

Estimation of population sizes and "home ranges" of polyphagous predators in alfalfa using mark-recapture: an exploratory study

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Abstract

The ground living predatory arthropod populations in an alfalfa field were investigated by marking and recapturing animals using live trapping pitfalls. Twelve pitfalls were set up in the field in a grid arrangement. The total capture and recapture data were used to calculate population sizes using the Petersen-Lincoln index, while the grid location and the time elapsed to recaptures were used to assess the "home range" of the animals. The study focused on the dominant predatory arthropods: *Harpalus rufipes* (Coleoptera, Carabidae), *Cicindela campestris* (Coleoptera, Cicindelidae), and *Pardosa agrestis* (Araneae, Lycosidae). There were few recaptures of beetles and of female wolf spiders. The resulting large error of the Petersen-Lincoln estimates precluded the drawing of final conclusions on the population sizes of all predators, except male *P. agrestis*. The size of the trapping grid permitted assessment of the "home range" only for male wolf spiders. The resulting estimate was a density of 4 spiders/m² and a maximum "home range" of about 300 m². Studies to estimate densities of such mobile animals seem only to be feasible if a sufficient number of recaptures can be achieved and the spatial scale of the trapping is comparable with the "home range" of the species studied.

Key words: Population estimation, mark-recapture, movement activity, predatory arthropods, wolf spiders

Introduction

The assessment of population size, "home range" and mobility of ground living arthropod predators is a difficult task for the field biologist, since something

Arthropod natural enemies in arable land · I Density, spatial heterogeneity and dispersal
S. Toft & W. Riedel (eds.). *Acta Jutlandica* vol. 70:2 1995, pp. 47-55.
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intangible is being measured. Collection methods useful in faunistic research often fail to give even a relative estimate of population sizes. Absolute density estimating methods, like enclosing an area or D-vac sampling can also fail in the case of highly mobile animals, which might escape on the approach of the investigator.

Pitfall trapping is a cost effective, widely used method of sampling ground living arthropod populations (Uetz & Unzicker 1976). The ecological interpretation of pitfall trap data has generated much controversy in the entomological literature (Lövei & Samu 1987, Halsall & Wratten 1988, Topping & Sunderland 1992). Conclusions have often been drawn on the relative abundance of the species caught. However, abundance is not the only factor which determines how many individuals from a local arthropod population will be caught. Catches from traps such as pitfalls, light or malaise traps, depend also on the mobility, "home range" and trap avoidance behaviour of the populations studied. Mobility has a simple effect on catches. The more mobile an animal, all other factors being constant, the higher the chance that it crosses the trap's perimeter and gets caught. Greater "home range", on the other hand, lowers the chances that the particular area of the trap opening will be encountered. Mobility and "home range" interact with each other. A species with a large "home range" and with high mobility can be caught with the same frequency as another species with small "home range" and small mobility. Trap avoidance behaviour can vary between different species. Some spiders build a web across the trap opening, and are underrepresented in the caught material (Topping 1993). Walking behaviour (fast or slow; to what extent the animals walk on the low vegetation or directly on the soil surface) acts also as a kind of trap avoidance and determines what proportion of the animals will fall in the trap. Trap avoidance can be regarded as a species-specific constant factor, at least within developmental stage and sex, while mobility can vary a lot due to weather, hunger and sexual activity even within a species or stage.

Marking studies can be useful to separate the combined information contained in pitfall trap data. Marking and recatching the animals (as in classical mark-recapture studies) can, by the dilution principle, give an idea of the population size of the species (Seber 1982). If many appropriately spaced traps and individual marking are used, the distance covered and time elapsed between two catches can be combined to give information on the "home range" of the animals (Otis et al. 1978).

Here we report on a small-scale study of this type in which ground living predatory arthropods of an alfalfa field were sampled by a grid of live trapping pitfalls, and then marked. The trapping data as such gave us the traditional information obtainable from a usual pitfall trapping session. From the recapture



rate we attempted to estimate the population sizes of the focal species, while from the spatial location of recaptures within the grid, and from the time elapsed between captures, we tried to assess the "home range" of the animals.

