

Effects of low grazing pressure on some ecological patterns in Normandy, France

Baudry J., Asselin A.

in

Baudry J. (ed.), Bunce R.G.H. (ed.).
Land abandonment and its role in conservation

Zaragoza : CIHEAM

Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 15

1991

pages 103-109

Article available on line / Article disponible en ligne à l'adresse :

<http://om.ciheam.org/article.php?IDPDF=92605084>

To cite this article / Pour citer cet article

Baudry J., Asselin A. **Effects of low grazing pressure on some ecological patterns in Normandy, France.** In : Baudry J. (ed.), Bunce R.G.H. (ed.). *Land abandonment and its role in conservation* . Zaragoza : CIHEAM, 1991. p. 103-109 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 15)



<http://www.ciheam.org/>
<http://om.ciheam.org/>

Effects of low grazing pressure on some ecological patterns in Normandy, France

JACQUES BAUDRY*

AGNES ASSELIN**

* INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE
DEPARTEMENT SYSTEMES AGRAIRES ET DEVELOPPEMENT
14170 LIEURY, FRANCE

** UNIVERSITE DE RENNES 1 LABORATOIRE D'EVOLUTION DES
SYSTEMES NATURELS ET MODIFIES CAMPUS DE BEAULIEU,
35000 RENNES, FRANCE

SUMMARY - Change in grazing pressure has a significant effect on the flora and fauna of pasture land. In Normandy, change in milk quotas and other factors have led to intensification of some land and decrease in grazing pressure on other land. Undergrazing may lead to invasion of meadows by unpalatable species of plants, with an increase in landscape heterogeneity and a decrease in predictability. Colonization of meadows is tightly coupled to surrounding vegetation. Also plant species differ in their ability to colonize these areas. In contrast, spiders have no difficulty in colonizing undergrazed pastures, but their presence is related to plant architecture.

Key words: Normandy, grazing, landscape, patch, spiders, colonization.

RESUME - "Effets d'une pression de pâturage faible sur quelques modèles écologiques en Normandie (France)". Les modifications de la pression de pâturage ont eu des conséquences marquées sur la faune et la flore des pâturages. En Normandie, la modification des quotas laitiers et d'autres éléments ont débouché sur une intensification de certaines terres et sur une réduction de la pression de pâturage sur d'autres. Le sous-pâturage peut mener à l'envahissement des prairies par des espèces végétales peu appétissantes, allant de pair avec un accroissement de l'hétérogénéité et une diminution de la prédictabilité du paysage. La colonisation des prairies est fortement liée à la végétation environnante. De même, l'aptitude des différentes espèces à coloniser ces terres varie fortement. Par contre, les araignées ont la plus grande facilité pour coloniser ces pâturages peu broutés, mais leur présence est liée à l'architecture végétale.

Mots-clés: Normandie, pâturage, paysage, patches, araignées, colonisation.

Introduction

Diminishing grazing pressure is a common feature of changing agricultural practices. It is different from abandonment in the sense that human activity is still present, but it is similar in another sense because it lets some type of ecological succession to take place. Given the negative effects of intensive use of grassland on flora and fauna (Park, 1988), extensification (low grazing pressure) can be seen as a way to go toward a better ecological state. Extensification is already proposed as a way to manage agricultural landscapes to prevent invasion by woody species and maintain herb species richness (EGPN, 1987). As a matter of fact, total abandonment of grazing cannot be seen as positive for species richness (see Bernáldez, this volume). The invasion by

shrubs often decreases species richness, though this can be seen as a more natural stage and species richness may not be the proper goal.

This paper reports results from an ongoing research in Normandy. The purpose of this research is to assess the ecological effects of a low grazing pressure on landscape structure and species composition. Two groups of species have been studied in the same landscape: plants and spiders. Changes in vegetation are the obvious indication of changing practices, while spiders are known to react quickly to vegetation dynamics (Duffey, 1975; Asselin and Baudry, 1989). Furthermore, spiders are very mobile while plants can move (colonize) very slowly. The study is in the same landscape where Burel (this volume) sampled carabids.

In previous work in the area on plants (Baudry, 1989) and spiders (Asselin and Baudry, 1989 a, b) we posed two main questions:

- 1) how does species composition change from grazed to ungrazed patches and
- 2) where do invading species come from?

