

Trophic diversity of the Barn Owl *Tyto alba* in continental Western Europe

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This comparative study of the trophic diversity of the Barn Owl *Tyto alba* is based on published data from Germany, France, Switzerland, Portugal, and Spain. Shannon's information function and Pielou's evenness index were used to assess trophic diversity. Barn Owls from temperate localities showed a strongly stenophagous diet, biomass consumed being almost entirely from mammalian preys, whereas birds from southern, Mediterranean localities fed on more varied kinds of prey, trophic diversity being much greater there. Such a 'generalization' of the diet should be interpreted as a predator response compelled by the decrease in diversity and abundance of small mammals which takes place in the Mediterranean regions studied.

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INTRODUCTION

The diversity of prey items taken by different predator species constitutes an essential variable in ecological studies of sympatric species. This variable is useful when regarding their niche breadth and the possibilities of overlap with the niche of neighbouring species, since these aspects are directly related with the study of interspecific competition. Trophic diversity (Hurtubia 1973, Hurtubia & di Castri 1973) may also be treated at an intraspecific level; for instance, changes in the trophic diversity of a given species throughout a large geographical area may give us some information on the various positions occupied by the species within different communities.

On the other hand, predation width is directly linked with structural and functional attributes of the community, especially abundance and diversity of potential prey items (cf. MacArthur & Pianka 1966, Schoener 1971), and on theoretical grounds one may predict contractions or enlargements of the food-niche, depending on changes in prey availability. The

main aim of this paper is to show that stenophagy and specialization, which are characteristics of the Barn Owl, decrease noticeably when the diversity and abundance of its main prey (small mammals) decrease, predation being then directed towards new prey items of lower energy values, and thus less optimal for the maintenance of the predator.

MATERIAL AND METHODS

Data on the food habits of Barn Owls from Germany, Switzerland, France, Portugal, and Spain were selected from the literature, and although not exhaustive, they were sufficient for a suitable statistical treatment. The only analyses used from the literature were those which totalled more than a hundred prey items, came from single localities defined geographically, and contained a detailed account of the specific composition of the small mammals and/or the contribution of higher taxonomic categories (mammals, birds, etc.) to the diet. Table I shows the distribution of the localities, and a full list of them is given in Appendix I.

The data gathered are probably heterogeneous since analyses from material collected at different times of the year are pooled together; it is a well-known fact that the Barn Owl's diet shows some monthly and yearly changes (Graaf 1960, Saint-Girons 1968, Marti 1973a, Webster 1973). However, the effects of seasonal changes on the results should be buffered enough, since of the 48 analyses studied, 25 exceeded five hundred prey items and, of these, there were 19 with more than a thousand prey items. Thus I believe these are very representative.

Trophic diversity was calculated with Shannon's information function:

$$H^1 = - \sum_{i=1}^S p_i \log_e p_i \quad (1)$$

where S is the total number of species in the sample and p_i is estimated by X_i/X ; X_i being the number of individuals belonging to the i -th species and X the total number of individuals of all species in the sample (e.g. MacArthur 1955, MacArthur & MacArthur 1961, Margalef 1957, 1968). H^1 can be obtained from (1) or by making use of the computing formula proposed by Lloyd & Ghelardi (1964):

$$H^1 = \log_e X - \frac{1}{X} \sum_{i=1}^S X_i \log_e X_i \quad (2)$$

When modifying the meaning of X_i , X and S

in (1) and (2), different significances are obtained for H^1 .

The various criteria of trophic diversity that have been used are as follows:

a. H^1 BGG. Trophic diversity in relation to the biomass supplied by the different higher taxonomic groups (mammals, birds, reptilians, amphibians, fishes, insects). In this case S is the number of taxonomic classes, X_i the biomass supplied by the i -th class, and X the total biomass contributed by all groups. H^1 BGG is a measurement of the diversity of the energy dependence of the predator.

b. H^1 NGG. Trophic diversity in relation to the number of individuals taken from each taxonomic group. Meaning of S is as above, X_i is the number of individuals belonging to the i -th group, and X is the total number of individuals in all groups. H^1 NGG is a measurement of the diversity of the predation upon the various groups.

c. H^1 NM. Small mammal (shrews and rodents) species diversity. S is the number of small mammal species in the analysis, X_i the number of individuals belonging to the i -th species, and X the total number of small mammals of all species. H^1 NM measures the diversity of the small mammals taken by the predator.

As a complement to the information gathered with the last three indices, Pielou's even-

Table I. Distribution by countries of the Barn Owl food analyses used in this study. A full list of the localities is shown in Appendix I

| Country | Number of analyses | Reference |
|-------------------|--------------------|---|
| Germany | 4 | Niethammer (1960), Rothkopf (1970) |
| France | 11 | Guerin (1928), Thiollay (1968) |
| Switzerland | 5 | Zelenka & Pricam (1964) |
| Portugal | 4 | Niethammer (1970), Engels (1972) |
| Spain: | | |
| Catalonia | 7 | Nos (1961), Vericad (1965), Nadal & Palaus (1967) |
| Cantabrian Region | 3 | Niethammer (1964) |
| Extremadura | 1 | Herrera (1974) |
| Andalusia | 13 | Valverde (1967), Herrera (1974) |
| Total | 48 | |

ness index $E = H'/H'_{\max}$ (Pielou 1969), was also calculated. Here H' is the observed diversity, and H'_{\max} is the maximum it could have obtained if the species or groups were equally distributed. Since H'_{\max} equals $\log_e S$ (Pielou op.cit.), $E = H'/\log_e S$. E-values near unity will show that the different kinds of prey have a similar significance in the diet, the predator depending (H' BGG) or preying (H' NGG) equally on each of them. Decreasing values will take place as stenophagy increases. E was calculated for each H' , and similar symbols were used (EBGG, ENGG, and ENM).

