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Ecological consequences of land abandonment on carabid beetles distribution in two contrasted grassland areas

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SUMMARY - Dispersal of carabid beetles was studied in grassland in Normandy and the Pyrenees. In both areas carabid dispersion acts similarly. Forest species can move only a short distance from forest into abandoned fields or pastures used more extensively. Corridor species can disperse if patches of brambles are present and persist long enough for the beetles to reproduce. The process of dispersion is strongly influenced by the landscape structure and the farmers practices.

Key words: landscape ecology, spatial structures, carabids, agricultural practices, Normandy, Pyrenees.

RESUME - "Conséquences écologiques de l'abandon des terres sur la distribution des scarabées Carabidae dans deux zones contrastées de prairies". Nous avons analysé ici la dispersion des scarabées Carabidae dans des prairies de Normandie et des Pyrénées. Dans ces deux régions, la dispersion des Carabidae s'est effectuée de façon semblable. Les espèces des forêts ne peuvent s'éloigner que peu de ces espaces pour pénétrer dans les champs abandonnés ou les pâturages plus extensifs. Les espèces des couloirs ne peuvent se disperser que s'il existe des roncières qui persistent pendant un temps suffisant à leur reproduction. Ce processus de dispersion est fortement influencé par la structure du paysage et les pratiques agricoles.

Mots-clés: écologie du paysage, structure de l'espace, Carabidae, pratiques agricoles, Normandie, Pyrénées.

Introduction

Recent trends in agricultural policy are leading to important changes in land use (EGPN 1987). In traditional grassland areas changes occur on the one hand from the ploughing of good soils but on the other from the progressive abandonment of difficult soils (Baudry and Deffontaines, 1988). Landscape is changing in such areas from a relatively homogeneous state to a more heterogeneous one. New patches of vegetation may appear in extensively used grasslands, as in land where grazing has changed to a low stocking rate (Asselin and Baudry, 1989). Vegetation cover and land use are modified at different spatial scales, from individual fields to the landscape.

These new dynamic relationships within the rural space offer new habitats within a developing landscape structure; and therefore, induce changes in the distribution of animals. Species from uncultivated areas (e.g. woodlands, heathlands and old fields...) may colonize new habitats or previously isolated ones.

In this paper, preliminary results are presented of two research studies, involving the dispersal of carabid beetles in two different grassland areas in France. These two areas not only differ geographically, one being in Normandy, the other in the Pyrenees, but also differ in the way they are used by the cattle and the nature and structure of the landscape. Carabid beetles were chosen for they are one of the best known of invertebrate groups (den BOER *et al.*, 1986). Many studies have focused on their spatial distribution and dispersal ability (Evans 1986). They have also been proved to react to landscape structure (Burel, 1988).

Study areas

In Normandy the study area, the Pays d'Auge, is mainly used by dairy and cattle enterprises. The landscape is characterised by the dominance of permanent grassland often planted with cider apple and pear trees. Hedgerows, often with emergent trees, delimit the fields and form a coarse mesh network. On steep slopes, some recent small woods have been planted or are the result of agricultural abandonment. The plateaus, where soils are very shallow and low in nutrients, are covered by forest.

Currently, two main factors are modifying the landscape:

(a) ploughing of most mesic pastures

(b) extensification of some grassland because of agronomic constraints, farming structure and production extensification. This changes the colonisation by non-palatable species, e.g. brambles (*Rubus* spp.) which lead to the formation of ungrazed patches.

The studied landscape is a mosaic of small woodlands, hedgerows, old fields, grassland and bramble patches.

In the Pyrenees the soils in the upper valleys were intensively cultivated in coordination with cattle which produced manure and grazed the large common pastures. In most of the valley the fields, previously ploughed, are now grassland (Balent, 1987). In the valley d'Oo, they are grazed by cattle and sheep, from autumn to spring, the whole territory being grazed by all the village animals which wander through the unenclosed area. During the summer each farmer makes his hay on his own personal holding within the common. Fields are very small, sometimes no more than 10 m wide and 100 m long. So, a mosaic of vegetation types appears during the summer which depends on fertility, which in turn is correlated to cultivation history, the current fertiliser inputs and to grazing intensity (Balent, 1986a, 1986b). Some woody hedgerows remain at the breaks in slopes but do not delimit fields.