Results show contrasted patterns. While ungrazed patches plant species composition is highly correlated to surrounding hedgerows species composition, spider species composition is independent of the place in the landscape, it is only related to patch type (grassland, ungrazed, hedgerow...). While most spider species present in hedgerows and woodland are found in ungrazed patches, few plant species are able to colonize. It was concluded that spiders have very good colonization ability and, under present conditions, are not sensitive to landscape structure, e.g. spatial arrangement of landscape elements, while plants are.

The purpose of this paper is two-fold i) to illustrate the methodological framework proposed in the introduction and ii) to look more in detail at the relationships between spiders and plants.

We first review broad changes in farming systems, their effect on landscape structure, then we evaluate the biological effects.

Regional and landscape approach

1. The study area and the causes of declining agricultural pressure on land.

The area where the investigations were made (*le Pays d'Auge*) is predominantly covered by grassland (75% of farmland), grazed by cattle. Meadows are 1-6 ha and are surrounded by hedgerows, where elm was once dominant, along with ash and hawthorn. Dairy production is the main enterprise but meat production, as a by-product, is also important. Since a few years, several changes are occurring: milk quotas and physical constraints have led to changes in land use: ploughing on the one side, extensive (low stocking rate) grazing on the other, even within a farm. One of the main reasons for extensification is availability of land. In our case it is due to a diminishing number of farmers. There is an apparent willingness of the farmers of the region to use most of the land. In fact, stocking rate has never been high (<1.5 cattle unit per ha and often barely above 1). Increase in farm size (from 23.6 ha in 1970 to 27 ha in 1980), decrease of the number of total working units in farms led to land management problems. Formerly, farmers had time to do the cleaning of their meadows by hand, to manage their hedgerows, even if some did not. Nowa-

days, only mechanical work is done, either cutting or spraying hedgerows, brambles or bracken fern. Another phenomenon is "grass selling", where landowners sell the grass produced by meadows each year instead of renting the land. This seems to be a major reason for mismanagement of grassland, as farmers only pay for what they get and are not sure to have the land the year after.

Association of low management and undergrazing together with extensification leads to the colonization of meadows by unpalatable species such as *Rubus spp* which develops in patches.

There has been also some abandonment since the 40's, at that time some meadows have been totally abandoned for reasons unknown to us. In the 70's some land-owners did some plantations to avoid to pay yearly taxes on land or to be constrained by renting regulations. In the study areas all meadows with such a status are invaded by *Rubus*. Last, in 1988 an old farmer got to the hospital and his children decided to leave the farm uncultivated, so unmown grassland appeared as a new type of landscape element.

Effects on landscape patterns are: new types of elements and more diverse spatial relationships. This topic will be addressed in the first part of the paper.

2. Changes in landscape patterns

2.1. Methods

To assess the changes we measured the evolution of landscape heterogeneity in the studied landscape. The measure, based upon information theory takes into account both the diversity of landscape elements and their spatial distribution (see Baudry and Burel, 1982, 1985; for details).

$$\text{The measure is } H = \sum p_{ij} \ln p_{ij}$$

where i and j are successive sampling points along a transect affected to a type of landscape element. These types are: forest (F), young woodlot (W), plantation (P), ungrazed grassland (U), unmown grassland (H), grazed grassland (G).

The redundancy of the landscape structure is R ,

$$R = 1 - H/H_{\max}, \quad H_{\max} = \ln(N^2), \quad N \text{ being the number of types.}$$

If H is close to H_{\max} , the spatial distribution of landscape elements appears as a random pattern. There is an equal probability to meet any type of element after another when moving along a transect.

Points on transects are 100 m apart, they were sampled for 4 periods.

2.2. Results

Since 1940, landscape heterogeneity increased (Fig. 1), due to new types of elements and a greater fragmentation, also seen in the diminishing redundancy.

This means that the landscape is less and less predictable when one moves along a transect. One cannot infer changes at one point either from its own state or from its neighbors state. The changes are only explained by land owner decisions. Here we have a case where processes at one level (field) are deterministic (a land-owner or a farmer does have a choice), and at a higher level landscape phenomena are unpredictable. This shows the importance of the study of socio-technical systems to understand changes in landscape and in their ecological characteristics.