In addition to the preceding indices, each analysis was also characterized by the number of taxonomic groups (SGG), the number of small mammal species (SM), and the geographical latitude (LAT) of the source locality.

RESULTS

The raw results are shown in Appendix I. From it were produced the data of Table II, where the correlation matrix for the nine variables concerned is shown. It can be seen that there are certain groups of non-independent, positively correlated variables, and these must be treated as a whole because of the parallel variation of their components. Such groups are as follows:

Group 1. H' BGG, H' NGG, EBGG, ENGG, SGG.

Group 2. H' NM, ENM, SM.

Group 3. LAT.

Dealing just with the correlation signs, a new, simplified correlation matrix could be written:

$$\begin{array}{cc|c} 2 & 3 & \\ \hline (-) & - & 1 \\ & + & 2 \end{array}$$

The variables belonging to group 1 are inversely correlated with the latitude (group 3), that is, their values increase from north to south. Regarding H' BGG and H' NGG first, we can conclude that predation breadth and diversity of energy dependence of the Barn Owl is larger

in the southern localities. The diet there is a more diverse one, including more often prey items from taxonomic classes other than mammals. This can also be seen in SGG, which shows a strong, negative correlation with latitude (Table II). EBGG and ENGG also increase southwards. Thus, in the southern localities, the various groups are closer to an equivalent significance in the predator diet, both in weight and numbers, whereas to the north, predation centres on one group (mammals), the bird depending and preying almost exclusively upon them. We can, then, conclude that the Barn Owl's trophic diversity is greater in the south, whereas the predator is deeply stenophagous in the northern localities (Fig. 1).

The variables belonging to the second group (H' NM, ENM, SM) are directly correlated with latitude (Table II), H' NM increasing from south to north, since specific diversity of small mammals in the food of the owl is higher in the northern localities and lower in the southern ones (Fig. 1). This is supported by the variation of SM, which shows a strong correlation with latitude (Table II). Relative abundance of small mammal species (as measured by ENM) are closer to an even distribution in the north, the significance of the various species in the diet being more similar there. This is not so at the southern localities, where the importance of each prey species varies to a greater extent.

Correlations between groups 1 and 2 are negative in all instances (Table II), although they are not statistically significant ($P > 0.05$) except for SM. It can be concluded that SM and the group 1 measurements change in an opposite way: a few species of small mammals represented in the sample implies a high trophic diversity for the analysis as a whole (as measured by H' BGG and H' NGG).

The food of the Barn Owl in continental Western Europe shows two essential aspects changing from place to place according to geographical latitude: northern localities show a low trophic diversity and a narrow predation breadth, besides a high species diversity in the mammalian component of the diet. To the south, trophic diversity increases, whereas small mammal species diversity decreases. In nor-

