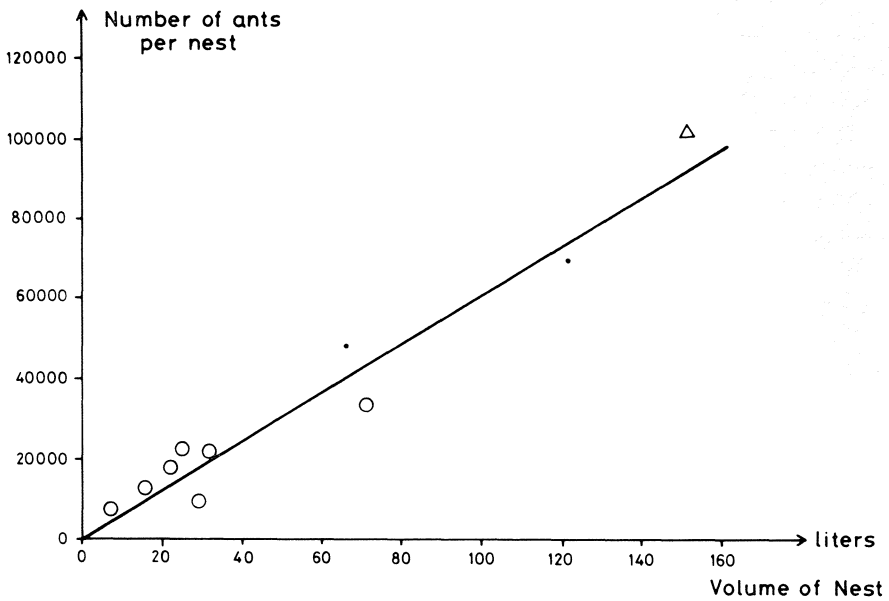

Fig. 6. Number of *Lasius flavus* workers in the nests as a function of aboveground volume. (o) whole nest is sorted, (·) half of the nest sorted, and (△) one fourth of the nest sorted.

Table 1. Distribution of *Lasius flavus* workers at the tidal meadow.

	Total area	Nests	Zone 0–30 cm from nests	Zone > 30 cm from nests
Area m^2	625	72.35	178.86	373.79
Percentage of total area	100	11.58	28.62	59.80
Mean territory for the nests m^2	3.28	0.38	0.94	1.96
Mean number of ants in each territory	23880 ± 2675	22100 ± 760	1325 ± 1565	450 ± 350
Percentage of total number in the territory	100	92.6	5.5	1.9
Density (ants per m^2)	7290 ± 815	58160 ± 2000	1400 ± 1665	230 ± 180
Biomass (mg d.w. per m^2)	2435 ± 270	19425 ± 668	470 ± 555	77 ± 60

strongly correlated with the mean. The values for 0–15 and 15–30 cm from the nests are not significantly different and therefore these two sets of samples are taken as one. The number of ants per sample for the zone 0–30 cm is then 24.2 ± 28.6 (n = 22).

The mean area surrounding the nests at the experimental site was 3.28 m^2 and the mean area for the nests was 0.38 m^2. The mean area of the zone 0–30 cm around the nest is 0.94 m^2 which gives an ant population of 1325 ants or 1400 ants per m^2. The zone more than 30 cm from the nests occupy 1.96 m^2 of the mean territory, and the ant population is then 450 or 230 ants per m^2.

In table 1 the values for the distribution of the ants on the area are summarized. 92.6 % of the ants are found in the nests. The area more than 30 cm from the nests, which covers 59 % of the total area, includes only 1.9 % of the ants. The ant density for the whole area is estimated to be 7290 ± 815 ants per m^2 which corresponds to 2435 ± 270 mg d. w. per m^2.

Discussion and Conclusions

On the experimental area on the tidal meadow 11.6 % of the ground is covered by *Lasius flavus* nests. Waloff and Blackith (1962) found that *Lasius flavus* nests occupy up to 10–11 % of the ground on a sandy dry

area at an altitude of about 60 meters in Berkshire, England. It is remarkable that nests of *Lasius flavus* on two so different localities can achieve the same high density.

The most accurate method to determine the population density of ant nests is to count all ants in the nest, but this method is highly time consuming and destructive. Because of the uneven distribution of the worker ants in the nests of *Lasius flavus,* it is difficult to take representative subsamples of the ant population. In this work subsamples taken as one sector of 45° of the nest showed such high variation that it was impossible to estimate the ant population from one sample. If two samples of 45° were taken in opposite directions the accuracy of the population estimation increased significantly.