In the flat part of the valley there are either common pastures which are never cut for hay or coppice wood on the steep slopes.

The study concerned the valley from the first terrace up the stream to the wood edge. The landscape surveyed included cut grasslands, hedgerows, grazed pastures and woods.

Dispersion of forest carabid beetles through rural landscapes

Previous studies on the dispersion of forest carabid species in a hedgerow network landscape showed that they are found in the fields only at the forest edge. Further away from the forest they occur preferentially on the top of earth banks. Some landscape features enhance beetle movements and differ according to these spatial levels of organisation (Allen and Starr, 1982; Burel 1989).

(a) at the hedgerow level only those with at least a few trees and a dense herbaceous layer will act as a corridor for the dispersion of forest species, even if they are close to the forest edge.

(b) at the level of a few nearby elements, lanes between two parallel hedgerows are the best shelter for forest species. Their dispersal efficiency depends upon their width and vegetation density.

(c) at the landscape level there is a distance effect from the forest edge on the first kilometre. This is due to the progressive disappearance of core forest species in the first 100 m and of peninsula species further on. Beyond one km, only corridor species remain in the rural area and their abundance is determined by the connectivity between lanes and by the vegetation structure of the hedgerows.

The principal characteristics of forest species dispersion in rural landscapes are summarised in Fig. 1 and serve as a basis for the sampling strategy.

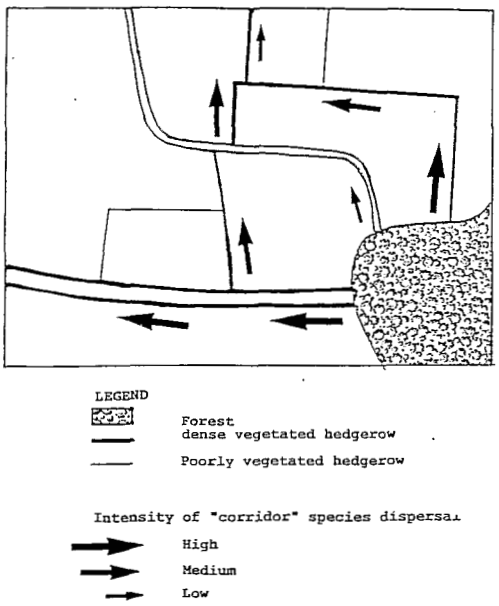


Fig. 1. Model of dispersal for forest carabid species

Methods

Carabids were collected in circular pitfall traps of 13 cm diameter by 25 cm deep.

In Normandy 30 sets of 3 traps were set in an area of 100 ha in order to sample the different landscape elements and to take into account the distance from the woody elements which plays a major role for forest core and peninsula species (Fig. 2). Two sampling sites were in forest, 7 in new small woods, 4 in grasslands, 3 in hedgerows, 2 in old fields, 8 in bramble patches.

In the Pyrenees 51 sets of 3 traps each were set; 40 along 2 transects, and 11 in a quadrat (Fig. 3). Along the transects going from the first terrace to the edge of the woods, sampling sites were set at a distance of 20 m from each other. The quadrat was located between the two transects at their lower extremity.

Traps were opened during seven days and were collected four times in Normandy and six in the Pyrenees. The trapping period lasted from mid-May to early July.

The data were analyzed by ordination procedures (Legendre and Legendre, 1984). Correspondence analysis (Benzecri, 1973) was performed using Addad software.

Results

1. Normandy study

In the Normandy study 32 taxa were captured (names according to Bonadona, 1971). All the sampled periods in the data matrix (30 sampling sites x 28 species) have been grouped in order to focus on spatial variation.

A correspondence analysis was performed using all the species for which the frequency was greater than 2%, giving 18 of the 28, as active variables, to form the basis of the factorial space. The other species were represented in the factorial space as supplementary elements. For the sampling sites a reference factorial plan was established using only what could be called "stable" land uses to act as active elements. They are patch types whose dynamic position is measured on a time scale greater than the bramble patches. Bramble patches were mapped on this factorial plan so that their species composition could be compared to that of the surrounding landscape elements which act as potential sources.