Materials and methods

Live trapping pitfall traps of 36 cm² upper area were planted in a 3x4 grid, 3 m apart from each other. This catching unit was unfenced and situated in the middle of a 150 m wide alfalfa field. Traps were visited daily. Trapped animals were marked individually with a "patch mapping" method (Samu et al., unpublished) using enamel paint (initially acrylic paint in the case of spiders). Plant material was placed on the bottom of the traps to serve as a refuge for the animals, and thus decrease predation and cannibalism among trapped animals. Marked animals were set free 0.5 m away from the trap where they were caught. The date and place of release of recaptured animals were identified by the marking pattern. For the safety of the identification, besides applying a unique marking to every individual, a new colour was used for each day. Over 1000 predatory arthropods were marked during the three weeks of study (30 July - 21 August 1991). The most numerous species were the carabid beetle *Harpalus rufipes* (De Geer), the tiger beetle *Cicindela campestris* L., and the wolf spider *Pardosa agrestis* Westring. Since virtually all recaptures occurred in these species, further analysis focused on them. Male and female wolf spiders (sexes are readily identifiable in the field) had different trappability and recapture rates, and so were treated separately. Weather data was obtained from the daily weather records of the Hungarian Meteorological Institute.

Population sizes of the studied species were calculated from the Petersen-Lincoln index modified for multiple releases and recaptures (Begon 1979, Demeter & Kovács 1991):

$$N = \frac{\sum M_i n_i}{(\sum m_i) + 1}$$

where N is the population size, M_i is the total number of marked animals at time i, n_i is the number of animals captured at time i, and m_i is the number of marked animals in that capture.



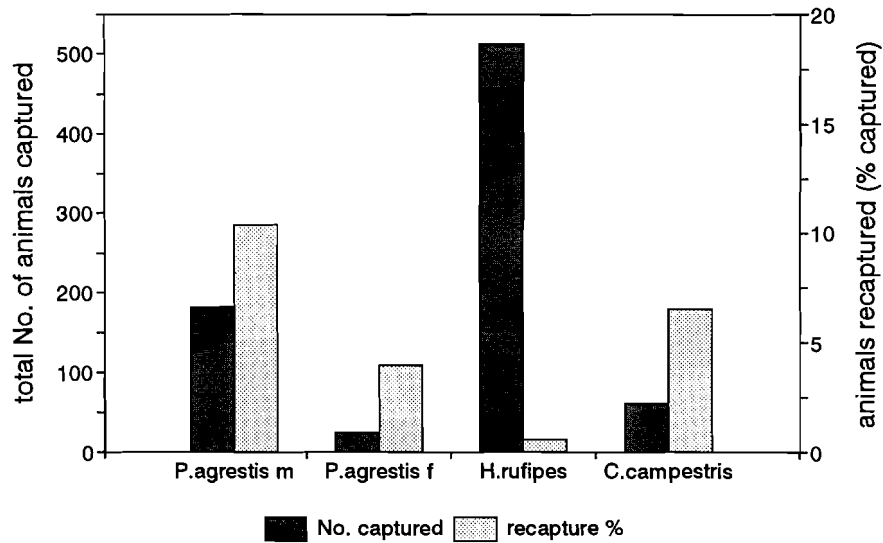


Fig. 1. Total number of individuals caught in the 12 pitfalls and recapture rate (percentage of total catch) of the three focal species.

Results

A total of 781 individuals of the three species investigated were marked and released during the 3 weeks duration of the study. *Harpalus rufipes* made up 65% of the captured animals. Daily captures of this beetle were 32 ± 15.4 (mean \pm S.D.). However, this species also had the smallest overall recapture rate, only 0.59% (Fig. 1). *Pardosa agrestis* was represented in the catches with a fairly high number, but there was a great difference between the daily catches of males and females (11.4 ± 9.03 vs. 1.6 ± 2.57). Overall recapture rate was around 10% for the males, and around 4% for the females (Fig. 1). *Cicindela campestris* was caught in smaller numbers (3.8 ± 3.52), but it was relatively frequently recaptured (recapture rate: 6%).

Variability in daily catches was very high. The time series of catches of *P. agrestis* (both sexes) and *C. campestris* changed together (Fig. 2). *H. rufipes* showed peak catches shifted by a day compared to the other two species. Over such a short period of time population changes can be ruled out; thus the fluctuations in daily catches must have reflected changes in the mobility level of the animals. Mobility of the animals on the other hand could be influenced by weather factors. Cold fronts indeed seemed to explain much of the variation observed (Fig. 2). *H. rufipes* showed peak activity at the arrival of the fronts

