

Peninsular patterns of breeding landbird richness in Italy: On the role of climatic, orographic and vegetational factors

CORRADO BATTISTI[°] AND ANNA TESTI*

[°]*Servizio Pianificazione ambientale, sviluppo parchi, riserve naturali - Provincia di Roma
via Tiburtina, 691 - 00159 Roma. E mail: cbattisti@inwind.it*

**Dipartimento di Biologia vegetale - Università degli studi di Roma «La Sapienza»
P.le Aldo Moro, 5 - 00185 Roma. E mail: anna.testi@uniroma1.it*

Abstract - In this study, an analysis of the breeding landbird distribution patterns in the Italian peninsula in relation to climatic, orographic, and indirectly, to vegetational factors has been carried out.

Data were drawn from the Atlas of Breeding Birds in Italy (Meschini and Frugis, 1993) and arranged in latitudinal bands (I.B). Three matrices (species/latitude, species/classes of I.B with same bioclimatic Mediterranean area, species/classes of LB with same altitudinal ranges) were obtained and analyzed with multivariate statistics.

Comparisons with thematic maps at national scale highlight that differences in the species richness among LB are localized in correspondence with orographic, bioclimatic, geobotanic, anthropic discontinuities along the peninsula.

Results, interpreting the preceding hypotheses on latitudinal changes of species richness, have evidenced that fauna changes occur at bioclimatic and orographic thresholds. These changes are due, in part, to quantitative differences in the number of species among the latitudinal bands, and in part to qualitative differences which will be investigated in successive works. Floristic and physiognomic-structural changes of vegetation probably contribute, indirectly, to these.

Climate at macroscale level, orography and vegetation at mesoscale level, may influence the observed patterns. Thus, a primary role of physical factors and a secondary role of biological ones, is confirmed in determining the breeding landbird richness patterns in peninsular Italy.

Introduction

The study of distribution patterns of species in peninsulas is a promising field of research in biogeography. This kind of investigation may be considered as part of the broader study on the spatial distribution of diversity (Brown 1988).

Simpson (1964) pointed out that, in some peninsulas, the number of species decreases towards the distal sections. He suggested that peninsula geometry could affect, through «extinction-recolonization» balance dynamics, the observed pattern of species richness (MacArthur and Wilson 1967, Taylor and Regal 1978). Cook (1969) named this phenomenon the «peninsular effect». Determinant factors of the peninsular effect may vary, according to the group, the context under study, and the scale of reference. This led investigators to a more thorough examination of the subject (Wiggins 1999).

Many controversial hypotheses on the determinant

factors have been put forward (McCoy and Connor 1980, Kaufman 1995). In peninsulas, besides the factors indicated by Simpson (1964), orographic, ecological *sensu lato* (climatic, vegetational, *etc.*), historical-biogeographical, and anthropic factors have been suggested as main causes of the observed patterns (*e.g.*, Brown and Opler 1990). These factors may have a role, in different modalities, also in latitudinal patterns at a continental scale (*e.g.*, Cook 1969, Kiester 1971, Wilson 1974, Cotgreave and Harvey 1994, Blackburn and Gaston 1996).

Orophysiology and geomorphology, as well as the reduction of altimetry and of ecological potentialities, may account for peninsular patterns in some contexts and for some biological groups (Lee 1980 in Busack and Hedges 1984, Means and Simberloff 1987, Schwartz 1988, Vargas *et al.* 1998).

In interdependence with the previous ones, it is feasible to add ecological factors, such as climate and vegetation (the last one intended as patterns of vege-

tation diversity, as physiognomic-structural modifications along gradients, as diversity and distribution of specific habitats, *etc.*: Cook 1969, Means and Simberloff 1978, Lee 1980, Due and Polis 1986, Schwartz 1988, Brown and Opler 1990, Sosa-Escalante *et al.* 1997, Vargas *et al.* 1998; see for vegetational patterns in peninsulas, Tackaberry and Kellman 1996).

Whittaker (1977), at α -diversity level, pointed out that richness of bird species were highly correlated to the vegetation structure and that the patterns were affected by climatic and topographic factors. The same factors may affect also the turnover of the species and the β -diversity along gradients (see, for continental scale, Gregory *et al.* 1998) as well as the γ -diversity (Tramer 1974).

Palaeoclimate (Cook 1969), availability of area (Schwartz 1988), and history (Lawlor 1983, Busack and Hedges 1984, Tackaberry and Kellman 1996, Vargas *et al.* 1998) have been proposed as further determinant factors.

All the mentioned factors may overlap those strongly linked to the dynamics of equilibrium *sensu* Simpson (Seib 1980, Lawlor 1983).

In the Italian peninsula, climatic, orographic, and ecological factors have been suggested as affecting the latitudinal patterns of species richness in different taxonomical groups (Massa 1982). Moreover, the breeding landbird patterns show fluctuations of species richness in specific districts of the peninsula (Battisti and Contoli 1997). The analyses of primary causal factors of the patterns are complex because latitude, bioclimate, orography are strongly correlated in the Italian peninsula (Battisti and Contoli 1999).

As regards mammals, Contoli *et al.* (1985) have indicated some present ecological and orophysiological factors as responsible for differences in the local faunas and communities. For *Lepidoptera*, these factors may determine the distribution in the peninsula, without excluding vegetation cover alteration due to anthropic factors (Racheli and Zilli 1985). Caporiacco (1950, in Due and Polis 1986) identified the climatic, ecological, and palaeogeographic factors as causes of the peninsular patterns of scorpion-fauna. Orographic, eco-biogeographical, and anthropic factors may explain the differences in the richness patterns of the distal subpeninsulas (Puglia and Calabria: Battisti and Contoli 1995, Contoli and Penko 1996, Battisti *et al.* 1997). Woody plants show the peak of diversity in the central areas of Italy, covering the «peninsula effect»; this deviation from the Simpson model (Feoli and Lagonegro 1982, Milne and Forman 1986) may be explained by the peculiar environmental heterogeneity of this Italian

district: here mixed deciduous woods of *Quercus frainetto* and *Q. cerris* are widespread and present the highest values of hierarchical diversity (structural, taxonomical, chorological, and vegetational) when compared with *Quercus ilex* and *Fagus sylvatica* woods (Feoli and Scimone 1984). This influences the «peninsula effect» in plants (Feoli and Lagonegro 1982) and can affect the diversity patterns in breeding landbirds.

