MOVEMENT OF ABAX ATER (COL. CARABIDAE) : DO FOREST SPECIES SURVIVE IN HEDGEROW NETWORKS ?

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MOVEMENT OF *ABAX ATER* (COL. CARABIDAE) : DO FOREST SPECIES SURVIVE IN HEDGEROW NETWORKS ?

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HEDGEROW NETWORK
FOREST CARABID BEETLES
ABAX ATER
METAPOPULATION
MARK – RECAPTURE METHOD
CONSERVATION BIOLOGY

ABSTRACT – Some forest carabid beetles can be found far from the forest although they have a very low power of dispersal. This study focuses on the movements of individuals of *Abax ater* living at the intersection of three lanes bordered by two wooded banks. Using the mark– recapture method, it is shown that individuals are resident and reproduce in this study site. This proves that a small population of *Abax ater* can settle in a node of a hedgerow network and survive there, at least for some time. From the point of view of conservation biology, this study provides guidelines for landscape management.

RÉSEAU BOCAGER
CARABIQUES FORESTIERS
ABAX ATER
MÉTAPOPULATION
CAPTURE – RECAPTURE
BIOLOGIE DE LA CONSERVATION

RÉSUMÉ – Certains Carabiques forestiers sont trouvés à une distance importante de la forêt la plus proche malgré un pouvoir de dispersion très limité. Cette étude porte sur les mouvements individuels chez *Abax ater*, individus vivant sur l'intersection de trois chemins bordés chacun de deux talus boisés. En utilisant la méthode de capture – recapture, il a été possible de montrer que les individus sont résidents et qu'ils se reproduisent sur le site. Cela signifie que de petites populations d'*Abax ater* peuvent s'installer sur les nœuds du réseau bocager et y survivre au moins à court terme. Du point de vue de la biologie de la conservation, ces résultats fournissent quelques orientations pour une meilleure gestion de l'espace.

INTRODUCTION

In north America and Europe, the temperate forest has become fragmented so that patches of forest are scattered throughout a cultivated matrix. In these landscapes, the survival of populations living in isolated forest habitats has become of interest from the point of view of conservation biology. Presence of woodlots has a positive effect on biodiversity (Whittaker, 1972; Pielou, 1975) because they can allow the survival of some forest species which otherwise would have disappeared. For some species, it has been shown that, in fragmented habitats, several populations of woodlots can be connected by dispersal movements (Fahrig and Merriam, 1985; Van Dorp and Opdam, 1987; Den Boer, 1990; Murphy *et al*, 1990; Verboom *et al*, 1990). These populations are considered as subpopulations of a metapopulation (Levins, 1970).

Carabids are a well known biological material (Thiele, 1977). Studies on carabids made probable that a local population may go extinct rapidly (30 or 40 years) when isolated (Den Boer, 1985). Dispersal movements, which can lead to the colonization of empty patches is thus of prime importance for the regional survival of these species. In this study, we focus on forest carabid species. For us, a forest species is a species that is more often found in mature forests than in other elements of the landscape. But, one may distinguish the "interior forest species" (Forman et Godron, 1986) as for example *Abax parallelus*, which are limited to the interior of the forest (Clavreul, 1984; Burel, 1987) from others, which are more eurytopic species.

In western France, the landscape "bocage" is characterized by the presence of a hedgerow network. The spatial distribution of carabids has been studied in several hedgerow networks in England (Pollard, 1968) and France (Deveaux, 1976) : the assemblages in hedgerows are characterized by the presence of some forest species which are also present in the landscape surrounding the forest (Burel, 1987, 1989). Some species, "corridor forest species" are found far from the forest in hedgerow network. For these species, the wooded linear elements of the landscape may act as corridors if their internal structure is suitable. Burel (1989) noticed that corridor forest species are particularly abundant when two hedgerows border a lane. For forest species living in hedgerows, the question is whether they use both forest and hedgerows which then might be considered as complementary habitats, or they may realize their whole life cycle within hedgerows. Corridor forest carabids may be present far (10 km) from the forest (Burel, 1989) although most of them are unable to fly (Den Boer, 1985). Thus, it appears unlikely that they use hedgerows only as corridors and return to the nearest forest for reproduction. To test this hypothesis, we studied the movements of individuals in a hedgerow.

In this paper, we focus on the behaviour of such species in a hedgerow network. The two main questions are :

— Are there local populations of corridor forest carabid species present in the hedgerow network ?

— What is the pattern of movements of individuals ?