On the first axis of the correspondence analysis (Fig. 4) the sites are distributed along a gradient of vegetation structure, from forest to grassland. The carabid species (nomenclature according to Bonadona, 1971) which determine this axis are *Carabus monilis, Poecilus cupreus, Amara lumicollis* and *Amara communis* which are found preferentially in open areas and cultivated fields, from one part, and *Abax ater* and *Steropus madidus*, which are forest species on the other part. On the second axis woody sites are divided into two groups, the old forest on the plateau in the first case, whereas the recent small woods present on the slopes form the second. The carabid species which are related to these groups are: *Procustes purcpurascens, Abax ovalis, Argutor oblongopunctatus* for the forests and *Steropus madidus* for the recent small woods. The first three species are "core" or "peninsula" forest species (Burel, 1989), while the final species is able to disperse widely where it is able to find some tree shade (Deveaux, 1978).

Bramble patches are distributed over the whole scatter diagram derived from the analysis with the carabid species composition varying from those typical of forests to those found in grasslands. Their position in the scatter diagram is, however, explained by their distance to a source of forest species, and by the nature of this source. For example, patch number 20 (Fig. 2) is close to a hedgerow bordering a lane, which is a good potential source, while patch number 19 is in the middle of a grassland isolated from any source. In patch nr. 20 the "corridor" forest species such as *Abax ater* and *Steropus madidus* are present whilst in patch 19 *Poecilus cupreus* and *Anara communis* form 75% of the individuals.

2. Pyrenees study

The results have not yet been fully analysed in the Pyrenees study because not all the carabid species have yet been identified. Therefore, only the forest species and a few of the fields are used in this analysis.

Ten taxa are considered (names according to Bonadona, 1971) and as in the Normandy study, all the periods are grouped so that the data matrix consists of 51 sampling sites and 10 species.

A correspondence analysis was performed with the whole matrix. On the first axis (Fig. 5) sites from the upper part of the two transects are opposed to the one on the terrace. Sites located close to a hedgerow have an intermediate position on this axis. The upper sites are characterised by *Carabus nemoralis, Abax ater* and *Steropus madidus,* all forest species. In the lower sites which are some distance away from hedgerows, the more abundant species are *Poecilus cupreus* and *Anchomenus dorsalis,* two field species. On the second axis the two woody landscape elements, ie hedgerows and forest, are separated. The first sites are determined by *Abax ater* and *Tomocarabus convexior* while the second sites are characterised by *Steropus madidus.*

The carabid species composition therefore enables the scatter diagram to be split into three zones:

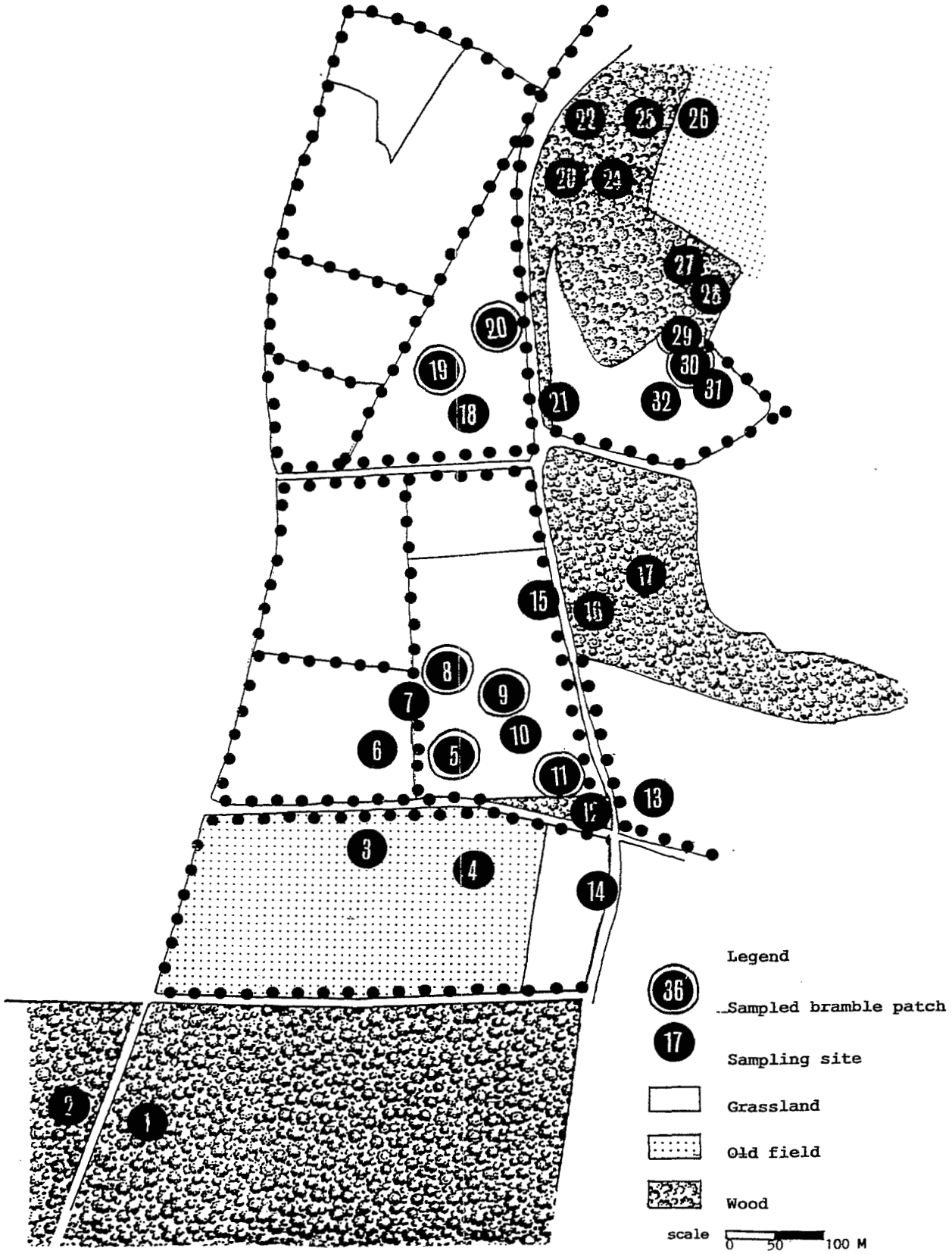


Fig. 2. Study