Through the analysis of latitudinal bands, the present study should help to focus on those factors that determine the richness patterns of breeding landbirds in the Italian peninsula.

Methods

The Italian peninsula was subdivided, North to South, into 27 latitudinal bands (LB). Each band comprised the group of the tables IGMI 1:100,000 located at the same latitude (Fig. 1). The number of breeding landbird species (from *Columbiformes* to *Passeriformes*, Vaurie 1959, 1965, see Massa, 1982) for each LB was taken from the Atlas of Breeding Birds of Italy (Meschini and Frugis 1993). A first «species/latitudinal bands (LB)» matrix (146x27) was drawn up and subjected to statistical multivariate analysis (data in each band do not account for possible different situations at the same latitude). The results obtained encouraged a deepening of the analysis.

A second matrix of «species/LB clustered by nine climatic classes» (146x9), and a third matrix «species/LB clustered in six orographic classes» (146x6), were drawn up (Tab. 1). The climatic classes were chosen on the basis of the percentage of the Mediterranean bioclimate area, calculated in each LB, according to Tomaselli *et al.* (1973), with an approximation of 5%. The orographic classes were chosen on the basis of the maximum altitude in each LB and provided cumulative information on vegetation belts. This is a measure of altitude range only for LB with a coast line (orographic classes without a coast line and with maximum altitude > 4000 m a.s.l. were excluded from the analysis).

An «effect area» on the presence/absence of the species is possible because of the different areas and number of LB for each class (see Tab. 1).

In the present study, each matrix was analyzed by means of multivariate statistics, using SYN-TAX software (Podani 1994). Cluster Analysis, Principal Component Analysis (PCA) and Metric Multidimensional Scaling (MMS) were chosen. As to distance, the Ochiai coefficient and complete linkage were applied.

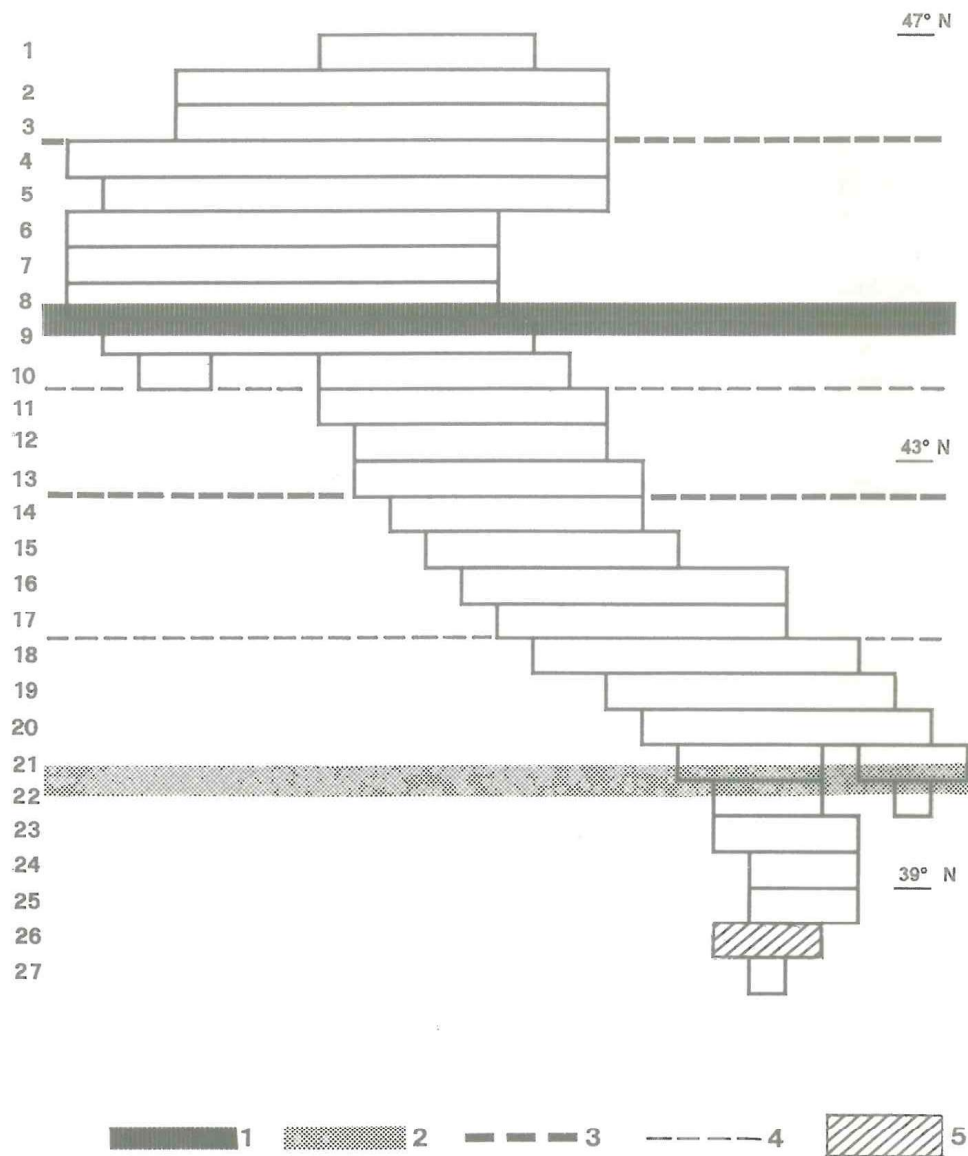


Fig. 1. 1:100,000 I.G.M.I. geographic grid of Italy. 1 to 27: LB. First matrix (species/latitude). The main clusters and subclusters of the dendrogram are reported: 1 = Division between two main clusters; 2 = Division between two main subclusters of Central-Southern Italy; 3 and 4 = further subdivisions corresponding to bioclimatic, orographic, geobotanical changes (see text); 5 = «Calabrian Serre». (Drawing of V. Salvati).