Distribution of plants and spiders: similarities and contrasts in patterns

1. Results of previous studies

For plants, Baudry (1989); Burel and Baudry (1990b) and report two main conclusions; first, species composition of ungrazed patches is highly correlated to surrounding hedgerows species composition; in none of the 51 sampled patches, was a species not present in a hedgerow found. Second, the species differ by ability to colonize: some (e.g. *Rosa canina*, *Galium aparine*,

Galium cruciata) are almost always found in patches if present in hedgerows, others (e.g. *Taxus baccata*, *Crataegus oxyantha*, *Ilex aquifolium*) are never found.

The results for spiders show no difference in spider species composition among ungrazed patches (Asselin and Baudry, 1989). Differences between landscape elements are mainly due to differences in vegetation structure, e.g. plant height, presence of semi-woody parts, shading effects. In the studied landscape there is no problem with colonization. Apparently sources are close enough to any piece of land and spiders react very quickly to changes in vegetation structure, e.g. bramble regrowth after cutting (within a month).

2. Analysis of joint patterns

Given the results reported above, we decided to concentrate on a gradient of patches from normally grazed to ungrazed; in the same meadow 21 patches were sampled for plants and spiders. The meadow (about 2 ha) is largely unmanaged for years, but still grazed every year. Diversity of physical conditions, from shallow soil on limestone, to peaty soils along a brook has given a fine grain mosaic of vegetation.

2.1. Sampling

Spiders had been sampled four times in May-June 1988, collection of individuals was made by visual search for 30 minutes in each patch. Three thousand one

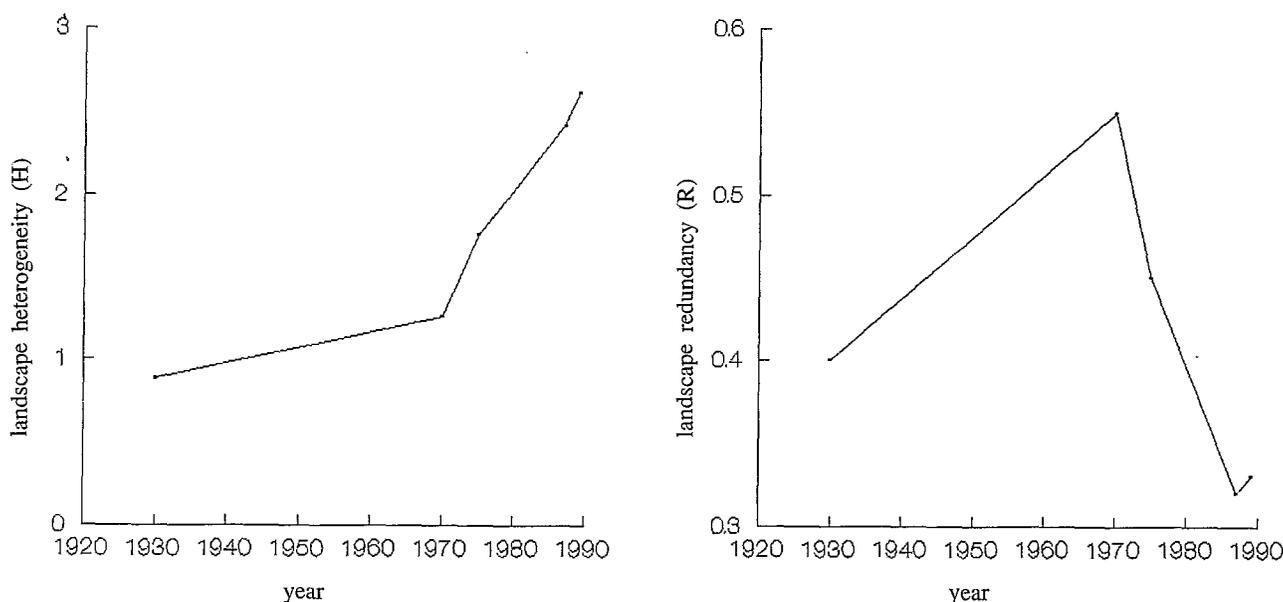


Fig. 1. Changes in landscape structural characteristics.

hundred and two individuals from 94 species were collected. For data analysis only species represented by at least 5 individuals were used (55 species).