area in Normandy

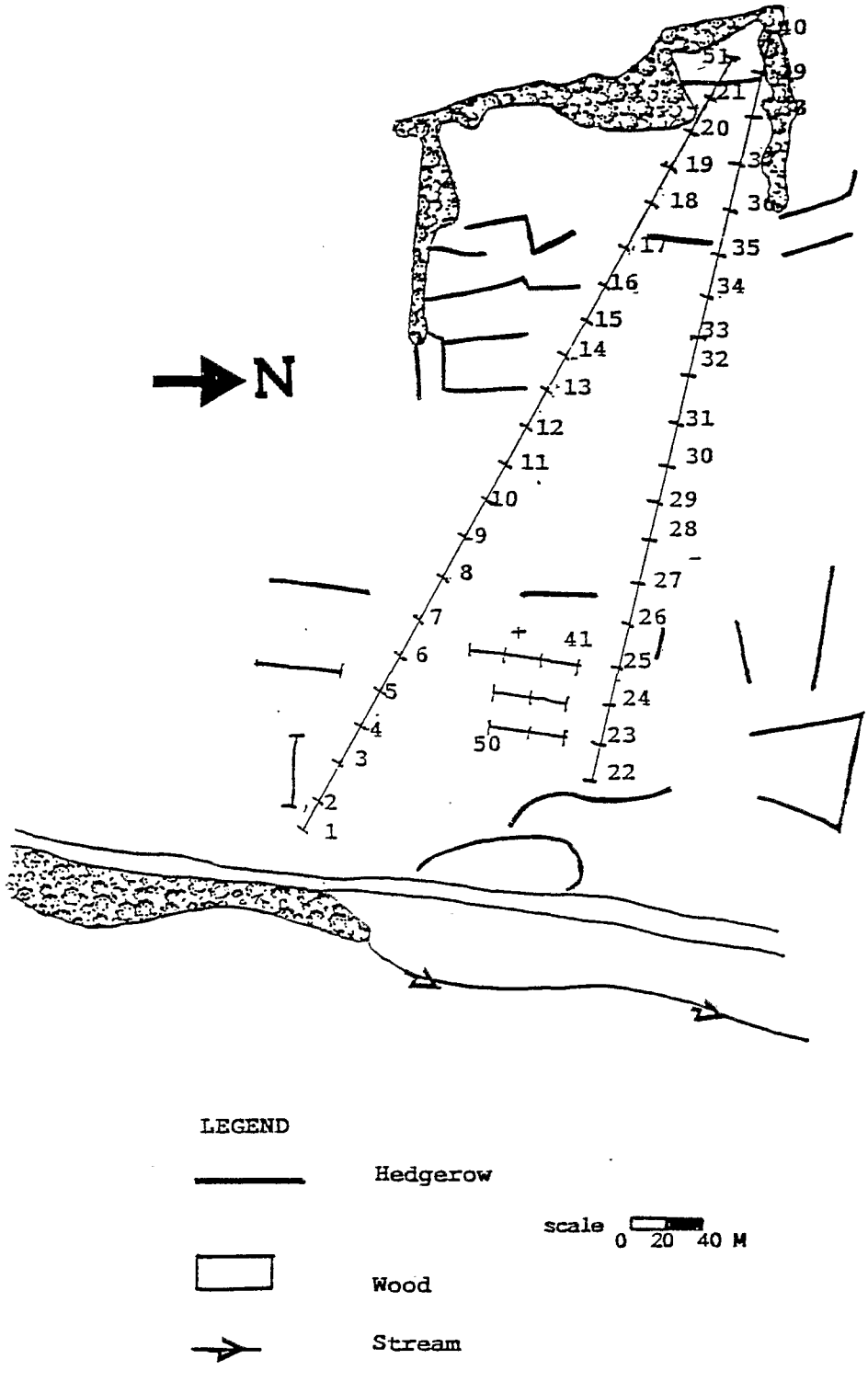