Results

The Cluster Analysis of the first matrix (Fig. 2) showed:

- two main groups: one in Northern Italy (LB 1-8), and one in Central-Southern Italy (LB 9-27);
- two subclusters in Northern Italy (LB 1-3 and 4-8);
- two main subclusters in Central-Southern Italy (LB 9-21 and 22-27): in the first one, two other groups were identified (9-13 and 14-21) with further distinctions between 10 and 11 (Northern-Central Italy) and between 17 and 18 (Central-Southern Italy). In the second subcluster the LB 26 was differentiated from the others.

PCA showed, in the ordination along axes 2 and 1, two well-divided groups: Northern Italy and Central-Southern Italy, divided by LB 9 and 10 (Fig. 3).

In the ordination along axes 2 and 3 (Fig. 4), besides the two main groups (Northern Italy and Central-Southern Italy) separated by LB 9 and 10 (start of the Pre-Apennine), further distinct subclusters were shown: truly Alpine (LB 1-3), Alpine and Po valley (4-8), Tuscan and Central Apennine (11-17), the Lucan area and Irpinia (18-21), and, more isolated than the others, the Calabrian area (22-27). The ordinations are in accordance with the dendrogram.

Cluster analysis and MMS of the second matrix showed the bioclimatic class 1 (Northern LB without

the Mediterranean area) well separated by the other classes; classes 2 and 3 (with the Mediterranean area up to 10 %) are plotted close to and separated by the classes with the Mediterranean area > 10 % (Fig. 5): a strong "separation" is recognizable when the Mediterranean area of LB increases from 10 to 20 % (the "arch effect", linked to this type of analysis, was evident; Podani 1994).

The ordination of the bioclimatic classes according to MMS analysis (Fig. 5) follows the changes in numbers of species among the classes (the changes were significant: $\chi^2_8 = 20.4$; $p < 0.01$). The more important changes was the decrease in the species number corresponding to bioclimate change (from class 1 to others; an effect due to the area can further affect the changes observed). Cluster analysis and MMS of the third matrix showed that the orographic class 1 (LB with altitudinal range up to 1500 m a.s.l.) was well separated from the others (Fig. 6): also in this case, the changes in species number among classes were significant ($\chi^2_5 = 15.78$; $p < 0.01$).

Tab. 1. Latitudinal bands (LB), number of breeding landbird species, Mediterranean bioclimate area of LB (in % of the total area) by Tomaselli *et al.* (1973), bioclimatic classes (class 1: 0%; 2: 5%; 3: 10%; 4: 20%; 5: 35%; 6: 75%; 7: 90%; 8: 95%; 9: 100%), altitudinal ranges (in m a.s.l.), orographic classes (class 1: maximum altitude up to 1500; 2: 1500-2000; 3: 2000-2500; 4: 2500-3000; 5: 3000-3500; 6: > 3500).

LB	no. of species	mediterranean bioclimate	bioclimatic classes	altitudinal range	orographic classes
1	104	0	1		
2	117	0	1		
3	123	0	1		
4	131	0	1		
5	131	0	1		
6	130	0	1	3676	6
7	130	0	1	3303	5
8	129	0	1	3841	5
9	114	5	2	3297	5
10	110	20	4	1654	2
11	110	10	3	1701	2
12	104	10	3	1576	2
13	115	10	3	2478	3
14	122	10	3	2912	4
15	121	35	5	2795	4
16	121	75	6	2283	3
17	115	90	7	2050	3
18	101	100	9	1533	2
19	106	95	8	1899	2
20	109	100	9	1836	2
21	108	100	9	2005	3
22	79	100	9	2267	3
23	91	100	9	1785	2
24	95	100	9	1928	2
25	79	100	9	1013	1
26	67	100	9	1423	1
27	76	100	9	1956	2

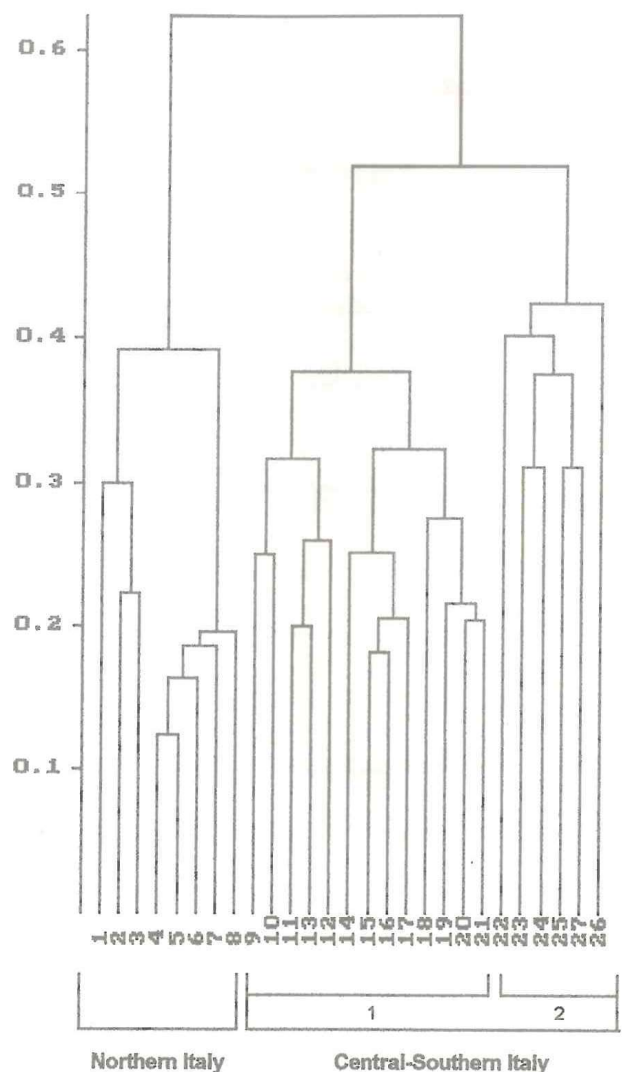


Fig. 2. Dendrogram from Cluster Analysis (1 - 27: LB) on the first matrix (species/latitude). Two clusters and two subclusters are highlighted.