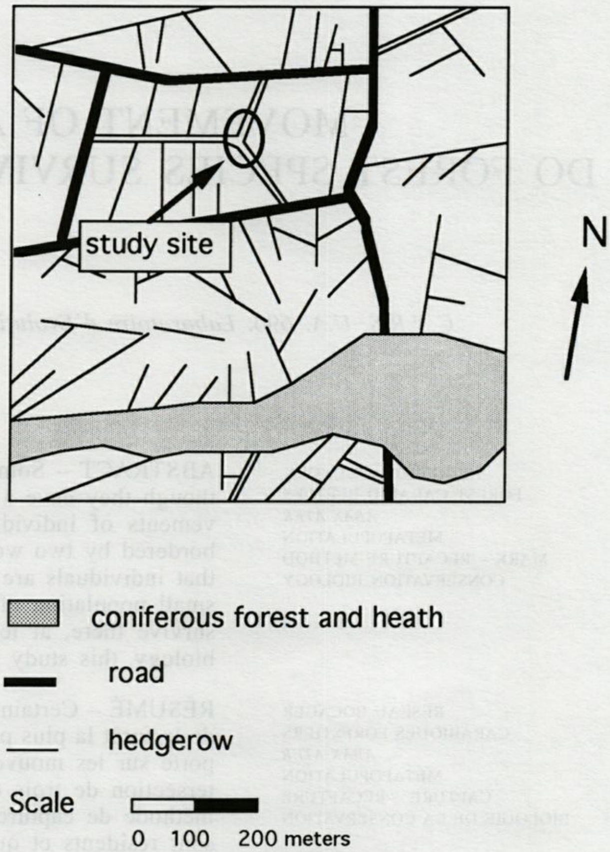

Fig. 1. – The study site and its surrounding.

THE STUDY AREA

The study area is located in a hedgerow network, near St Aubin du Cormier, 30 km West of Rennes, France. In this typical bocage area, land use is mainly meadows grazed by cows, and some fields cultivated for cereal crops. There are also some patches of coniferous forest and heath.

The study site is the intersection of three lanes, each bordered by two wooded banks (fig. 1). It is surrounded by two meadows and one crop field. None of the lanes is maintained or used by the resident farmers so that the study site, between the banks, is becoming wooded. The herbaceous layer is dense and the shrub layer is dominated by Blackberry bushes (*Rubus fruticosus*). Trees are mainly present on the banks. They are Oak (*Quercus pedunculata*), Chestnut (*Castanea sativa*) and Aspen (*Populus tremula*). This site is characterized by a dense cover of vegetation and the presence of leaf litter.

MATERIALS AND METHODS

Studying the spatial distribution of a population requires a study of the movements of individuals. Thus, we used the mark-recapture method. We chose *Abax ater* among several "corridor" forest species because it is common and of medium size (16-22 mm) which allows to apply marking techniques easily. It is active between April and October and reproduction occurs between April and July (Greenslade,1965; Turin *et al.*, 1977; Drach, 1980). Like many other carabids, it is a polyphageous predator (Loreau, 1983).

Twenty seven pitfall traps, 13 cm diameter by 25 cm deep, were spread over the site, the top of the wooded banks included. Trapping occurred from the beginning of June to the beginning of August 1991. The pitfall traps were emptied every two days and individuals were marked by scraping certain positions on the elytra so that each one had a unique number (Murdoch, 1963). Individuals were sexed and individuals with soft elytra, which are only a few days old, were distinguished from the others. All of them were released at a distance of one meter from the trap where they were caught.

For each beetle, the distances covered between two captures and the time taken to cover these distances were recorded as well as the value of the mean duration of residence was estimated. This is the mean time of residence observed between trappings of the same individual. It was compared with the maximal residence i.e. the period of residence in the case where all individuals caught during the experiment would have been still present at the end of the study.

In order to characterize quantitatively the movements of individuals, we used a method originating from the diffusion model (Box 1) (Drach and Cancela da Fonseca, 1990).

Box 1 :

Method of calculation of the coefficient of diffusion of individuals originating from the diffusion model (Drach and Cancela Da Fonseca, 1990) :

At a time 0, individuals are considered to be concentrated at one spot, then they scatter over the site. After a given time, the proportion of individuals located at a distance lower than a distance R from the center of diffusion is called g(R). This model permits to determine an indicator of activity level for the population, called D, coefficient of diffusion, which is the square of the mean displacements of individuals per time unit t. The diffusion model gives the equation

$$ln\ (1\text{-}g(R)\ =\ -\ R^2/4D_t$$

g(R) is the proportion of individuals that are recaptured at a distance lower than a distance R from the pitfall trap where they were released.

R is the distance from the pitfall trap where they were released.

D is the coefficient of diffusion = the square of the mean displacements of individuals per time unit t. It is an indicator of activity level.

p is the probability that an individual stands fixed where it was released. It is an indicator of inactivity level.

t is the time unit.

D and p can be calculated with a linear regression 1n (1-g(R)) on R^2 of the form

$Y = A + BX$; where $Y = 1n\ (1\text{-}g(R))$; $X = R^2$; $A = 1n\ (1\text{-}p)$; $B = 1/4Dt$ is the regression coefficient.