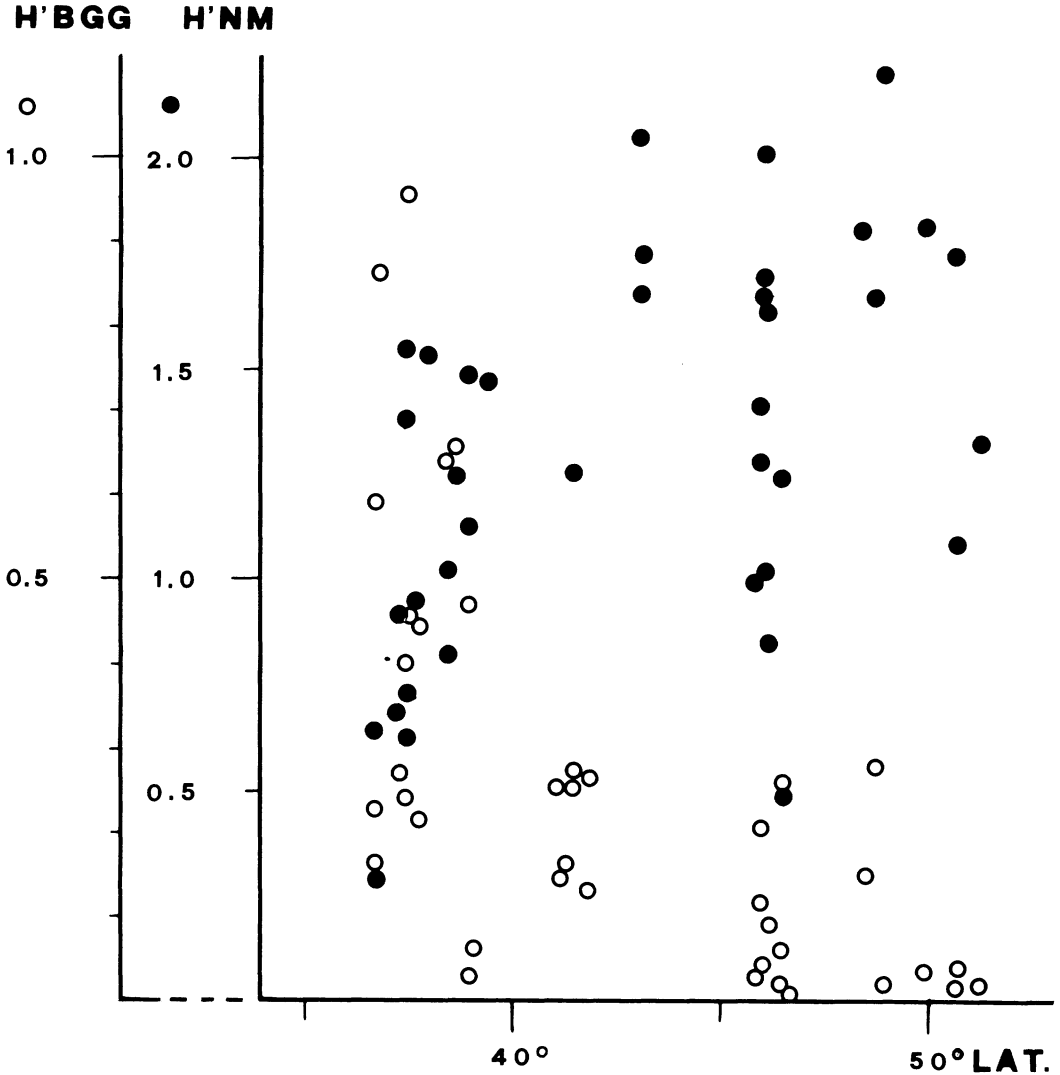


Fig. 1. Changes of H'BGG ($r_s = -0.624$, $P < 0.001$) and H'NM ($r_s = 0.349$, $P < 0.05$) with latitude. H'BGG (open circles): trophic diversity in relation to the biomass supplied by the diverse taxonomic groups to the Barn Owl's diet. H'NM (filled circles): small mammal (shrews and rodents) species diversity in the samples. For further explanation see text.

thern places, predation is centred on mammals, the almost exclusive prey, the diet more frequently including insects, amphibians, reptilians, and birds in the southern localities.

DISCUSSION AND CONCLUSIONS

The geographical latitude of an area occupied by a predator species constitutes one of the

most important factors in a long chain of inter-related factors determining its food habits. The relationships among those factors are exemplified in the present study. When starting at the 'food' point of the chain, the first link that we find is the prey species. The composition of a predator's diet depends necessarily on the abundance and availability of prey. The main prey are, for the Barn Owl and the majority

of birds of prey, primary consumers at the second level of the ecological pyramid (Odum 1959, Valverde 1964, Frochot 1967), which feed on the producers, that is, the plant community. We find here a new link in the chain. Plant communities are more conditioned by abiotic environmental factors such as temperature, moisture, and light, and its structure, specific composition, and productivity will depend upon the collection of factors we call climate, which in turn is a link more closely tied to the terminal point of the chain; geographical latitude. Thus, a discussion on the geographical changes in a given predator species diet must take into account the former theoretical model and consider the steps which constitute it.

As regards climate, we can expect the food habits of Barn Owls from localities showing different climatic types to be dissimilar as well. There are two main types of climate in the area covered by the localities studied in this paper: Mediterranean and temperate type climates. The former is characterized by a dry, hot period of variable length within the annual cycle, which is absent in the temperate climate. Localities were classified according to their

climatic type into 'Mediterranean' and 'temperate' ones (see Appendix I) on the basis of the map published by Emberger et al. (1963). These classes are perhaps too wide but they have been suitable for the purpose of comparison. It can be seen easily in Fig. 2 that the two groups of localities differentiated by their climates are also segregated according to the values of H'BGG and H'NM. A latitude axis was only introduced to make comparisons easier. In general, it may be noted that the Barn Owl's diet is essentially distinct in the Mediterranean and temperate localities, the high values of H'BGG at the Mediterranean stations being particularly noticeable.

Standard prey of the Barn Owl are small mammals, mainly shrews and rodent species, and changes in availability of these will influence the overall composition of the predator's diet. H'NM, as calculated from the food analyses, may be used as a rough estimate of the population diversity of small mammals in an area. The mammalian ingredients of the Barn Owl's food have often been taken as indicative of the composition of populations in the wild (e.g. Saint-Girons & Spitz 1966, Heim de Bal-