In this experiment the standard deviation decreased from 51 % of the mean to 19 % when two opposite samples were used instead of one.

The regression between number of ants and aboveground volume of the nest shows a strong correlation ($r = 0.96$), and therefore the number of ants in the nests is calculated with high accuracy. The values for the number of ants outside the nests show a high variation, but the values are much smaller than the number of ants in the nest, so the estimations of total ant density still have a good accuracy.

Odum and Pontin (1961) used capture-recapture method to estimate the population density in ant nests, but they did not make any test of efficiency for their method (Nielsen, 1974). This might be the reason why they only found up to 10000 ants in a big nest, whereas Waloff and Blackith (1962) found up to 24500 ants per nest, and we have found up to about 100000 ants in our largest nest.

Using their low estimate of number of ants per nest, Odum and Pontin (1961) only found a population density of 1130 ants per m^2 for the area with the highest values. Our estimate of 7290 ants per m^2 is in fine agreement with Waloff and Blackith (1962) who found a mean density of 5210 ants per m^2 for their three areas.

Acknowledgements

For permission to work at the study area we wish to thank Brattingborg Property. For very valuable assistance during the work at Samsø we want to express our gratitude to Ole V. Jakobsen and for assistance during the laborious sortings we want to thank stud. scient. Hans Jørgen Skuldbøl and Mrs. Jenny Petersen. We also want to thank Jette Schellke Nielsen for drawing the graphs and Dr. S. Lægaard for identification of the plants. Finally we want to thank Dr. Stephen F. MacLean for criticism of the manuscript and for linguistic improvements.

References

Carey, E. and C. Diver, 1937: Territory in the yellow field ant, *Lasius flavus*. *J. Anim. Ecol.* 6: 193–194.

Elmes, G. W., 1974: The spatial distribution of a population of two ant species living in limestone grassland. *Pedobiologia*, 14: 412–418.

Gallé, L., 1972: Study of ant-populations in various grassland ecosystems. *Acta Biologica Szeged*, 18: 1–4.

Nielsen, M. G., 1974: The use of Lincoln Index for estimating the worker population of *Lasius alienus* (Först) (Hymenoptera: Formicidae). *Natura Jutlandica*, 17: 87–90.

Odum, E. P. and A. J. Pontin, 1961: Population density of the Underground Ant, *Lasius flavus*, as determined by tagging with P-32. *Ecology*, 42: 186–188.

Pickles, W., 1936: Populations and Territories of the ant, *Formica fusca*, *Acanthomyops flavus*, and *Myrmica ruginodis* at Thornhill, York. *J. Anim. Ecol.* 5: 262–272.

Pickles, W., 1937: Populations, Territories, and Biomasses of Ants at Thornhill, Yorkshire 1936. *J. Anim. Ecol.* 6: 54–61.

Pickles, W., 1938: Populations, Territories, and Biomasses of Ants at Thornhill, Yorkshire 1937. *J. Anim. Ecol.* 7: 370–380.

Pickles, W., 1940: Fluctuations in the populations, weights and biomasses of ants at Thornhill, Yorkshire, from 1935 to 1939. *Trans. R. Ent. Soc. Lond.*, 90: 467–485.

Pontin, A. J., 1957: An investigation of the interaction between *Lasius flavus* (F.) and *Lasius niger* (L.). *Proc. R. Ent. Soc. London* (C), 22: 49.

Pontin, A. J., 1960: Field experiments on colony foundation by *Lasius niger* (L.) and *L. flavus* (F.) (Hym., Formicidae). *Insectes sociaux*, 7: 227–230.

Pontin, A. J., 1961: Population stabilization competition between the *Lasius flavus* and *L. niger*. *J. Anim. Ecol.*, 30: 47–54.

Pontin, A. J., 1963: Further considerations of competition and the ecology of the Ants *Lasius flavus* and *Lasius niger*. *J. Anim. Ecol.*, 32: 565–574.

Waloff, N. and R. E. Blackith, 1962: The growth and distribution of the mounds of *Lasius flavus* (Fabricius) (Hym., Formicidae) in Silwood Park, Berkshire. *J. Anim. Ecol.*, 31: 421–437.