RESULTS

More than fifty individuals were marked individually at the study site and 61,4 % was recaptured. The sex ratio was 0,5 for marked individuals and 0,45 for recaptured individuals. Some individuals were caught 5 times and one even 6 times. Population size was estimated with the Jolly-Seber stochastic model (1965); for the whole trapping period, density was about 0.15 individuals per square meter.

All the movements recorded during the trapping period are given in figure 2. This figure clearly reveals a spatial heterogeneity in captures and it appears that traps set at the top and near the banks remained almost empty. Figure 3 shows the movements during two months of the male that was re-

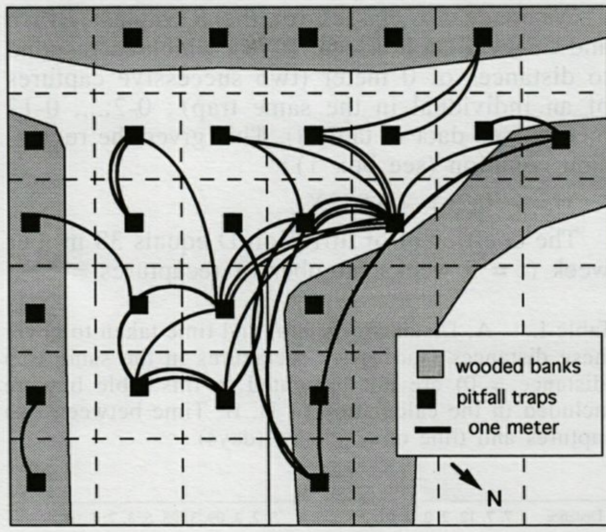

Fig. 2. – Trajectories recorded on the study site between the 12/06/91 and the 14/08/91.

captured 6 times. It was often caught in the same traps and it moved around the centre of the study site without a preferred direction.

Distances between two captures (in meters) and the time taken to cover these distances (in days) are listed in table IA. The time between two captures and the observed time of residence are known for every individual; the minimal, maximal and mean values are recorded in table IB. The value of the mean time of residence (27 days) equals 2/3 of the maximal period of residence (40 days). The Pearson coefficient of correlation between distances covered and the time needed by carabids to cover these distances is not significant (n = 45; r = 0,232 NS).

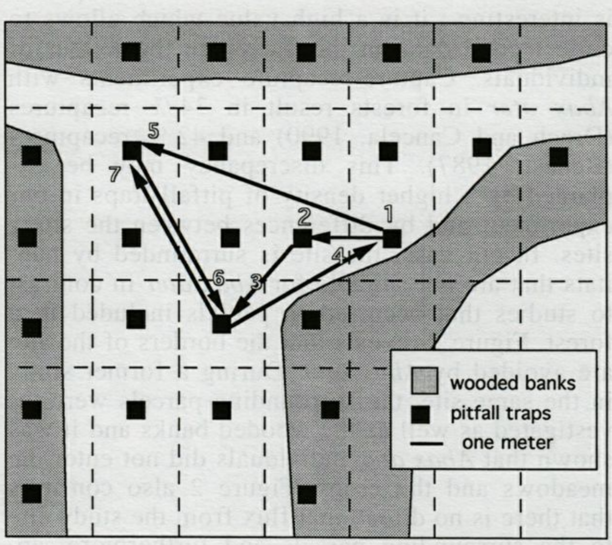

Fig. 3. – Dated trajectory of the male which was recaptured six times.
1 = 12/06/91; 2 = 14/06/91; 3 = 18/06/91; 4 = 27/06/91; 5 = 07/08/91; 6 = 13/07/91; 7 = 14/08/91.

We made six classes for the R values (Drach and Cancela Da Fonseca, 1990), which correspond to distances of 0 meter (two successive captures of an individual in the same trap) : 0-2;..., 0-12 meters (see data in table I). This gives the regression equation (see box 1) :

$$Y = -0{,}261 - 0{,}023X$$

The coefficient of diffusion D equals 38 m^2 per week (t = 9 weeks, number of recaptures = 52).

Table I. – A, Distance (meters) and time taken to cover these distances (successive recaptures in the same trap (distance = 0) are not presented in this table but are included in the calculation of D. B, Time between two captures and time of residence (days).

A

Distance (meters)	7. 7. 12. 2. 2. 2. 07. 5. 08. 5. 8. 5. 2. 2. 09. 3. 05. 5. 3. 7. 5. 03.
Time (days)	2. 9. 27. 2. 2. 2. 22. 2. 48. 2. 32. 2. 2. 6. 19. 2. 25. 7. 2. 9. 5. 30.
Distance (meters)	3. 3. 1. 1. 01. 04. 10. 10. 11. 9. 04. 02. 2. 4. 9. 07. 08. 7. 05. 3. 3.
Time (days)	2. 2. 2. 6. 19. 22. 14. 13. 15. 2. 31. 52. 2. 6. 2. 30. 27. 4. 21. 2. 2.