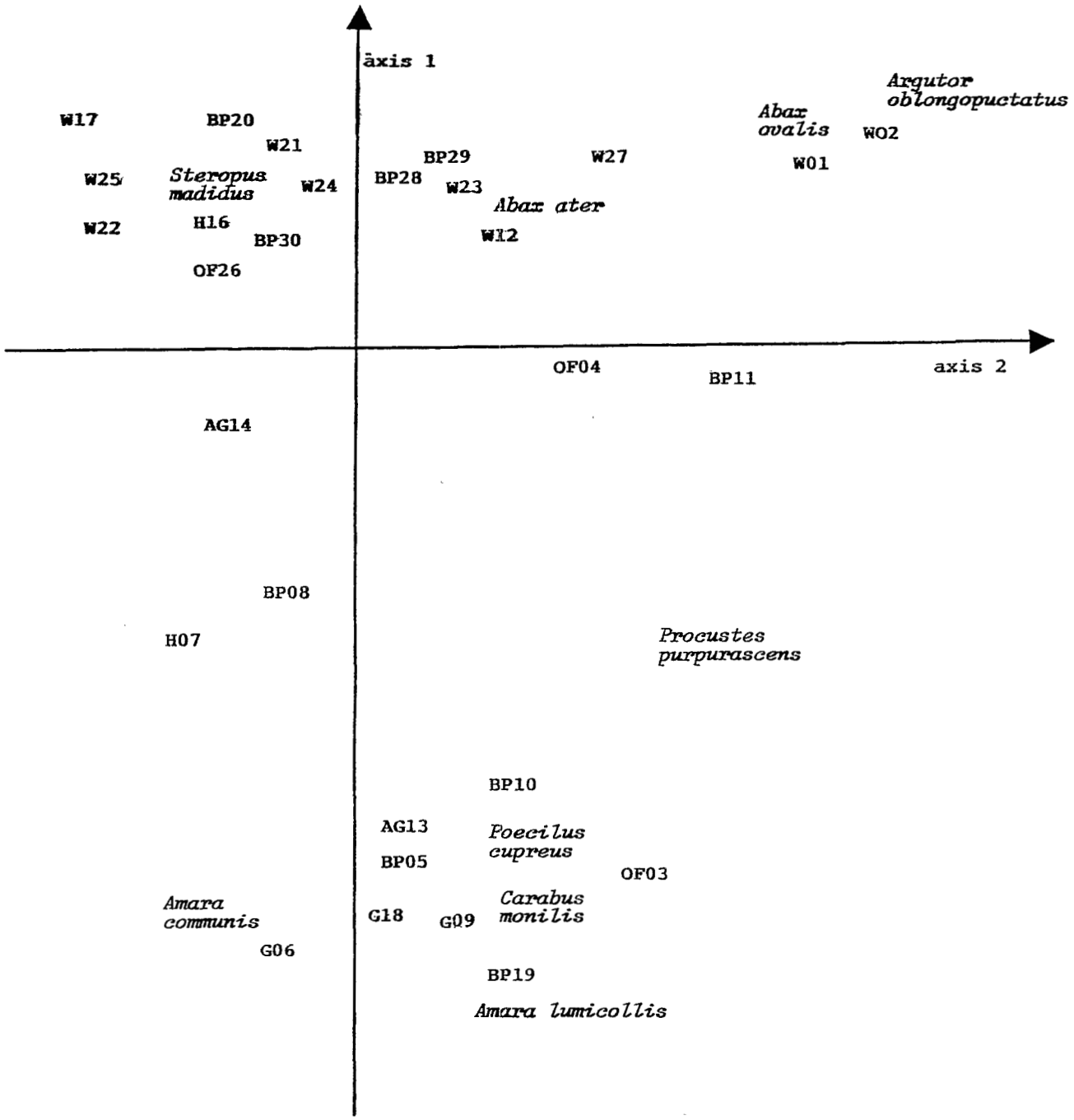