Discussion

Results of the statistical analysis support the hypotheses on the influence of climatic, orographic and, indirectly, vegetational factors on the latitudinal patterns of breeding landbird richness in the Italian peninsula. The ordinations suggest that the complexity of the environmental system significantly affects the patterns of species richness.

Gradient analysis

As regards the first matrix (species/latitude), two ordinations along the axes 2-1 and 2-3 support the hypothesis of a bioclimatic gradient, along which LB 9 and 10 mark the borderline between the two Italian bioclimatic regions, *i.e.* the Euro-Siberian and the Mediterranean (Pedrotti 1991) (Fig. 3, 4). Just at this

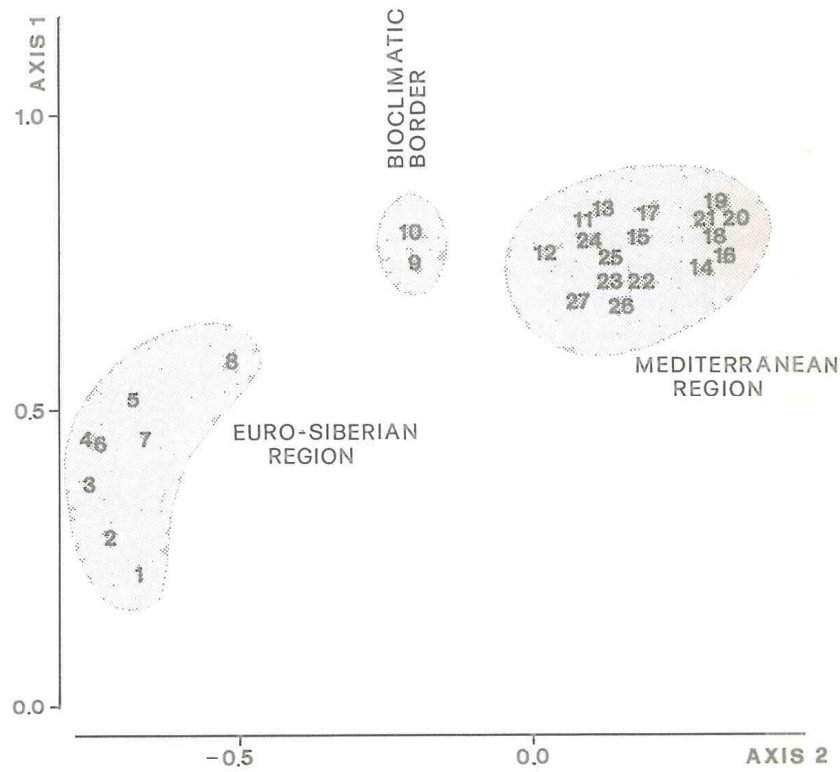


Fig. 3. PCA ordination diagram according to axes 1 and 2 on the first matrix (species/latitude). The two bioclimatic Regions are highlighted. (Drawing of V. Salviati).

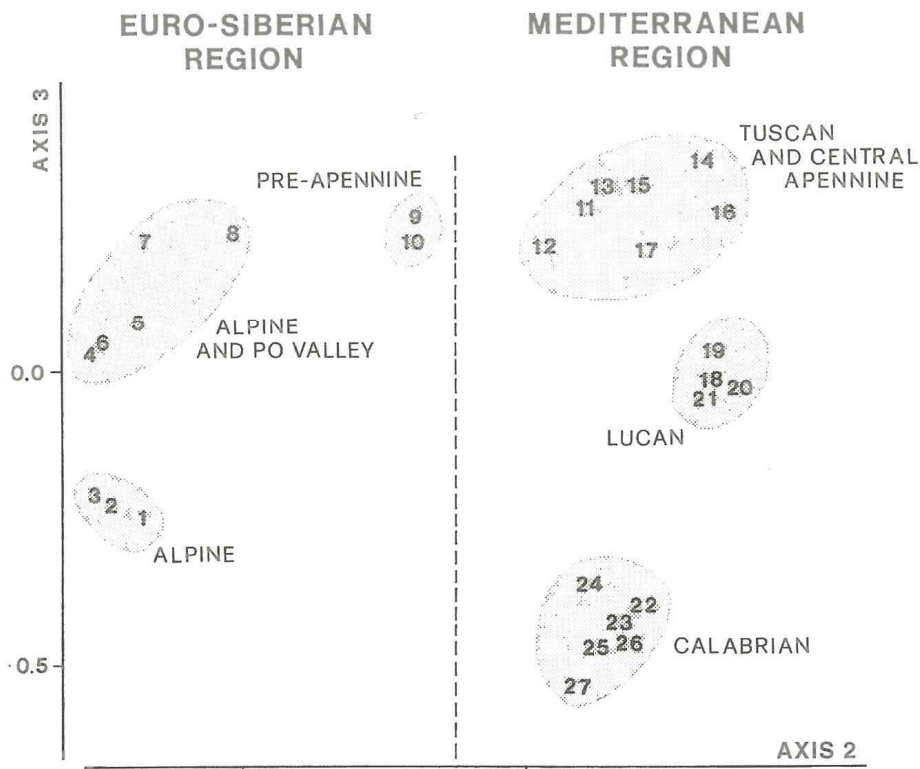


Fig. 4. PCA ordination diagram according to axes 2 and 3 on the first matrix (species/latitude). Main geographic areas (partially corresponding to geobotanical districts) are highlighted. «Pre-Apennine» is referred to the beginning of the Pre-Apennine. (Drawing of V. Salviati).