Plants were sampled in June 1988, contribution of each species to above-ground biomass was estimated in each patch (about 4 m²). Ninety species have been recorded, only 46, whose contribution to the biomass was more than 5% were used for the analysis.

It should be noted that the number of species of plants and spiders are very similar.

2.2. Data analysis

ADDAD software (Lebeaux, 1985) was used for all the analysis: ordinations, clustering, mapping of clusters in factorial space.

To study the relationships between plant and spider species composition, we used presence/absence data. We first transformed the samples x plant species and samples x spider species data matrices into two cross tables: 1) spider species x spider species, and 2) spider species x plant species (Fig. 2). The tables give the co-occurrence of spider species and the co-occurrence of plants and spiders. Then we run a correspondence analysis on the spiders x spiders table. In this factorial space, the plants were mapped as supplementary variables to see the relationships between plants and spiders. So, gradients of plant species are constraints on the gradients of spider species in the factorial space. This means that the place of plants along the gradient is determined by their co-occurrence with spiders, not by co-occurrence among themselves, though, of course, the two are not independent. These plant species ordinations are called plant/spider gradients hereafter.

A cluster analysis was done on the factorial scores of plants and the clusters were mapped on factorial plans.

We also performed a factorial analysis on the matrix plant species x samples to yield gradients of samples plant species composition, it is the plant ordination. We, then, compare the two ordinations.

2.3. Results

* Spider ordination

The first three factors of the factorial analysis explain 76% of the variance. According to the literature (Duffey, 1962, 1975; Christophe *et al.*, 1979; Maelfait *et al.*, 1988), spiders from different habitats are found.

On the first axis (Fig. 3), there is an opposition between spiders of grassland (*Pocadicnemis pumila*, *Oedothorax retusus*, *Dicymbium nigrum*, *Pachygnatha degreeri*, *Alopecosa pulvurenta*, *Xysticus cristatus*, *Pirata*

	spider species			plant species		
	l	i	s	l	k	p
spider specien _{i,i}n _{i,k}		
n _{j,i}n _{j,k}		

Fig. 2. Matrices used in the correspondence analysis plants/spiders. There is p plant species and s spider species. n_{i,i} = number of occurrence of spider species i
n_{j,j} = number of co-occurrence of spider species i and j
n_{i,k} = number of co-occurrence of spider species i and plant species k

The matrix spider x spider is the active matrix in the correspondence analysis, the matrix spider x plant is a supplementary matrix.

latitens) and spiders of shrubby vegetation (*Tetragnatha montana*, *Theridion varians*).

The second axis discriminates 3 species found only on specific plants (*Pteridium*, *Urtica*, *Brachypodium*), each found only in one patch.

Axis 3 segregates spider species of mesic grassland from those of high (*Trochosa terricola*, *Tetragnatha extensa*) and wet grassland (*P. hugrophilus*).

* Plant/spider gradients

The cluster analysis on plant species yields 4 groups that are best discriminated on factorial plan 1-3 (Fig. 3). The gradient of plants perceived by spiders looks very much like a gradient of herbage quality or grazing pressure. The first group of plants is characterized by *Lolium perenne*, *Cynosurus cristatus*, *Plantago lanceolata* which are the basic species of mesic well managed meadows in the region (Vivier and Baudry, 1988). Plants of the second group are: *Holcus lanatus*, *Anthoxantum odoratum*, *Carex* spp, *Ranunculus acer*, *Solanum dulcamara*, *Rumex acetosa*. *Carex*, *Solanum* and often *Holcus* indicate that the soil is saturated by water at least part of the year. *Anthoxantum* indicates less fertile soils. So the species of this group are not necessarily found together, but they are colonized by similar species of spiders. The species representative of the third group is *Juncus lamprocarpus*, associated with high herbaceous vegetation of wet meadow species grazed only in early spring. The fourth group is made of species of ungrazed patches: *Rubus* spp, *Angelica silvestris*, *Pteridium* and