Fig. 3. Study area in the Pyrenees



Legend

w : wood
H : hedgerow
OF : old field
AG : abandoned grassland
G : grassland
BP : bramble patch

Fig. 4. First plan of the factorial analysis in the Normandy study

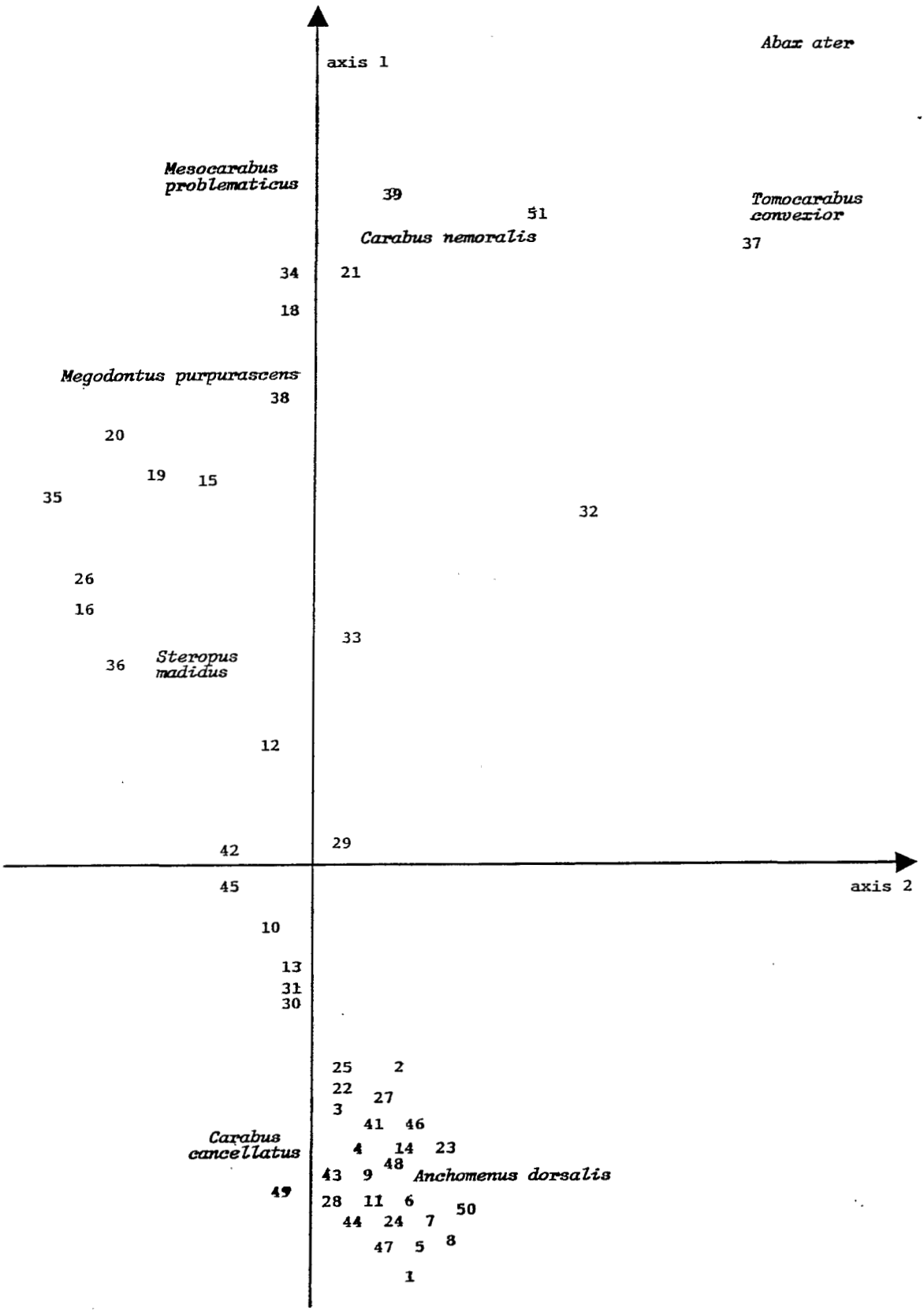


Fig. 5. First plan of the factorial analysis in the Pyrenees study

(1) the upper part of the transects, close to the forest, which are characterised by the presence of forest species,

(2) sites close to hedgerows where *Steropus madidus* is particularly abundant

(3) lower sites in grassland vegetation which are characterised by *Peocilus cupreus* and *Anchomenus dorsalis*.

Discussion

In these studies the dispersion of carabid beetles from uncultivated areas to lightly grazed grasslands form the same patterns as seen for the forest species as the distance to the source population is critical. When they are present in woods or, for "corridor" forest species, in hedgerows, they are only trapped in the grassland area very close to the forest edge. In Normandy, however, the species find the bramble patches to be suitable habitats, but are able to colonize only the nearby as the grassland represents a barrier. Thus, a distance of only 20 m from hedgerows is too great for colonisation.

The two study areas, therefore, differ by their landscape structure and by the way which are managed by farmers.

Firstly, in Normandy, the landscape is a mosaic of woods, old fields, grasslands and fields, delimited by a highly connected hedgerow network. Forest "corridor" species are present in all interconnected hedgerows and so there is a high probability for nearby bramble patches to be invaded by new species. Colonisation of the extensively grazed meadows may therefore be seen as a step by step process, from bramble patch to bramble patch, at least if they remain long enough for species to reproduce in them. Patches should therefore be considered as stepping stones for dispersion.

In the Pyrenees the study area may be divided into two quite different parts. The upper part is a grassland fixed in a woody matrix whereas in the lower part grassland is set amidst isolated hedgerows, only one of which is connected. In the first zone species from the wood are trapped everywhere, as if it was a continuous edge zone. By contrast, in the other zone, the grassland is only slightly influenced by woody elements, and forest carabid species are only seldom trapped in sites adjacent to hedgerows. In this case, the landscape structure is far less favourable for the dispersion of forest species than in Normandy, which shows therefore the importance of the presence of interconnections and pattern in landscape for colonisation and dispersal.

The grassland management also differs between the two regions.

In Normandy the decisions by farmers are taken at field level. A certain number of animals remain in a field for a certain time period and manuring, if any, is the same for a whole field. The spatial heterogeneity of grazing is related to the patterns of cattle behaviour and feeding habits which, in turn, are correlated with the heterogeneity of physical conditions. Changes in vegetation cover are thus directly governed by farmers' decisions at field level. Each field will have its own internal dynamic relationship with the surrounding elements and forest carabid species will become more and more heterogeneous.

In the Pyrenees the entire study area is grazed during winter time by a wandering flock. In the beginning of spring when animals are restricted to the upper section there is consistent growth of vegetation in the lower section. A microscale heterogeneity of vegetation structure then evolves until the first hay cut. Even so, the forest carabid species are unable to colonize those fields which are less intensively grazed, or even left for hay. The less intensively used patches of this mosaic cannot be used as habitats by forest species because the time scale of the periodic changes which occur each year in vegetation grain size is too fine compared to the life cycle of the beetles. The upper part of the transects is grazed during the whole year and its carabid species composition is totally different as the forest species can move through the whole area. There is a clear distinction between the two transects, which coincides with the limit of area used in hay production.