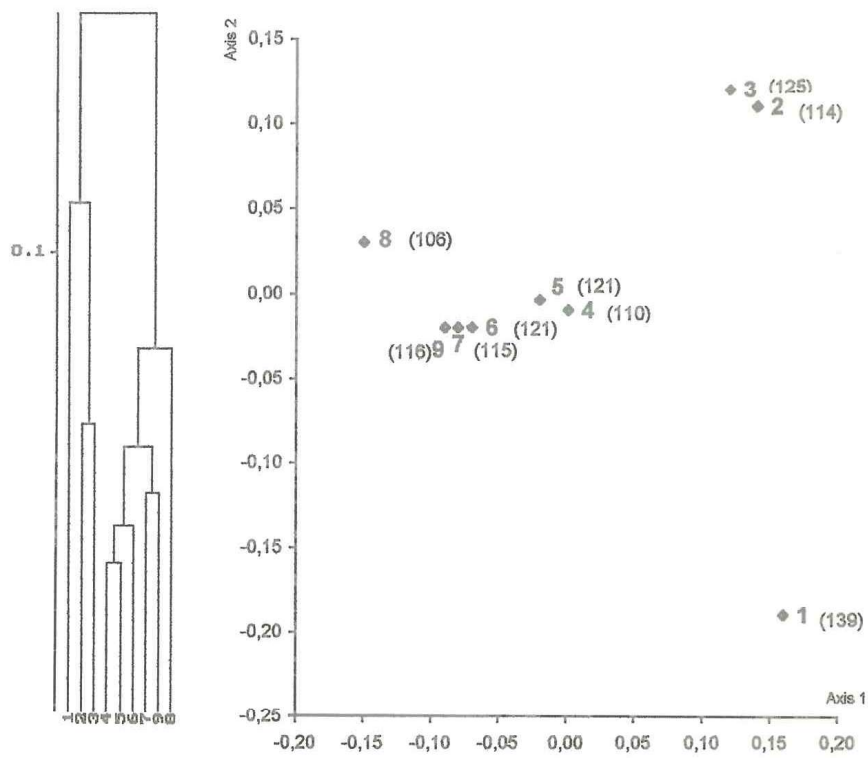


Fig. 5. Dendrogram from Cluster Analysis and MMS according to axes 1 and 2 on the second matrix (species/bioclimate). Number of species are reported in brackets.

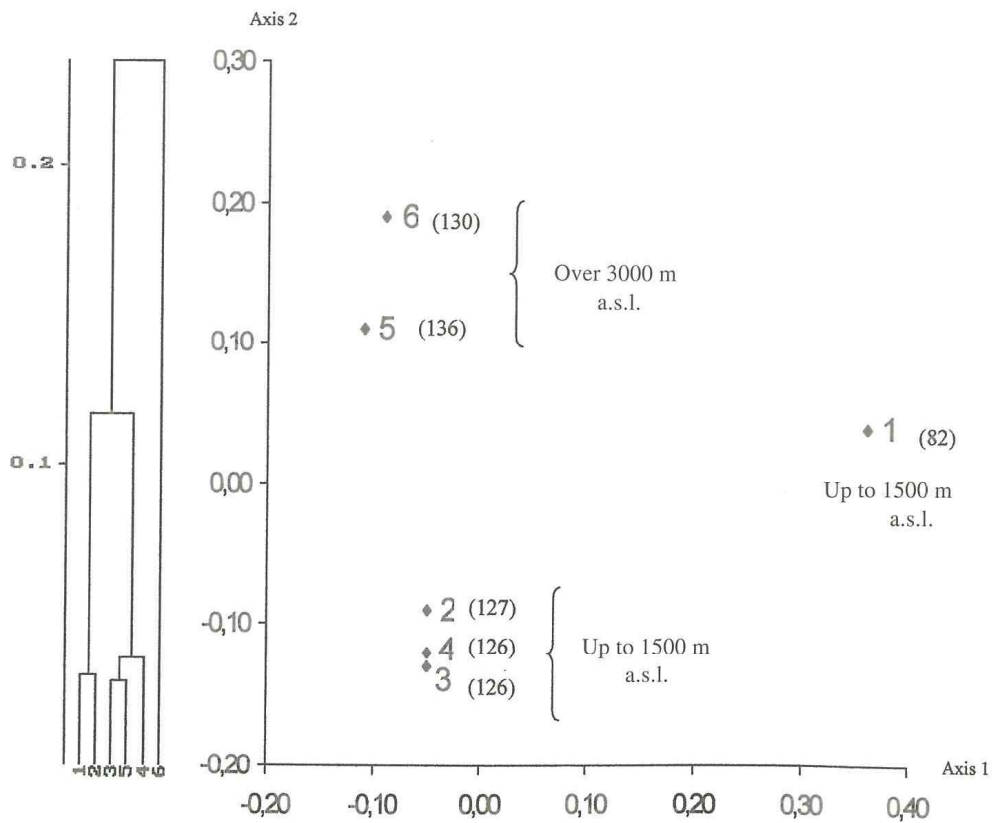


Fig. 6. Dendrogram from Cluster Analysis and MMS according to axes 1 and 2 on the third matrix (species/altitude range). Numbers of species are reported in brackets.

level (LB 9-10), the observed bioclimatic gradient is highlighted by an increase in the Mediterranean area (Tab. 1).

The distribution of LB in this ordination is in accordance with Contoli (2000) regarding the shape of the peninsula (see also Contoli and Penko 1996).