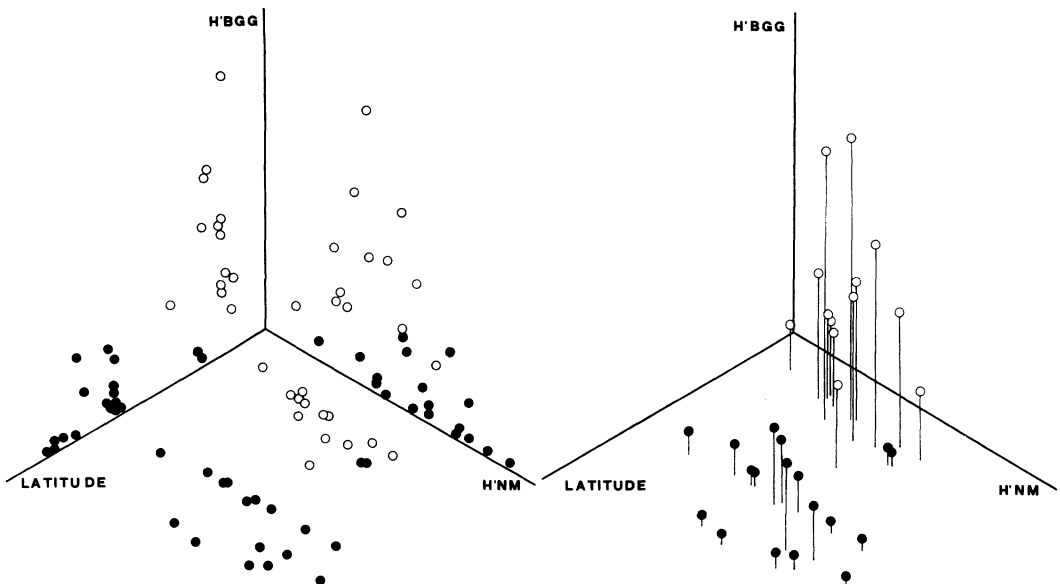


Fig. 2. Comparison between the diet of the Barn Owl in Mediterranean (open circles) and temperate (black circles) localities from Western Europe in relation to H'BGG and H'NM. For further details see text.

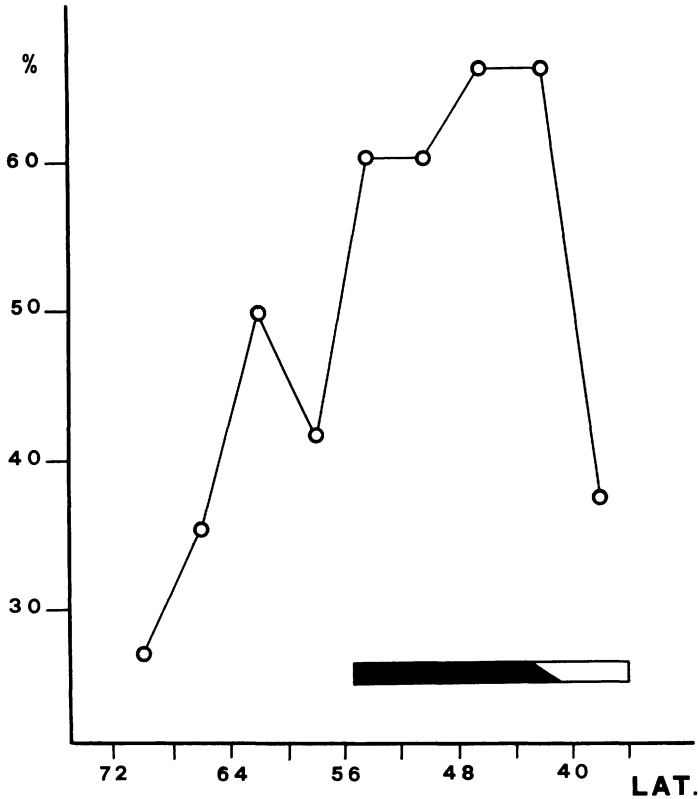


Fig. 3. Latitudinal changes in the number of small mammal species (shrews and rodents) in Western Europe (west of a straight line running from Eastern Finland throughout the Balearic Islands), expressed as the percentage of the total number of species in the area occurring at each latitudinal belt four degrees wide. Bar shows the breeding range of the Barn Owl, from which food analyses were studied, and is broken into temperate (black) and Mediterranean (open) climate areas. It can be seen that the number of potential prey species decreases noticeably in the Mediterranean region. Mainly based on Brink (1957), but also on Niethammer (1956, 1964), Heim de Balsac & Beaufort (1969), Niethammer (1970), Garzón & Castroviejo (1971), Rey (1971), Engels (1972), Rey (1972), Herrera (1973), Rey & Landin (1973) and Vericad & Meylan (1973) for more recent distributional data from the Iberian Peninsula.

sac & Beaufort 1966, Spitz & Saint-Girons 1969), assuming the predator is scarcely selective in its captures (Saint-Girons 1965, 1968, 1973). H¹NM shows lower values at the Mediterranean localities (Fig. 2) and this agrees well with the clear decrease in the number of small mammal species which takes place in the Mediterranean region (Fig. 3). Several hypotheses have been proposed to explain gradients in species diversity and various factors suggested as responsible (cf. Pianka 1966, MacArthur 1972). The present case appears to fulfil the synthetic model of MacArthur (1972).

The reduced diversity of small mammal pop-

ulations in the Mediterranean region is accompanied by a pronounced decrease of the total densities in the field of all species combined (Herrera, unpublished data; Valverde, pers. comm.; all data from southern half of Spain).