B

	Mean	Minimal	Maximal
Time between two captures	13	2	51
Observed time of residence	27	2	63

DISCUSSION

Density of *Abax ater* in the study site, of 0.15 individuals per square meter is comparable to those found in forests by Thiele (1956) and Loreau (1984) which vary from 0.03 to 0.28. The fact that more than 60 % of the individuals was recaptured is interesting : it is a high value which allows to collect good data on the movement behaviour of individuals. Capture-recapture experiments with *Abax ater* in forests result in 34 % recaptures (Drach and Cancela, 1990) and 42 % recaptures (Benest, 1987). This discrepancy may be explained by a higher density of pitfall traps in our experiment and by differences between the study sites. In our case, the site is surrounded by habitats that are not suitable for *Abax ater* in contrast to studies that occurred in parcels included in a forest. Figure 2 reveals that the borders of the site are avoided by *Abax ater.* During a former study in the same site, the surrounding parcels were investigated as well as the wooded banks and it was shown that *Abax ater* individuals did not enter the meadows and the crops. Figure 2 also confirms that there is no directional flux from the study site to the surrounding parcels and furthermore, apparently no significant flux to other parts of the three lanes included in the hedgerow network (fig.1). Movements of individuals are clearly restricted to the interior of the site.

The high proportion of recaptures also contradicts the possible hypothesis of a continuous passage of individuals from elsewhere through the site. Also the lack of a relation between distances and the time needed to cover these distances indicates that the beetles did not walk uninterruptedly with a preferred direction. A striking point is that the coefficient of diffusion, 38 m^2 per week, is similar to the 36 m^2 per week calculated for *Abax ater* inside a forest (Drach and Cancela da Fonseca, 1990). This means that individuals of a forest population and those of this hedgerow network show the same intensity of movement. This pattern of movement resembles that of others carabids described by Baars (1979) and Rijnsdorp (1980) called random walk by these authors ie small displacement, moderate velocity and random choice of direction. This locomotory activity is apparently mainly motivated by foraging or egg laying and seems to occur only in habitats suitable for the species.

The value of the mean time of residence is high if we take into account mortality in the site during the two months of study. As the high proportion of recapture, it indicates that most individuals are sedentary in the interior of the site during this period and probably during the whole season of activity. The sex ratio did not change during the experiment and reveals the presence of females in the site during the entire trapping period, which is also the reproduction period of *Abax ater*. The fact that some new hatched individuals were caught at the end of the study indicates that reproduction occurred and was successful in the study site; apparently, individuals did not have to return to the nearest forest for reproduction.

All these elements support the opinion that the study site is a real suitable habitat for *Abax ater*, where individuals behave as if they were in a forest. They show the same pattern of movement and succeed in reproducing. In Brittany, forests and woodlots are not so common; at the landscape level survival of the kind of species we studied is mainly related to the presence of the hedgerow network and to the nodes of this network. Such small habitats composed of intersections of hedgerows and lanes are very common and allows to expect that this species occurs frequently, even far from a forest. An important question now becomes how this set of populations can maintain itself in the bocage. In a forest, populations are large or may be composed of several small populations so that they can face demographic stochasticity easely. But small populations of carabids, as those in the hedgerow network may go extinct rapidly if isolated from others populations. Den Boer (1990) estimated the average life expectancy of small isolated populations of *Abax ater* to be about 100 years. Analysis of old cadastral survey (1833) proves the temporal stability of landscape structure in the study area since the forest boundaries did not change and the three lanes were already present 150 years ago and possibly before. This means that the population of *Abax ater* we studied and probably some others present in nodes of the network are not remnant of a large forest population recently fragmented but rather the result of some colonization processes. For other populations resulting of an ancient fragmentation, we can suppose that they are not isolated from a source of colonizers otherwise they would have become extinct. Individuals of corridor forest species are commonly trapped in hedgerows internal structure of which is suitable. It would be interesting to know whether single hedgerows can support carabid populations comparable to those in the nodes of the network or they are only used by individuals dispersing between local populations.

As a study dealing with relationships between landscape structure and species survival, the results provide some guidelines for landscape management of the bocage in a conservation perspective for the kind of forest species we studied. It appears clearly that the hedgerow network can support populations of some forest species and that these populations have to be interconnected for the long term survival of the species. Connectivity between populations is ensured by individuals using hedgerows as corridors for their movements through the network. In practical terms, species conservation at the landscape level requires to avoid breaks in the bocage and preservation of good connections between hedgerows.

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