In the second ordination (Fig. 4), the subclusters may be, at least partially, referred to geo-botanical districts that are found in the peninsula: Central-Eastern and Western Alps, Po valley, start of the Pre-Apennine, Central-Apennine (Tuscany-Emilia and Umbria-Marche-Abruzzo), the Campanian-Lucan Mountains and Calabrian districts (Pedrotti 1996).

Statistical analyses on the bioclimatic classes (Fig. 5), as well as on the orographic classes (Fig. 6), have shown that the changes in the species number influence the affinities between the classes. Moreover, the passage between the two bioclimates in Italy is underscored by an appreciable reduction in the number of species, as well as by their possible turnover (in correspondence with bioclimatic classes 1-2 and orographic classes 5-2: Tab. 1).

Furthermore, the analyses suggest the existence of thresholds, besides the 10 % one of the Mediterranean area, and at 1500 m a.s.l., at which significant changes in the number of species are observed. At the orographic threshold the number of species is also strongly affected by the available area; orographic class 1 corresponds in fact to the LBs with the smallest surface area and with the smallest number of species (Tab. 1). This confirms the overlapping of causal factors in the patterns of species richness (Lawlor 1983).

These observations support the hypotheses in literature focused on how climate, orography, latitude, area and vegetation play a role in the peninsular patterns of species and highlight critical thresholds along the gradients observed. As concerns the orographic threshold, although based on cumulative altitudinal ranges, it can also be related to the vegetation change in structure as well as in ecology. Physiognomic-structural factors of vegetation, in fact, may affect richness patterns of landbirds (Whittaker 1977), when, for example, the vegetation changes from a woody to shrub and herbaceous structure along the altitude belts. According to Cook (1969), the reduction of the structural complexity of vegetation may cause a decrease of the landbird species density.

Analysis of thematic maps

Comparing our results with the thematic maps at national level of the orography (AA.VV. 1957), bioclimate (Tomaselli *et al.* 1973), geobotany and vegetation (Pedrotti 1991, 1996) and of the anthropization level (Bulgarini 1999), the following

observations may be made: from the first matrix (Figs. 3, 4):

1. The differences found in Northern Italy between LB 3 and 4 show a clear-cut separation of the mountain system of the Central-Eastern Alps from the rest of Italy.

2. The differences between LB 8 and 9 overlap the beginning of the Pre-Apennine.

3. The discontinuity found between LB 10 and 11 overlaps the beginning of the Mediterranean bioclimate, which may represent an element of differentiation among faunas. This is confirmed by the strong changes of the Mediterranean bioclimatic area at this latitude (Tab. 1).

4. The discontinuity between LB 13 and 14 is located at the level of the greatest development of the mountain system of the Central Apennines.

5. The difference between clusters of LB 17-18 overlaps the Southern extremity of the Central Apennine mountain system and the relative cold region.

The analysis of the wilderness condition at national level has recently shown a strong anthropic impact on the "Irpinia" area, at the Southern extremity of the Central Apennines. Historical-anthropic causes (such as deforestation), besides orographic causes, may be very significant in this region, contributing towards determining a discontinuity between the Central and Southern areas of the peninsula (Bardi *et al.* 1996, Bologna 1997). Moreover, anthropic causes largely affect the vegetation structure in Mediterranean evergreen communities, which influences plants and breeding landbirds diversity (Spada 1993, Testi *et al.* 1996; Massa 1993, Covas and Blondel 1998).

6. The discontinuity observed in Southern Italy between LB 21 and 22 may be explained, at least partially, by the orography coinciding with the Southern extremity of the Campanian-Lucan district and the beginning of the Sila Mountains (Calabrian system).

7. The isolation of LB 26 (Fig. 1, 2), located between the Silas and Aspromonte, may be explained by the decrease of the maximum altitude («Calabrian Serre» with low altitudes) and of the available area. Both these factors affect ecological potentialities, species richness and affinities among faunas. In fact, the number of species of LB 26 (67, see Tab. 1) is the lowest of them all.

These results are in accordance with the observations of Massa (1982) who noted a limit of continentality in Tuscany (LB 9-13) and in the Naples-Gargano line (LB 17-18). More recent analyses of bird peninsular patterns confirm a decrease from North to South of the species richness and species density (number of species/log₁₀area) (Battisti and Contoli 1997). The Authors also identify marked fluctuations at the

extremity of the Central Apennines and at the level of the Calabrian-Lucan Apennines. Similar patterns were shown also for rodents (Contoli and Penko 1996).

Analysis of literature as well as our preliminary interpretation of data from the Atlas of Meschini and Frugis (1993), indicates the role of the factors affecting the observed peninsular patterns of species richness in Italy. Although the distribution area of each species may be limited by many factors, none of them can be the only one to affect the patterns, which are, at this level, complex and stochastic (Kathleen Lyons and Willig 1999), as shown also by our gradients. Nevertheless, a relationship between landbird patterns and bioclimate – at macroscale level – as well as orography, geobotany and vegetation – at mesoscale level – has been found.

Vegetation, therefore, may no longer be taken as the main «indicator» of the climatic changes at different scales; landbird patterns, well reflecting climatic, orographic and ecological gradients, could be used, e.g., for bioclimatic maps. This confirms similar results from a previous study on other animal taxa (mammal trophic systems and plant communities: Contoli and Testi in press).

Our results are also in accordance with Brown (1988) who showed a primary role of physical factors and a secondary role for biological ones in determining the patterns of diversity.

Finally, the analysis of landbird species richness may also be a useful tool for identification of discontinuities in the peninsular system, of isolated systems and vulnerable areas at this scale, as well as for national ecological planning (Properzi *et al.* 1998, Bulgarini 1999, Romano *et al.* 1999).

Acknowledgments - We are grateful to Dr. Longino Contoli and Dr. Alberto Zilli, for their careful reading of the manuscript and their useful suggestions, Dr. Roberto Rossi, for his critical review of the geographical-physical aspects, Dr. Gianni Amori for his suggestions about data processing, Dr. Alessandro Zocchi, for his translation into English, Mr Peter Glendening for revising the English version and Mr. Vincenzo Salviati (Centro di Genetica Evoluzionistica del CNR), for his assistance with the illustrations. We wish also to thank the referee who stimulated the authors to improve the paper.