As seen above, 'Mediterranean' Barn Owls show a greater trophic diversity than 'temperate' ones, feeding more often upon prey other than mammals. This apparent enlargement of the food dimension of the species niche hypervolume (sensu Vandermeer 1972, Whittaker et al. 1973) which takes place at the southern localities must be interpreted as a predator response compelled by the sharp decrease in

the abundance and diversity of their main prey in European temperate localities (mammals), a shift which seems to take place with even higher intensity in the Mediterranean areas of northern Africa (cf. Valverde 1955, Brosset 1956, Mayaud & Heim de Balsac 1962). It agrees well with some theoretical models predicting 'generalization' of the diet as prey density decreases (MacArthur & Pianka 1966, Schoener 1971), the predator eating a greater diversity of food items. In the present instance, new prey more frequently eaten are birds, reptilians, amphibians and insects, which are of less energy value per individual than small mammals. The mean weight of prey taken by Barn Owls at the Mediterranean stations was 19.57 g ($n=20$ localities, S.D. = 5.68) against 23.60 g ($n=20$, S.D. = 4.33) at the temperate ones, the observed difference being statistically significant ($t=2.43$, $P < 0.05$). If we now consider prey weight as a rough estimate of its nutritional value, 'Mediterranean' owls seem to support themselves on relatively poorer food items. Furthermore, as stated above, small mammal densities are low in these areas. These two facts could account together for the weak population densities attained by the Barn Owl in southern Spain (Herrera, unpublished data), taking into account their high energy requirements and low resistance to starvation (Honer 1963, Marti 1973b).

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REFERENCES

- Brink, F. H. van den 1957. *Die Säugetiere Europas*. Paul Parey, Berlin.
- Brosset, A. 1956. Le régime alimentaire de l'Effraye *Tyto alba* au Maroc Oriental. *Alauda* 24, 161-205.
- Emberger, L., Gaussen, H., Kassar, M. & de Philippis, A. 1963. *Carte bioclimatique de la zone méditerranéenne (Etude écologique de la zone méditerranéenne)*. UNESCO-FAO, Paris and Rome.
- Engels, H. 1972. Kleinsäuger aus Portugal. *Bonn. zool. Beitr.* 23, 79-86.
- Frochot, B. 1967. Reflexions sur les rapports entre prédateurs et proies chez les rapaces. II. L'influence des proies sur les rapaces. *Terre et Vie* 21, 33-62.
- Garzón-Heydt, J. & Castroviejo, S. & J. 1971. Notas preliminares sobre la distribución de algunos micromamíferos en el norte de España. *Säugetierk. Mitteil.* 19, 217-222.
- Graaf, G. de 1960. 'N ontleding van uilklonte van die Nonnetjiesuil *Tyto alba*. *Ostrich* 21, 1-5.
- Guerin, G. 1928. *Régime et croissance de l'Effraye commune en Vendée*. Lechevalier, Paris.
- Heim de Balsac, H. & Beaufort, F. 1966. Régime alimentaire de L'Effraie dans le Bas-Dauphiné. Applications à l'étude des Vertébrés. *Alauda* 34, 309-324.
- Heim de Balsac, H. & Beaufort, F. 1969. Contribution à l'étude des micromammifères du Nord-ouest de l'Espagne (Santander, Asturias, Galice, Leon). *Mammalia* 33, 630-658.
- Herrera, C. M. 1973. *Neomys anomalus* au sud de l'Espagne: nouvelle donnée sur la répartition de cette espèce. *Mammalia* 37, 514-515.
- Herrera, C. M. 1974. Régimen alimenticio de *Tyto alba* en España sudoccidental. *Ardeola* 19, 359-394.
- Honer, M. R. 1963. Observations on the Barn Owl (*Tyto alba guttata*) in the Netherlands in relation to its ecology and population fluctuations. *Ardea* 51, 158-195.
- Hurtubia, J. 1973. Trophic diversity measurement in sympatric predatory species. *Ecology* 54, 885-890.
- Hurtubia, J. & di Castri, F. 1973. Segregation of Lizard niches in the Mediterranean Region of Chile, pp. 349-360 in di Castri, F. & Mooney, H. A. (Eds.) *Mediterranean Type Ecosystems*. Springer-Verlag, Berlin-Heidelberg-New York.
- Lloyd, M. & Ghelardi, R. J. 1964. A table for calculating the 'equitability' component of species diversity. *J. Anim. Ecol.* 33, 217-225.
- MacArthur, R. H. 1955. Fluctuations of animal populations, and a measure of community stability. *Ecology* 36, 533-536.
- MacArthur, R. H. 1972. *Geographical Ecology. Patterns in the Distribution of Species*. Harper & Row, New York.
- MacArthur, R. H. & MacArthur, J. W. 1961. On bird species diversity. *Ecology* 42, 594-598.
- MacArthur, R. H. & Pianka, E. R. 1966. On optimal use of a patchy environment. *Amer. Natur.* 100, 603-609.
- Margalef, R. 1957. La teoría de la información en