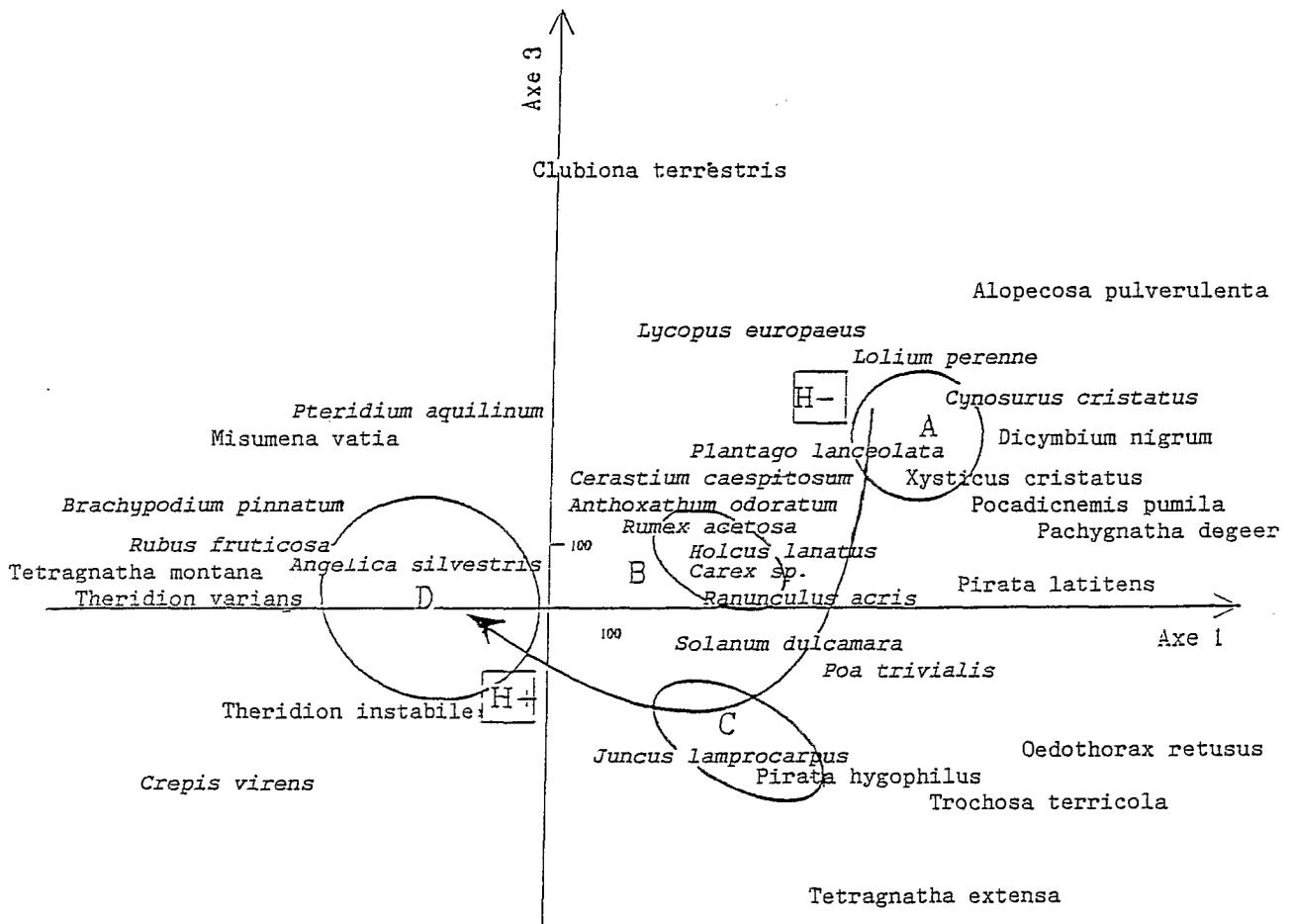


Fig. 3. Factorial plan axis 1 x axis 3, of plant/spider correspondence analysis. Plant species names are in italic, spider species names normal.

A, B, C, D are plant species cluster, ellipses represent ellipses of inertia of the clusters.

Brachypodium pinnatum. *Angelica* is a tall forb mainly found on wet soils, while *Brachypodium* grows on thin calcareous soils. This gradient is consistent with what is known of spider ecology.

Comparison of the plant/spider ordination and the plant ordination shows both similarities and dissimilarities.

The first axes of the two ordinations are correlated ($r = 0.705$), both gradients are related to grazing pressure. The gradient contrast grasses (*Lolium perenne*, *Cynosurus cristatus*...) and ungrazed species (e.g. *Pteridium*, *Rubus*...) (Fig. 4). There is also a weak correlation between the two third axes which are related to soil humidity.