Riassunto - È stata condotta un'analisi sui patterns di ricchezza specifica dell'avifauna terrestre nidificante lungo la penisola italiana, in relazione a fattori climatici, orografici e, indirettamente, vegetazionali.

Dall'Atlante degli uccelli nidificanti in Italia (Meschini e Frugis 1993), sono state ricavate le specie presenti in bande latitudinali (LB) di fogli IGMI, costruendo tre matrici: specie/latitudine, specie/classi di LB a stessa superficie bioclimatica mediterranea, specie/classi di LB a stesso range altitudinale, trattate successivamente con metodi di analisi statistica multivariata. Il confronto dei dati ottenuti dall'analisi statistica con cartografie tematiche a scala nazionale sottolinea come le differenze nella composizione specifica fra le LB corrisponda in gran

parte a discontinuità orografiche, bioclimatiche, vegetazionali, nonché antropiche, lungo la penisola.

L'analisi sulle classi mostra, inoltre, differenze fra le faune in corrispondenza di soglie bioclimatiche e altitudinali, in parte imputabili a differenze, significative, nel numero di specie fra classi. Fattori fisionomico-strutturali della vegetazione, oltre che strettamente climatici e orografici, possono contribuire a spiegare tali differenze.

Clima, a livello di macroscale, orografia e vegetazione, a livello di mesoscale, possono, così, influenzare i patterns peninsulari di ricchezza avifaunistica osservati, confermando il ruolo primario dei fattori fisici e quello secondario dei fattori biologici.

References

- AA.VV. 1957. L'Italia fisica. Conosci l'Italia, vol. I. Touring Club Italiano, Milano.
- Bardi A., Fraticelli F., Petrella S. (a cura di) 1996. Ecosistema Italia. Attenzione WWF 3.
- Battisti C., Contoli L. 1995. La componente di ricchezza della diversità avifaunistica in Italia: una sintesi cartografica. Ric. Biol. Selvaggina 96: 1-13.
- Battisti C., Contoli L. 1997. Sulla componente di ricchezza della diversità avifaunistica in Italia: peninsularità ed insularità. Riv. ital. Orn. 67: 113-126.
- Battisti C., Contoli L. 1999. Mean range of the species, bird richness and ecogeographical factors: data from Italian peninsula and islands. Avocetta 23: 48-57.
- Battisti C., Cignini B., Contoli L. 1997. Geographical peninsular effects on the trophic system "*Tyto alba*-micromammals" in Salento (Italy). Hystrix 9: 13-22.
- Blackburn T. M., Gaston K. J. 1996. Spatial patterns in the species richness of birds in the New World. Ecography 19: 626-638.
- Bologna G. 1997. Conservazione e ricerca in Italia: una proposta del WWF. Atti Conv. "Parchi e riserve naturali: conservazione e ricerca ieri e oggi". Atti Conv. Lincei 132: 99-110.
- Brown J. H. 1988. Species diversity. In: Myers A.A., Giller P.S. (Eds). Analytical Biogeography. An integrated approach to the study of animal and plant distributions. Chapman and Hall, London and New York: Chapt. 3: 57-89.
- Brown J. W., Opler P. A. 1990. Patterns of butterfly species density in peninsular Florida. J. Biogeogr. 17: 615-622.
- Bulgarini F. 1999. La carta delle aree selvagge come base per l'individuazione di possibili connessioni. Dossier "Reti ecologiche": XXXI-XXXIII. Attenzione WWF 16.
- Busack S. D., Hedges S. B. 1984. Is the peninsula effect a red herring? Am. Nat. 123: 266-275.
- Caporiacco L. de 1950. Le specie e sottospecie del genere *Euscorpis* viventi in Italia ed in alcune zone confinanti. Mem. Soc. Linné 8: 159-230.
- Contoli L. 2000. Rodents of Italy: species richness maps and *formae Italiae*. Hystrix 11: 39-46.
- Contoli L., Penko D. 1996. Sulla componente di ricchezza specifica nella Diversità dei roditori del territorio italiano. Ric. Biol. Selvaggina 99: 1-22.
- Contoli L., Testi A. in press. Are animal trophic systems as reliable expression of climate as are plant communities? Evidence from the Thyrrenian belt in Italy. Ecologia Mediterranea.
- Contoli L., Salucci M. P., Vigna Taglianti A. 1985. Per una biogeografia dei sistemi trofici: il sistema "micromammiferi terragnoli-*Tyto alba*" nell'Italia peninsulare e nelle isole maggiori. Biogeographia, Lav. Soc. ital. Biogeogr. 11: 211-231.
- Cook, R. F. 1969. Variations in species density in North American birds. Syst. Zool. 18: 63-84.