- ecología. *Mem. R. Acad. Cien. Ar. Barcelona* 32, 373-449.
- Margalef, R. 1968. *Perspectives in ecological theory*. Chicago Univ. Press, Chicago.
- Marti, C. D. 1973a. Ten years of Barn Owl prey data from a Colorado nest site. *Wilson Bull.* 85, 85-86.
- Marti, C. D. 1973b. Food consumption and pellet formation rates in four owl species. *Wilson Bull.* 85, 178-181.
- Mayaud, N. & Heim de Balsac, H. 1962. *Les Oiseaux du Nord-ouest de l'Afrique*. Lechevalier, Paris.
- Nadal, J. & Palaus, X. 1967. Micromamíferos hallados en egagrópilas de *Tyto alba*. *Publ. Inst. Biol. Apl., Barcelona*, 42, 5-15.
- Niethammer, J. 1956. Insektenfresser und Nager Spaniens. *Bonn. zool. Beitr.* 7, 249-295.
- Niethammer, J. 1960. Über neue Gewöllinhalte rheinischer Schleiereulen (*Tyto alba*). *Decheniana* 113, 99-111.
- Niethammer, J. 1964. Ein Beitrag zur Kenntnis der Kleinsäuger Nordspaniens. *Z. f. Säugetierk.* 29, 193-220.
- Niethammer, J. 1970. Über Kleinsäuger aus Portugal. *Bonn. zool. Beitr.* 21, 89-118.
- Nos, M. R. 1961. Estudio de los ovillos regurgitados por una pareja de *Tyto alba* en la comarca de La Maresma (Prov. de Barcelona). *Misc. Zool.* 1, 139-146.
- Odum, E. P. 1959. *Fundamentals of Ecology*. Saunders, Philadelphia.
- Pianka, E. R. 1966. Latitudinal gradients in species diversity: a review of concepts. *Amer. Natur.* 100, 33-46.
- Pielou, E. C. 1969. *An Introduction to Mathematical Ecology*. Wiley, New York.
- Rey, J. M. 1971. Contribución al conocimiento de la musaraña enana, *Sorex minutus*, en la Península Ibérica. *Bol. R. Soc. Española Hist. Nat. (Biol.)* 69, 153-160.
- Rey, J. M. 1972. Sistemática y distribución del Topillo rojo *Clethrionomys glareolus* Schreber, 1780 (Mammalia, Rodentia) en la Península Ibérica, y descripción de una nueva subespecie: *Clethrionomys glareolus bernisi*, del Sistema Ibérico. *Bol. Est. Cent. Ecol., Madrid* 1, 45-56.
- Rey, J. M. & Landin, A. 1973. Sobre la presencia de *Crocodyrus suaveolens* en el sur de Andalucía. *Bol. R. Soc. Española Hist. Nat. (Biol.)* 71, 9-16.
- Rothkopf, D. 1970. Eine Analyse von Gewöllin der Schleiereule *Tyto alba* aus der Eifel. *Bonn. zool. Beitr.* 21, 63-82.
- Saint-Girons, M.-C. 1965. Notes sur les mammifères de France. IV. Prelevements exercés sur des populations de petits mammifères par la Chouette Effraie, *Tyto alba* (Région de Lyon). *Mammalia* 29, 42-53.
- Saint-Girons, M.-C. 1968. Analyse des fluctuations du régime de L'Effraie *Tyto alba*, dans le département de la Somme (Nord de la France) pendant une pullulation de *Microtus arvalis*. *Acta Soc. Zool. Bohemoslov.* 32, 185-198.
- Saint-Girons, M.-C. 1973. L'âge des micromammifères dans le régime de deux rapaces nocturnes, *Tyto alba* et *Asio otus*. *Mammalia* 37, 439-456.
- Saint-Girons, M.-C. & Spitz, F. 1966. A propos de l'étude des micromammifères par l'analyse des pelotes de rapaces. Interet et limites de la methode. *Terre et Vie* 20, 3-18.
- Schoener, T. W. 1971. Theory of feeding strategies. *Ann. Rev. Ecol. Syst.* 2, 369-404.
- Siegel, S. 1956. *Nonparametric Statistics for the Behavioral Sciences*. McGraw-Hill, New York.
- Spitz, F. & Saint-Girons, M.-C. 1969. Etude de la repartition en France de quelques Soricidae et Microtinae par l'analyse des pelotes de rejection de *Tyto alba*. *Terre et Vie* 23, 246-268.
- Thiollay, J. M. 1968. Le régime alimentaire de nos rapaces: quelques analyses francaises. *Nos Oiseaux* 29, 249-269.
- Valverde, J. A. 1955. Aves de Marruecos español en Julio. *Ardeola* 2, 87-114 and 213-240.
- Valverde, J. A. 1964. Remarques sur la structure et l'évolution des communautés de vertébrés terrestres. I. Structure d'une communauté. II. Rapports entre predateurs et proies. *Terre et Vie* 18, 121-154.
- Valverde, J. A. 1967. *Estructura de una Comunidad Mediterránea de Vertebrados Terrestres*. Cons. Sup. Inv. Cient., Madrid.
- Vandermeer, J. H. 1972. Niche theory. *Ann. Rev. Ecol. Syst.* 3, 107-132.
- Vericad, J. R. 1965. Nuevos datos sobre el contenido de ovillos de lechuza (*Tyto alba*) en Orrius (Maresma, prov. de Barcelona). *Misc. Zool.* 2, 145-147.
- Vericad, J. R. & Meylan, A. 1973. Resultats de quelques piegeages de micromammifères dans le Sud-est de l'Espagne. *Mammalia* 37, 333-341.
- Webster, J. A. 1973. Seasonal variation in mammal contents of Barn Owl castings. *Bird Study* 20, 185-196.
- Whittaker, R. H., Levin, S. A. & Root, R. B. 1973. Niche, habitat and ecotope. *Amer. Natur.* 107, 321-338.
- Zelenka, G. & Pricam, R. 1964. Variations d'effectifs des populations de petits mammifères révélées par le régime alimentaire d'un rapace nocturne. *Terre et Vie* 18, 178-184.