Sammendrag:

Studier over den gule engmyre, *Lasius flavus* F. (Hymenoptera, Formicidae). I. Populationstætheder, biomasse og fordeling af tuerne.

Den gule engmyre *Lasius flavus* F. bygger nogle meget karakteristiske kuppelformede jordtuer, som man især finder på enge og strandenge. Myrerne ses sjældent på jordoverfladen, da de samler al deres føde under jorden.

Formålet med dette arbejde var at bestemme fordelingen af tuerne og populationstætheden af *Lasius flavus* på en strandeng ved Stavns Fjord og på den nærliggende ø Hjortholm, Samsø. Figur 1 viser det undersøgte område ved Stavns Fjord, der oversvømmes nogle få gange om året. Arealet bliver brugt til græsning for kreaturer, og vegetationen mellem tuerne domineres af rød svingel (*Festuca rubra* L.) og almindelig hvene (*Agrostis tenuis* Sibth.). Vegetationen på tuerne var betydelig mere artsrig, men de to dominerende arter var de samme.

Ved Stavns Fjord udvalgtes et typisk område på 25×25 m, hvor alle tuerne blev kortlagt (fig. 3). For hver tue blev den største og mindste diameter samt højden målt, og det elliptiske areal og det overjordiske volumen beregnet. Arealet af myretuerne udgjorde 11,6 % af området, og tuernes volumen varierede fra 1,2 til 115,4 liter med et gennemsnit på 36,8 liter.

På det udvalgte område på Hjortholm, fig. 2, dækkede myretuerne 6,6 % af arealet, og den gennemsnitlige tuestørrelse var 40,5 liter.

Waloff og Blackith (1962) fandt på et område i Berkshire i England, at *Lasius flavus* tuer udgjorde 10–11 % af arealet.

For at bestemme myrernes fordeling i tuerne blev der taget udsnit af tuerne ved hjælp af en metaltrekant på 45°, der kunne presses ned i tuerne og yderligere ca. 15 cm ned i jorden. Alle prøverne blev håndsorteret, og de fleste myrer blev suget fra gallerierne i jorden. Derefter blev sandet sigtet fra, og myrerne i det resterende materiale blev uddrevet i modificerede Berlese apparater. Denne sorteringsmetode er meget arbejdskrævende, men til gengæld var vores effektivitet meget høj, 98 %. Antallet af myrer blev beregnet ved vejning, og ca. 10 % af myrerne blev optalt som kontrol.

Fig. 4 viser fordelingen af myrer i en tue i forhold til verdenshjørnerne. Figuren viser, at myrerne ikke er ensartet fordelt i tuerne. Der var dog en udtalt tendens til koncentration af myrerne i de nordøstlige udsnit af tuerne og en tilsvarende mindre tæthed i de sydvestlige udsnit. Ved at addere antallet af myrerne i modsatrettede udsnit får man en betydelig mere repræsentativ prøvestørrelse, der med rimelighed kan anvendes til bestemmelse af totalpopulationen, fig. 5.

Populationsstørrelsen i 11 tuer af forskellig størrelse blev bestemt, og antallet af myrer i hver tue blev korreleret med tuernes overjordiske volumen, fig. 6:

$y = 303 + 609x$ ($r = 0{,}96$), hvor
y er antal myrer i tuen, og
x er overjordisk volumen i liter.

Til bestemmelse af antallet af myrer uden for tuerne blev der taget prøver med jordbor (177 cm^2) i forskellig afstand fra tuerne. Antallet af myrer uden for tuerne viste meget stor variation, men værdierne er meget mindre end antallet af myrer i tuerne, så estimeringen af den totale population kan stadig beregnes med god nøjagtighed. I afstanden 0–30 cm var populationstætheden 1400 ± 1665 myrer/m^2, og i afstande større end 30 cm fandtes 230 ± 180 myrer/m^2.

I tabel 1 ses, at 92,6 % af myrerne blev fundet i tuerne, og i afstand større end 30 cm blev kun fundet 1,9 % af myrerne.

På forsøgsområdet ved Stavns Fjord varierede antallet af myrer pr. tue fra 1030 til 70500 med et gennemsnit på 22100 ± 760. For hele området fandtes en populationstæthed på 7290 ± 815 myrer/m^2 svarende til 2,44 ± 0,27 gram tørvægt/m^2, hvilket er i overensstemmelse med Waloff og Blackith (1962) opgivelser om populationstætheder på 5210 myrer/m^2.

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