- Cotgreave P., Harvey P. H. 1994. Associations among biogeography, phylogeny and bird species diversity. *Biodiv. Lett.* 2: 46-55.
- Covas R., Blondel J. 1998. Biogeography and history of the Mediterranean bird fauna. *Ibis* 140: 395-407.
- Due A. D., Polis G. A. 1986. Trends in scorpion diversity along the Baja California peninsula. *Am. Nat.* 128: 460-468.
- Feoli E., Lagonegro M. 1982. Syntaxonomical analyses of beech woods in the Apennines (Italy) using the program package IAHOPA. *Vegetatio* 50: 129-173.
- Feoli E., Scimone M. 1984. Hierarchical diversity: an application to broad-leaved woods of the Apennines. *Giornale Botanico Italiano*, 118 (1-2): 1-15.
- Gregory R. D., Greenwood J. J. D., Hagemeyer E. J. M. 1998. The EBCC Atlas of European Breeding Birds: a contribution to science and conservation. *Biol. Cons. Fauna* 102: 38-49.
- Kathleen Lyons S., Willig M. R. 1999. A hemispheric assessment of scale dependence in latitudinal gradients of species richness. *Ecology* 80: 2483-2491.
- Kaufman D. M. 1995. Diversity of New World mammals: universality of the latitudinal gradients of species and bauplans. *J. Mammal.* 76: 322-334.
- Kiester A. R. 1971. Species density of North American amphibians and reptiles. *Syst. Zool.* 20: 127-137.
- Lawlor T. E. 1983. The peninsula effect on mammalian species diversity in Baja California. *Am. Nat.* 121: 432-439.
- Lee J. C. 1980. An ecogeographic analysis of the herpetofauna of the Yucatán peninsula. *Misc. Publ. Univ. Kans. Mus. Nat. Hist.* 67.
- MacArthur R. H., Wilson E. O. 1967. The theory of island biogeography. Princeton Univ. Press, Princeton, New Jersey.
- Massa B. 1982. Il gradiente faunistico nella penisola italiana e nelle isole. *Atti Soc. ital. Sci. Nat., Museo civ. stor. nat. Milano* 123: 353-374.
- Massa B. 1993. Gli uccelli della fauna italiana. *Contrib. Centro Linceo interdisciplin. "B. Segre"*, XIX Seminario "Evoluzione biologica e i grandi problemi della biologia", Roma, 26-28/2/1992, *Atti Conv. Lincei* 86: 79-86.
- McCoy E. D., Connor E. F. 1980. Latitudinal gradients in the species diversity of North American mammals. *Evolution* 34: 193-203.
- Means D. B., Simberloff D. 1987. The peninsula effect: habitat-correlated species decline in Florida's herpetofauna. *J. Biogeogr.* 14: 551-568.
- Meschini E., Frugis S. (Eds.) 1993. *Atlante degli uccelli nidificanti in Italia. Suppl. Ric. Biol. Selvaggina* 20: 1-344.
- Milne B. T., Forman R. T. T. 1986. Peninsulas in Maine: woody plant diversity, distance, and environmental patterns. *Ecology* 67: 967-974.
- Pedrotti F. 1991. Carta della vegetazione reale d'Italia. Scala 1:1,000,000. Relazione sullo stato dell'ambiente. Ministero dell'Ambiente, Roma.
- Pedrotti F. 1996. Suddivisioni botaniche dell'Italia. *Giornale Botanico Italiano* 130: 214-225.
- Podani J. 1994. Multivariate data analysis in ecology and systematics: a methodological guide to the SYN-TAX 5.0 package. - The Hague: SPB Academic Publishing. - III. - (Ecological Computations Series (ECS): Vol.6).
- Properzi P., Romano B., Tamburini G. 1998. Carta della continuità ambientale in Italia. XXII Congr. INU - Istituto Nazionale di Urbanistica, Perugia.
- Racheli T., Zilli A. 1985. Modelli di distribuzione dei Lepidotteri nell'Italia meridionale. *Biogeographia, Lav. Soc. it. Biogeogr.* 11: 165-194.
- Romano B., Battisti C., Figliuoli F. 1999. La continuità ambientale a scala nazionale: spunti da studi di pianificazione e da analisi faunistiche. Workshop su "Paesaggi rurali di domani: la gestione degli ecosistemi agro-silvo-pastorali e la tutela della connettività ecologica del territorio extraurbano. Torino, 10.9.1999. ANPA-ARPA Piemonte: 136-142.
- Schwartz M. W. 1988. Species diversity patterns in woody flora on three North American peninsulas. *J. Biogeogr.* 15: 759-774.
- Seib R. L. 1980. Baja California: a peninsula for rodents but not for reptiles. *Am. Nat.* 115: 613-620.
- Simpson G.G. 1964. Species density of North American recent mammals. *Syst. Zool.* 13: 57-73.
- Sosa-Escalante J., Sánchez-Cordero V., Hernández Betancourt S. 1997. Diversity and distribution of terrestrial mammals at the N-E region of the Yucatan peninsula, Mexico. *Abstract VII Int. Ther. Congr., Acapulco, 6-11/9/1997*: 333.
- Spada F. 1993. Incendi e vegetazione potenziale nell'Italia medio-tirrenica. In: *Introduzione all'ecologia degli incendi*. (a cura di S. Mazzoleni e G. Aronne). Ed. Liguori, Napoli.
- Tackaberry R., Kellman M. 1996. Patterns of tree species richness along peninsular extensions of tropical forests. *Global Ecol. and Biogeogr. lett.* 5: 85-90.
- Taylor R. J., Regal P. J. 1978. The peninsular effect on species diversity and the biogeography of Baja California. *Am. Nat.* 112: 583-593.
- Testi A., Napoleone I., Cigni A. 1996. Floristic and phytogeographical diversity in some protected areas in Italy. *Ecologia Mediterranea* 22: 81-100.
- Tomaselli R., Balduzzi A., Filippello S. 1973. Carta bioclimatica d'Italia. Collana verde, 33. Min. Agr. For., Roma.
- Tramer E.J. 1974. On latitudinal gradients in avian diversity. *Condor* 76: 123-130.
- Vargas J. M., Real R., Guerrero J.C. 1998. Biogeographical regions of the Iberian peninsula based on freshwater fish and amphibian distributions. *Ecography* 21: 371-382.
- Vaurie C. 1959, 1965. *The Birds of the Palearctic Fauna. Vol. I (Passeriformes), II (non Passeriformes)*. Whitherby ed., London.
- Whittaker R. H. 1977. Evolution of Species Diversity in Land Communities. In: Hecht M.K., Steere W.C., Wallace B. (Eds.). *Evolutionary Biology*. Plenum press, New York and London. Vol. 10: 1-67.
- Wiggins D. A. 1999. The peninsula effect on species diversity: a reassessment of the avifauna of Baja California. *Ecography* 22: 542-547.
- Wilson J. W. III 1974. Analytical zoogeography of North American mammals. *Evolution* 28: 124-140.