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Appendix I. Localities from which Barn Owl food analyses were taken for this study and values obtained in each of them for the various variables used to assess trophic diversity. (a): Expressed to the nearest 20'. (b): T=temperate type climate, M=Mediterranean type climate. See text on p. 182 for meaning of symbols.

| No. | Locality | Country | Latitude ^(a) | SGG | H'BGG | EBGG | H'NGG | ENGG | SM | H'NM | ENM | Climate ^(b) | Reference |
|-----|-----------------------|---------|-------------------------|-----|-------|-------|-------|-------|----|-------|-------|------------------------|----------------------------|
| 1 | Vlaesrath | Ger. | 51° 20' | 2 | 0.022 | 0.032 | 0.017 | 0.025 | 15 | 1.319 | 0.485 | T | Niethammer (1960) |
| 2 | Morenhoven | " | 50° 40' | 2 | 0.017 | 0.025 | 0.022 | 0.032 | 13 | 1.081 | 0.422 | T | " |
| 3 | Eicks | " | 50° 40' | 2 | 0.042 | 0.061 | 0.038 | 0.055 | 12 | 1.768 | 0.710 | T | " |
| 4 | Eifel | " | 50° | 2 | 0.035 | 0.051 | 0.036 | 0.052 | 18 | 1.842 | 0.635 | T | Rothkopf (1970) |
| 5 | Joches | Fr. | 48° 20' | 6 | 0.151 | 0.084 | 0.218 | 0.121 | 21 | 1.838 | 0.612 | T | Thiollay (1968) |
| 6 | Faute-sur-Mer | " | 46° 20' | 3 | 0.064 | 0.058 | 0.067 | 0.061 | 9 | 0.380 | 0.209 | T | " |
| 7 | ca. Paris | " | 48° 40' | 6 | 0.283 | 0.157 | 0.185 | 0.103 | 12 | 1.673 | 0.604 | T | " |
| 8 | Epernay | " | 49° | 3 | 0.024 | 0.022 | 0.033 | 0.029 | 16 | 2.207 | 0.882 | T | " |
| 9 | La Porte-de-l'Île | " | 46° | 4 | — | — | 0.623 | 0.445 | — | — | — | T | Guerin (1928) |
| 10 | ca. Fontenay | " | 46° | 5 | — | — | 0.943 | 0.589 | — | — | — | T | " |
| 11 | St-Hilaire-des-Loges | " | 46° | 5 | 0.117 | 0.083 | 0.138 | 0.098 | 9 | 1.410 | 0.641 | T | " |
| 12 | Fontenay-le-Comte | " | 46° 20' | 4 | 0.259 | 0.185 | 0.528 | 0.377 | 7 | 1.240 | 0.652 | T | " |
| 13 | Auzay | " | 46° | 2 | 0.029 | 0.042 | 0.040 | 0.057 | 5 | 0.993 | 0.621 | T | " |
| 14 | Chateau de Terreneuve | " | 46° ? | 4 | 0.033 | 0.023 | 0.044 | 0.031 | 9 | 0.990 | 0.450 | T | " |
| 15 | Bois-Volant | " | 46° ? | 4 | 0.206 | 0.147 | 0.271 | 0.193 | 9 | 1.282 | 0.582 | T | " |
| 16 | Bellerive | Switz. | 46° 20' | 2 | 0.090 | 0.130 | 0.094 | 0.137 | 7 | 0.852 | 0.437 | T | Zelenka & Pricam (1964) |
| 17 | Hernance | " | 46° 20' | 2 | 0.016 | 0.023 | 0.018 | 0.027 | 14 | 2.011 | 0.759 | T | " |
| 18 | La Zonette | " | 46° 20' | 1 | 0 | — | 0 | — | 10 | 1.661 | 0.722 | T | " |
| 19 | Messery | " | 46° 20' | 1 | 0 | — | 0 | — | 10 | 1.651 | 0.718 | T | " |
| 20 | Nernier | " | 46° 20' | 2 | 0.013 | 0.019 | 0.015 | 0.022 | 15 | 1.719 | 0.634 | T | " |
| 21 | Epincira | Port. | 39° | 3 | 0.031 | 0.028 | 0.048 | 0.044 | 10 | 1.481 | 0.644 | T | Niethammer (1970) |
| 22 | Rio Maior | " | 39° 20' | 4 | 0.062 | 0.047 | 0.098 | 0.075 | 12 | 1.470 | 0.588 | T | " |
| 23 | Porto Covo | " | 38° | — | — | — | — | — | 9 | 1.538 | 0.631 | M | Engels (1972) |
| 24 | Alcácer | " | 38° 20' | — | — | — | — | — | 8 | 1.022 | 0.491 | M | " |
| 25 | La Roca (Barcelona) | Sp. | 41° 20' | 3 | 0.259 | 0.235 | 0.578 | 0.525 | 7 | — | — | M | Nadal & Palaus (1967) |
| 26 | Sarriá (Barcelona) | " | 41° 20' | 3 | 0.166 | 0.150 | 0.727 | 0.660 | 5 | — | — | M | " |
| 27 | Prat (Barcelona) | " | 41° 20' | 4 | 0.248 | 0.191 | 0.541 | 0.416 | 5 | — | — | M | " |
| 28 | Mollerusa (Lérida) | " | 41° 40' | 4 | 0.132 | 0.094 | 0.350 | 0.250 | 8 | — | — | M | " |
| 29 | Balaguer (Lérida) | " | 41° 40' | 4 | 0.262 | 0.187 | 0.497 | 0.355 | 7 | — | — | M | " |
| 30 | Seo de Urgel (Lérida) | " | 42° 20' | 3 | 0.155 | 0.110 | 0.555 | 0.396 | 9 | — | — | T | " |
| 31 | Orrius (Barcelona) | " | 41° 20' | 4 | 0.269 | 0.202 | 0.495 | 0.380 | 7 | 1.253 | 0.647 | M | Nos (1961), Vericad (1965) |
| 32 | Ramales (Santander) | " | 43° 20' | — | — | — | — | — | 13 | 2.056 | 0.771 | T | Niethammer (1964) |