The two main invading species (*Rubus* and *Pteridium*) are opposed on the fourth axis of the plant

ordination. This shows that if spiders react to plant structure (height, density) change and to soil humidity (only hunting spiders) they do not appear to react to plant species "per se".

3. Discussion

From this brief study of grazing extensification as well as Burel's work on carabids in the same area (this volume), we can draw some conclusions in terms of biological resources. The process, at this stage, does not drive new species in the area. The species that colonize ungrazed patches were already present in the landscape. The interesting points are the factors that control colonization and the way we perceive the patterns.

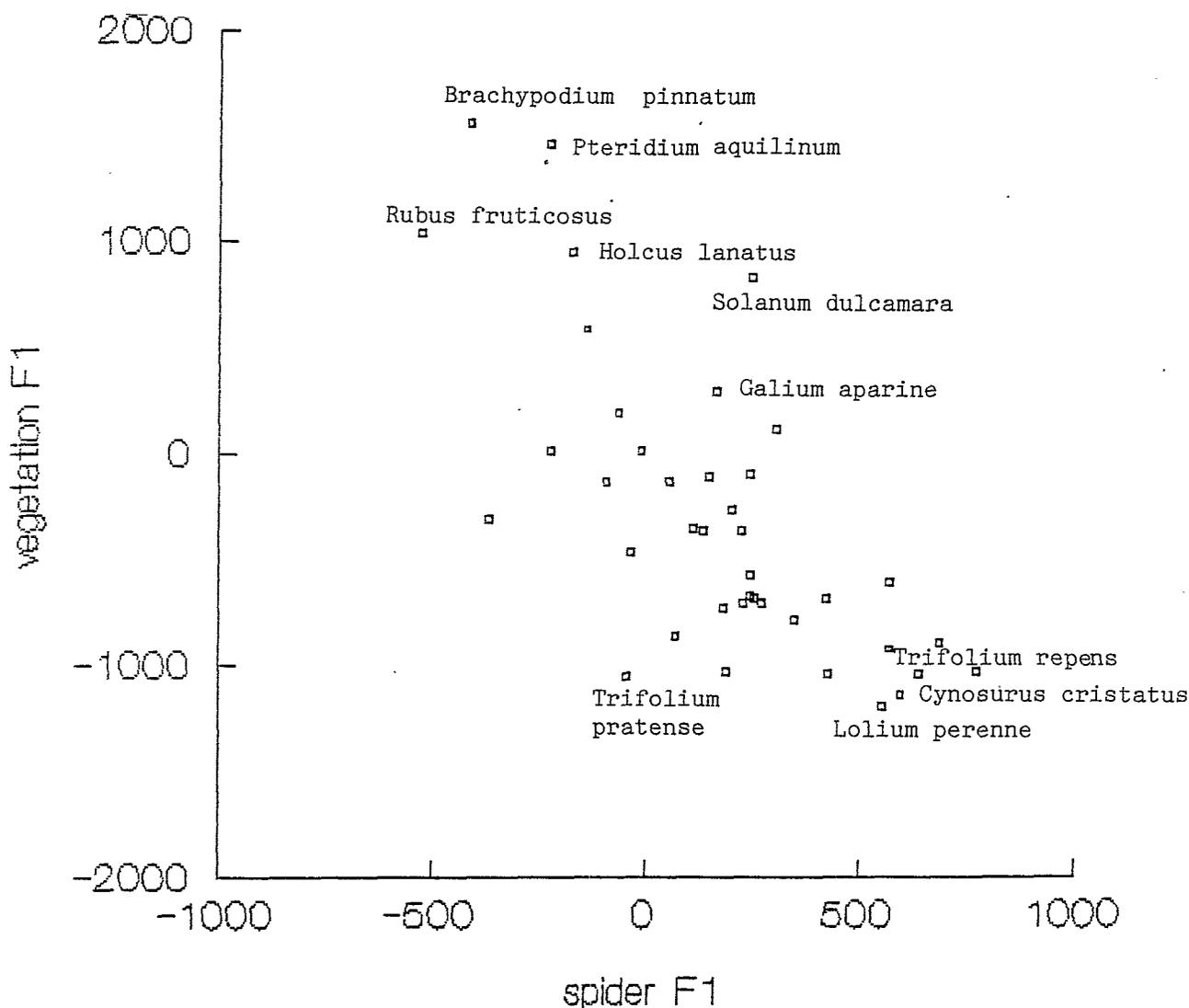


Fig. 4. Relationships between plant species positions along the first ordination axes of plant and plant/spider ordinations. Only species with the most important contribution to axes inertia are named.