Conclusions

This research indicates the value of using carabids as landscape dynamic descriptors and their potential for further studies. In the two current study areas, as well as in the previous study carried out in Brittany, the forest species have behaved identically. Forest core and peninsula species penetrate into the rural landscape not further than about 100 m, while the corridor species use interconnected hedgerows for dispersion. The latter are able to reach recently developed bramble patches if they are close to a source of new individuals.

In the two regions of similar agricultural production, farmer practices and current landscape structure will therefore drive carabid dispersion in different ways.

Further research is being planned to enhance the understanding of the links between landscape patterns and colonisation. Trapping will be carried out in landscapes with different structural characteristics. The result can then be directly applied in the development of appropriate conservation policies.

Acknowledgements

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References

ALLEN, T.F.H. and STARR (1982): Hierarchy: perspectives for ecological complexity. The university of Chicago Press, Chicago and London, 310 pp.

ASSELIN, A. and BAUDRY, J. (1989): *Conséquences écologiques* de la déprise agricole en zone herbagère: Aranéides et flore dans le Pays d'Auge. Ministère de l'Environment Comité Ecologie et Gestion du Patrimoine Naturel, CERESA, INRA. 163 pp.

BALENT, G. (1986-a): Modélisation de l'évolution des surfaces pastorales dans les Pyrénées Centrales. Mise au point d'un référentiel micro-régional de diagnostic au niveau de la parcelle. Cahiers de la Recherche-Développement *9/10*: 92-99.

BALENT, G. (1986-b): The influence of grazing on the evolution of botanical composition of previously cultivated fields. The exemple of the Pyrénées. *in:* Rangeland: a resource under siege (Joss P.J., Lynch, P.W. and Williams, O.B., eds.). Australian Academy of Science, Can.

BALENT, G. (1987): Structure, fonctionnement, et évolution d'un système pastoral. Le pâturage vu comme un facteur écologique piloté, dans les Pyrénées Centrales. Thèse de Doctorat d'Etat, Université de Rennes 150 pp.

BAUDRY, J. and DEFFONTAINES, J.P. (1988): L'abandon et la sous exploitation des terres agricoles: quelques remarques sur la dynamique et l'aménagement des espaces ruraux. Colloque de l'Union Européenne des Forestiers. Nancy, Août 1988 7 pp.

BENZECRI, J.P. (ed.) (1973): L'analyse des données, tome 1: la taxinomie Donod, Paris 615 pp.

BOER (den): P.J., LUFF, M.L., MOSSAKOWSKI D and WEBER F. (1986): Carabid beetles, their adaptations and dynamics. Gustav Fischer, Stuttgart, New York 551 pp.

BONADONA, P. (1971): Catalogue des coléoptères carabiques de France. Publication de la nouvelle revue d'entomologie. 130 pp.

BUREL, F. (1988): Biological patterns and structural patterns in agricultural landscapes. Pages 107-110 *in*: Connectivity in landscape ecology (Schreiber K.F., ed.). 2nd IALE seminar Münstersche Geographische Arbeiten no 29.

BUREL, F. (1989): Landscape structure effects on carabid beetles spatial patterns in Western France. Landscape Ecology *2*: 215-226.

DEVEAUX, D. (1978): Recherches sur la répartition spatio-temporelle des peuplements en carabiques (col. carabidae): en zone bocagère de l'Ouest. Thèse de troisième cycle de l'Université de Rennes. 389 pp.

EGPN (1987): Conséquences écologiques de la déprise agricole et du changement d'affectation des terres ; Séminaire de Florac, Avril 1987 Ministère de l'Environnement, SRETIE, Comité EGPN, doc poly 273 pp.

EVANS, M.E.G. (1986): Carabid locomotor habits and adaptations. Pages 59-79 in Carabid beetles, their adaptations and dynamics (Boer (den), P.J. et al., eds.). Gustav Fischer, Stuttgart, New York.

LEGENDRE, L. and P. LEGENDRE (1984): Ecologie numérique T. 1 : le traitement multiple des données écologiques (deuxième édition): Masson. Presses de l'Université du Québec. 260 pp.