| | | | | | | | | | | | | | | |
|----|--------------------------|---|---------|---|-------|-------|-------|-------|-------|----|-------|-------|---|-----------------|
| 33 | Lanestosa (Vizcaya) | " | 43° 20' | - | - | - | - | - | - | 15 | 1.680 | 0.623 | T | " |
| 34 | Concha (Vizcaya) | " | 43° 20' | - | - | - | - | - | - | 14 | 1.770 | 0.681 | T | " |
| 35 | La Roca (Badajoz) | " | 39° | 4 | 0.470 | 0.362 | 0.709 | 0.546 | 0.709 | 6 | 1.119 | 0.622 | M | Herrera (1974) |
| 36 | Sanlúcar (Cádiz) | " | 36° 40' | 4 | 0.137 | 0.106 | 0.215 | 0.166 | 0.215 | 6 | 0.294 | 0.163 | M | " |
| 37 | Arcos (Cádiz) | " | 36° 40' | 4 | 0.233 | 0.179 | 0.358 | 0.275 | 0.358 | 7 | 0.645 | 0.333 | M | " |
| 38 | ca. Aznalcázar (Sevilla) | " | 37° 20' | 4 | 0.271 | 0.208 | 0.522 | 0.401 | 0.522 | 6 | 0.693 | 0.384 | M | " |
| 39 | ca. Carmona (Sevilla) | " | 37° 20' | 3 | 0.406 | 0.369 | 0.741 | 0.674 | 0.741 | 7 | 0.622 | 0.320 | M | " |
| 40 | Carmona (Sevilla) | " | 37° 20' | 3 | 0.243 | 0.221 | 0.282 | 0.256 | 0.282 | 7 | 0.738 | 0.380 | M | " |
| 41 | Gerena (Sevilla) | " | 37° 40' | 5 | 0.215 | 0.134 | 0.296 | 0.185 | 0.296 | 7 | 1.552 | 0.783 | M | " |
| 42 | Cabra (Córdoba) | " | 37° 20' | 5 | 0.957 | 0.598 | 1.007 | 0.630 | 1.007 | 7 | 0.927 | 0.468 | M | " |
| 43 | ca. Cabra (Córdoba) | " | 37° 20' | 5 | 0.453 | 0.283 | 0.526 | 0.328 | 0.526 | 9 | 1.380 | 0.627 | M | " |
| 44 | La Carlota (Córdoba) | " | 37° 40' | 4 | 0.448 | 0.344 | 0.911 | 0.701 | 0.911 | 7 | 0.941 | 0.475 | M | " |
| 45 | Belalcázar (Córdoba) | " | 38° 20' | 4 | 0.639 | 0.492 | 0.809 | 0.622 | 0.809 | 6 | 0.823 | 0.456 | M | " |
| 46 | Almodóvar (C. Real) | " | 38° 40' | 4 | 0.660 | 0.508 | 0.753 | 0.579 | 0.753 | 6 | 1.241 | 0.689 | M | " |
| 47 | Jerez (Cádiz) | " | 36° 40' | 5 | 0.594 | 0.371 | 0.907 | 0.567 | 0.907 | - | - | - | M | Valverde (1967) |
| 48 | Doñana (Huelva) | " | 37° | 5 | 0.868 | 0.543 | 1.353 | 0.846 | 1.353 | - | - | - | M | " |