Plants come from surrounding hedgerows by stochastic processes. Pattern only appears when data are smoothed at field scale. Unpublished data show that hedgerow species composition is controlled by physical conditions and connectedness in the network. So plant species composition of a given ungrazed patch is very dependent of its place in the landscape.

Colonization by spiders seems to be driven by plants height and architecture; patches with similar vegetation structure have similar spider species whatever their place in the landscape.

Carabid species composition is controlled by both vegetation and landscape structures. It does not seem to

be affected by soil conditions.

So the three groups exhibit different patterns of reaction to abandonment and low grazing pressure. Vegetation is but one aspect of changes.

These results tend to indicate that if we adopt a hierarchical perspective in our studies of land abandonment, i.e. if we study stands and landscape at the same time, we will be able to build models predicting changes in species composition after abandonment. But the predictability of abandonment is another point. It is to be found in the functioning of farming systems, not in the landscape itself (see Burel and Baudry, 1990a).

Acknowledgements

We thank the Ministère de l'Environnement (Comité Ecologie et Gestion du Patrimoine Naturel de France) for its financial support during this study, and H. Gray Merriam for comments.

References

- ASSELIN, A. and BAUDRY, J. (1989a): Conséquences écologiques de la déprise agricole en zone herbagère : Aranéides et flore dans le Pays d'Auge. Ministère de l'Environnement, Comité Ecologie et Gestion du Patrimoine Naturel, CERESA, INRA. 163 pp.
- ASSELIN, A. and BAUDRY, J. (1989b): Les aranéides dans un espace agricole en mutation. *Acta Oecologica Oecol. Appli.* 10: 143-156.
- BAUDRY, J. (1989): Colonization of grassland under extensification by hedgerow species. Pages 765-774 *in*: Brighton Crop Protection Conference, Weeds-1989. British Crop Protection Council no 2.
- BAUDRY, J. and BUREL, F. (1982): La mesure de la diversité Spatiale: Utilisation dans les évaluations d'impact. *Acta Oecologica Oecologica Applicata* 3: 177-190.
- BAUDRY, J. and BUREL, F. (1985): Système écologique, espace et théorie de l'information. Pages 87-102 *in*: Paysage et système. (Berdoulay V. and Phipps, M., eds.). Presses de l'Université d'Ottawa.
- BUREL, F. and BAUDRY, J. (1990a): Structural dynamics of a hedgerow network landscape in Brittany, France. *Landscape Ecology* (in press):
- BUREL, F. and BAUDRY, J. (1990b): Hedgerow networks as habitats for colonization of abandoned agricultural land. *in*: Species dispersal in agricultural environments (Bunce, R.H.G. and Howard, D.C., eds.). Belhaven Press: Lymington (in press):
- CHRISTOPHE, T., PLAIS, J.M. and BLANDIN, P. (1979): L'écologie des populations et des peuplements d'araignées en Europe depuis 1953: une bibliographie analytique. *Revue d'Arachnologie* 2: 45-86.
- DUFFEY, E. (1962): A population study in limestone grassland. Description of study area, sampling methods and population characteristics. *J. Anim. Ecol.* 31: 571-599.
- DUFFEY, E. (1975): Habitat selection by spiders in man-made environments. *Proceedings 6th International Arachnol. Congress Amsterdam, 1974*, 53-67.
- 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.
- LEBEAUX, M.O. (1985): ADDAD Association pour le Développement et la Diffusion de l'Analyse des Données. *Multigraph* 195 pp.
- PARK, J.R. (ed.) (1988): Environmental Management in Agriculture: European perspectives. Publication EUR 11169 of the Commission of the European Communities. Belhaven Press, London, 260 pp.
- VIVIER, M. and BAUDRY, J. (1988): Fermes herbagères de l'Isihme du Cotentin. Département sur les Systèmes Agraires et le Développement, Lieury, 14170 Saint Pierre sur Dives, 217 pp.