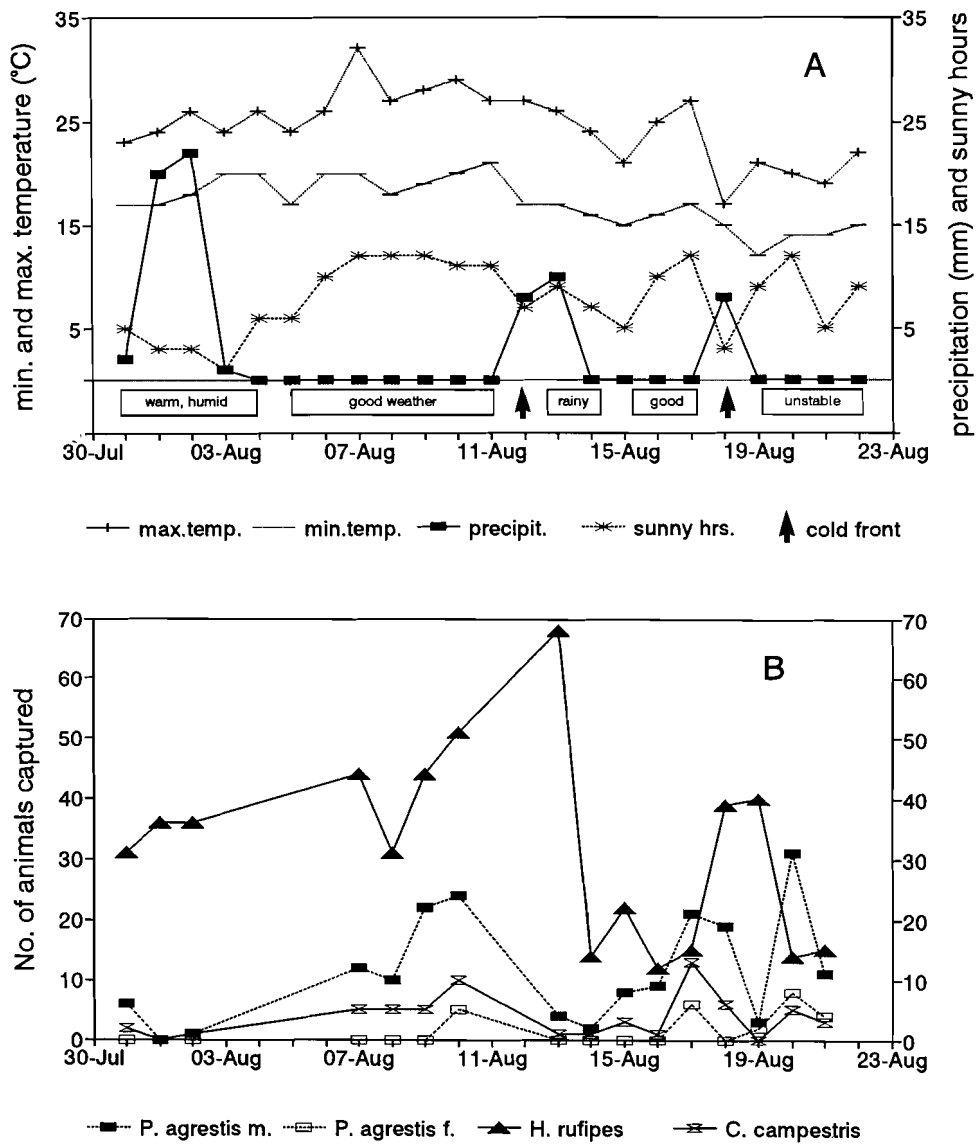


Fig. 2. A. Variation in weather during the study period. B. Daily No. of animals caught in the pitfalls. Data, even in the case of the two interruptions of the continuous observation, refer to the catch of the preceding 24 hours.



and then declined, while the wolf spider and the tiger beetle species had an activity minimum from the beginning of the fronts. Catches in all groups were high during the good weather periods.

The distance at which marked animals were recaptured, measured from the release trap, can provide an estimate of the distances these animals can travel between captures (Table 1). Of the four tiger beetles recaptured, all were recaptured on the day following release, three in the same trap, one in a neighbouring trap. *H. rufipes* was recaptured only on three occasions, twice on the next day, and once 11 days after the marking. In the latter case the exact release site was not determinable. In *P. agrestis* 65% of the males were recaptured in the same trap. Contrary to the tiger beetles, these spiders were not always recaptured on the next day, but on the average 2.3 days after marking. The remaining recaptures occurred either in the closest or the second closest neighbouring trap (maximum distance 6.7 m). Mean time elapsed between capture and recapture, considering all recaptures, was also 2.3 days. There was no correlation between the time to recapture and the distance covered during this time (d.f. = 15, $r=0.24$, N.S.).

Estimation of the population size gave the highest value in the case of *H. rufipes*, where the highest pitfall catches were associated with the lowest recapture rates. The *Pardosa* population was also shown to be substantial, but estimations for males and females were very different. The smallest population size was calculated for the tiger beetles (Table 1).

Discussion

Mark-recapture studies can give information about the size of a population. Precision of the estimation by the Petersen-Lincoln index, or indeed any other model, is largely dependent on the number of animals recaptured. In the present study low recapture rates are reflected by the large standard deviations associated with the population estimates. Therefore care should be taken in the interpretation of these values, with the possible exception of male wolf spiders. These figures give rather the order of magnitude of the population sizes. Apparently a larger scale sampling is needed to study the relatively more mobile carabid populations than the more sedentary wolf spiders.