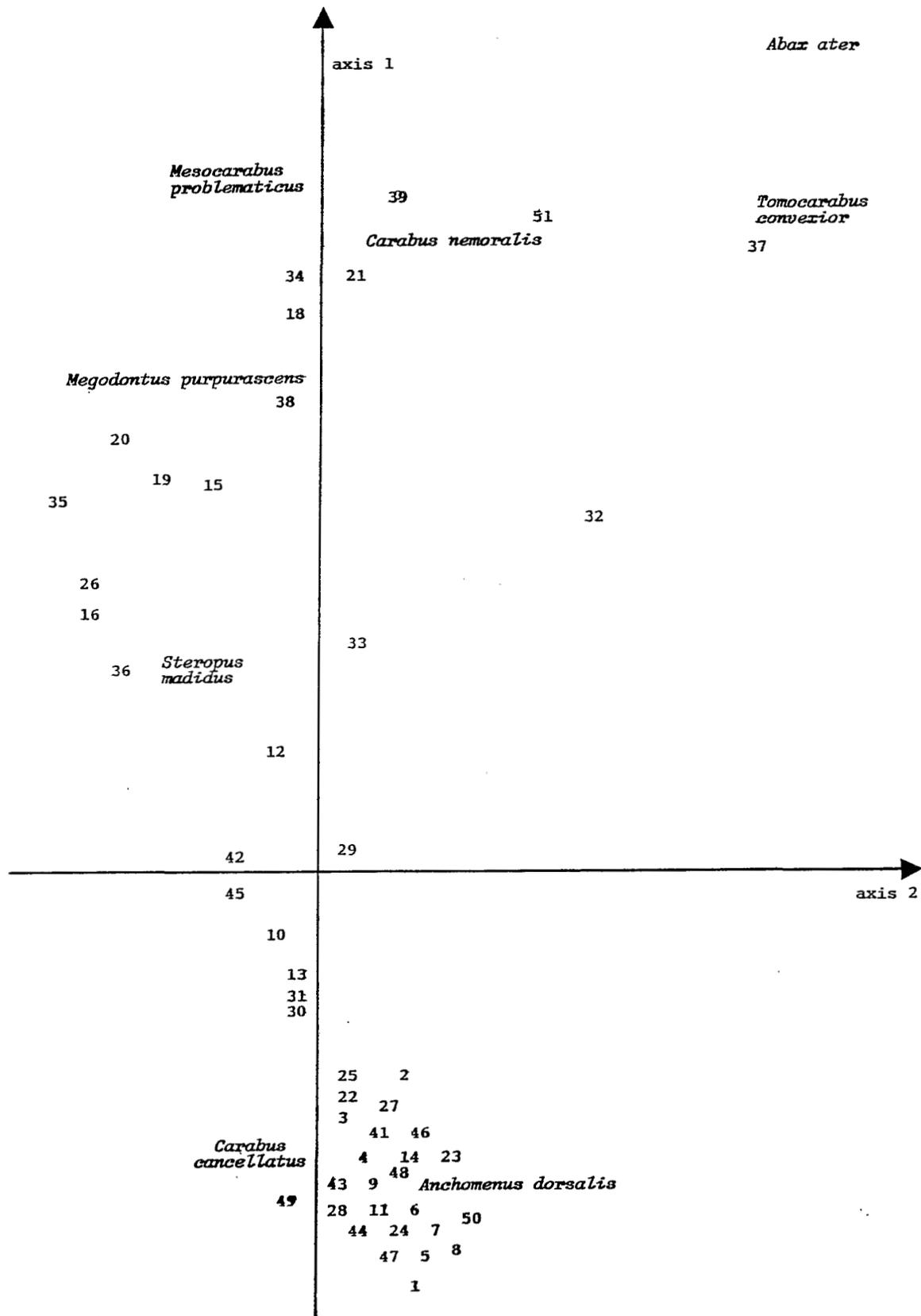


Fig. 5. First plan of the factorial analysis in the Pyrenees study

(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

I thank J. Baudry, G. Balent, J.P. Thaud and D. Volland for help in sampling. This research was made possible by a financial support of the Ministère de l'Environnement (Comité Ecologie et Gestion du Patrimoine Naturel de France).

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'Environnement 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.