Daily variation in the mobility of animals might substantially change catches of the pitfalls from day to day. Such very short-term activity changes are often caused by changing weather conditions. Weather fronts have been shown to change flight activity of carabids significantly (Honek 1988, Kádár & Szentkirályi 1991). In mark-recapture situations weather unavoidably changes



Table 1. Mean and standard deviation of the distance covered and time elapsed between marking and recapture, and the estimate of mean population size by the Petersen-Lincoln index.

	<i>P. agrestis</i> ♂♂ mean ± SD	<i>P. agrestis</i> ♀♀ mean ± SD	<i>H. rufipes</i> mean ± SD	<i>C. campestris</i> mean ± SD
Distance covered (m)	2.14 ± 2.94	6.00 ± -	3.00 ± -	0.75 ± 1.30
Days to recapture	2.32 ± 1.45	4.00 ± -	4.33 ± 1.41	1.00 ± 0.00
Population size*	701 ± 165.6	116 ± 153.5	23144 ± 15846	284 ± 162.5

* Estimated by the Petersen-Lincoln index weighted by the number of recaptures.

the capture rate during the study. If sufficient data is available, mark-recapture models less sensitive to such changes (e.g. the Jolly-Seber model; Seber, 1982) would be preferred.

To know not only the population size, but the density of a population as well, the area which the animals can cover, i.e. their "home range" has to be known. The grid arrangement of the traps and the individual marking aimed at this goal, but success varied with species, as was the case with population size.

In *Harpalus rufipes* the large pitfall catches and small recapture rate indicated a very large population. One recapture after 11 days suggested that the population was not in migration. This species is regarded as very mobile and capable of flight (Kádár & Lövei 1992). The location of the recaptures in the grid could not be considered in calculating "home range", because they were too few, and in the light of its high mobility it is possible that the sampling grid did not completely encompass the "home range". The lack of information on "home range" precludes any conclusion on the density of the carabid population.

Adult males of the wolf spider *Pardosa agrestis* were trapped more frequently than females. Since there is no indication that sex ratio would be (at least at the initial phase of adulthood) different from 50% (Edgar 1972; pers. observation), different catches must be attributed to the different activity and possibly different trap avoidance behaviour of the sexes (Hallander 1967, Topping & Sunderland 1992). *Pardosa* species are considered to employ a "sit-and-wait" predatory strategy. The pattern of movement consists of long motionless waiting, then short bursts of movements (Ford 1978). Even if this pattern is different for males in the mating period, Hallander's (1967) studies on two other *Pardosa* species demonstrated that average daily distances covered even in the mating period did not exceed 2.5 m on the average and 12 m at the maximum. The present data demonstrate that most recaptures occurred in the same or in the neighbouring trap. This suggests that the 9 m by 12 m sampling grid represented approximately the same dimensions as the "home range" of the spiders. Thus a rough estimate of 10 m activity radius, and a "home range" of

300 m² is perhaps not unrealistic. This allows a rough estimation of the density of *P. agrestis*, namely c. 4 spiders (of both sexes) per square meter. Such figures are very approximate, but even if they were not, we need to know more about the spatial and temporal variation in density. However, such approximate figures can be helpful in giving the order of magnitude on which other studies can be based.

Less information could be extracted from the capture and recapture data of the tiger beetle *Cicindela campestris*. Despite being rather mobile, like *H. rufipes*, a modest recapture rate allowed a calculation of population size. However, all recaptures occurred on the day after the release of the marked animals, and these were either in the same or in the neighbouring trap. Such a recapture pattern unfortunately does not exclude the possibility that the population was actually migrating. In this case all recaptures could have been the result of the beetles falling back in the same or neighbouring trap in the vicinity of which they were released. This, besides making the population size estimation less reliable, also prevents the next stages of the deduction, the calculation of "home range" and density of the tiger beetles.

Good-sighted, mobile, but small animals will pose problems to biologists in the future, too. Some sophisticated methods are now available for tracking a few individuals (Baars, 1979; Mascanzoni & Wallin, 1986), but these are still only applicable to relatively large, hard-bodied invertebrates. Pitfall trapping together with marking is an accessible, but labour-intensive method, and as the present example has shown, finding the right scale is essential for obtaining sound density data of natural populations.

Acknowledgements

We are grateful to Dr. K.D. Sunderland and F. Kádár for the helpful comments on the manuscript, and to Dr. V. Rácz for the weather data. The work was supported by the OTKA grant No. F5042.

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