REMARKS ON THE FAUNISTIC DIVERSITY OF THE THYSANURANS (MICROCORYPHIA AND ZYGENTOMA: INSECTA) IN THE EASTERN ATLANTIC ISLANDS

L.F. MENDES

Faculty of Sciences of Lisboa/Portugal, Department of Zoology and Anthropology. Centro de Zoologia of the I.I.C.T. Fellow of the I.N.I.C. / PL2

INTRODUCTION

FISCHER et al (23) were the first ones to investigate faunistic diversity creating an \( E \) index to relate the number of species and subspecies of a zoological group and the number of studied specimens in a certain area. Later, MARGALEFF (25) proposed his \( A \) index which, although theoretically not so correct as the former, is much easier to utilize. Quite similar in their results, these two methods share, however, two negative points: both impose the number of studied specimens (commonly unknown) and both neglect the surface of the analysed area; this last item, seems particularly important when faunistic diversities of countries with very different areas are compared and, particularly, in the case of islands -see also (24). This same problem, led RIBEIRO to investigate (52) and to apply (53) a new \( d \) index, calculated by the formula

\[
d = \frac{E - 1}{\log_e (A + 1)}
\]

being \( E \) the number of studied taxa, \( A \) the analysed area and \( e \) the base of the natural logarithms.

METHODS

Trying to apply this last index to the thysanuran faunas of the eastern Atlantic islands, I faced a further problem: is the area \( A \) the addition of the individual areas of all the islands of each archipelago or will it be the total area covered by the archipelago? The problem seems more evident when we try to compare "short" or "compact" archipelagoes (like the Madeira--Porto Santo--Desertas), with isolated islands (as St. Helena or Fernando Poo) and "diffuse" archipelagoes (like the Azores). So, as this problem concerns directly the effect of area, I propose to utilize a close but distinct formula, similar to that of RIBEIRO but which, I believe, will "soften" the problem. In this new \( d' \) index I propose to work with both areas, \( A \), the surface of the terra firme (the sum of the individual island areas) and \( A' \), the surface of the archipelago as a whole, as follows:

\[
d' = \frac{E - 1}{\log_e \left( \frac{A + A'}{2} + 1 \right)}
\]

This new index is reduced to its original form when isolated islands (v.g. St. Helena, Principe, S.Thome) are investigated.

In this paper, diversity indexes are calculated independently to MICROCORPHYA and to ZYGENTOMA (quite distinct groups in the phylogenetic but also in the ecological point of view). Two indexes are, further, calculated to each one of these Orders, one concerning the total number of known taxa, the other the probably autochthon species only --excluding, then, the cosmopolitan and tropicopolitan species and the obviously introduced taxa. To each one of the studied archipelagoes, we will present the following four indexes: \( \text{RIBEIRO} \), the modified RIBEIRO index to the total MICROCORPHYA which number of species.
is EM; $\delta'M$, the modified RIBEIRO index to the probably autochthon MICRO-
CORYPHIA, which number of known species is $E'M - \frac{Z}{2}$. The modified RIBEIRO
index to the ZYGENTOMA, being its number of species $E'Z$ and $\delta'Z$, the modified
RIEIRO index to the non introduced ZYGENTOMA, which number of spe-
cies is $E'Z$.

RESULTS
Subsequently, the known thysanuran faunas of MICROCORYPHIA and ZYG-
GENTOMA in the eastern Atlantic islands are presented (TABLES 1 and 2).

<table>
<thead>
<tr>
<th>Species</th>
<th>Madeira (1)</th>
<th>Porto Santo</th>
<th>Desertas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machilinus kleinenbergi</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Machilinus portosantensis</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Machilinus rupestris sp.</td>
<td>-</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td>Neomachilellus gestroi</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Pseudomeinertellus fess</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Pseudomeinertellus gretwelli</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Pseudomeinertellus snowi</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Dilta altai</td>
<td>-</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td>Dilta hybernica</td>
<td>-</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td>Dilta insulicola</td>
<td>-</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td>Dilta littoralis</td>
<td>-</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td>Dilta saxicola</td>
<td>-</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td>Janetschekilis dolichopsis</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Janetschekilis grandpalpus</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Lepismachilis sp. (?)</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Metagrapheitarsus doriae</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Parapetarbius aroricus</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
<tr>
<td>Petrobius brevistyli</td>
<td>A</td>
<td>A</td>
<td>A*</td>
</tr>
<tr>
<td>Petrobius maritimus</td>
<td>A</td>
<td>A</td>
<td>A*</td>
</tr>
<tr>
<td>Trigoniophthalmus alternatus</td>
<td>-</td>
<td>-</td>
<td>A*</td>
</tr>
</tbody>
</table>

TOTAL: 1A 4A 5A 7A 2A 3A 7A 2A 1A 4A

TABLE 1 - Known distribution of the species of MICROCORYPHIA in the eastern Atlantic
islands. A- Probably autochthon species; A* - Endemics; B- Almost certainly
introduced species. (MADEIRA (1) = Porto Santo + Desertas).

None data are available from the following islands, where no thysanurolo-
gical prospections have been made: Ano Bom (=Pagalu), in the Guinea Gulf,
where some species must be found in the future; Ascension, very wide apart
from the African and the Brazilian coasts, where, as it happens with St. Helena,
a few species might be present; Tristan da Cunha, Gough and Bouvet, where,
due to their geographical isolation and known climate, we believe quite probab-
ly that none species (with the eventual exception of synanthropic introduced
Acrotelsa collaris
Afrolepisma wygodzinskyi
Ctenolepsima ciliata
Ctenolepsima diversisquamis
Ctenolepsima dubitalis
Ctenolepsima feae
Ctenolepsima lindbergi
Ctenolepsima lineata
Ctenolepsima longicaudata
Ctenolepsima sancintaeheleena
Ctenolepsima unistyla
Ctenolepsima vieirai
Ctenolepsima sp. 1
Lepisma saccharina
Monachina stylifera ssp.
Neosterolep. myrmecobia
Neosterolep. pelagodromae
Neosterolepsima sp. 1
Prolepsismina pulchella
Thermobia aegyptiaca
Therbobia domestica
Gastrotheus seticeps
Gastrotheus brachyurus
Gastrotheus nanus
Grassiella modesta
Luratea aequatorialis
Oarthroceria brevicauda
Proatelurina pseudolepisma
Santhomesiella thomensis
Hematelura gestroi
Subnicolecia feae

TOTAL

18 28 38 2A+ 2A+ 3A+ 3A+ 3A 5A+ 2A+ 28 18 18 88 28 38

TABLE 2 - Known distribution of the species of ZYGENTOMA in the eastern Atlantic islands.

A, A*, B, B* and MADEIRA (1) as in TABLE 1.

populations) would occur. The faunas of the remaining archipelagos are more or less well known, with the exceptions of those from Fernando Po and Principe.

20 species of MICROCTERYPHIA (fam. Meinerteliidii and Nacillidae) and 31 species of ZYGENTOMA (fam. Lepismatidae, Atelundae and Nicoletiidae) are known to occur in the studied insular entities; these data have been obtained through the following origins: to ICELAND (59); to IRELAND (9)(10)(11)(12)(13)(14)(15)(16)(17)(18)(19)(22)(27)(28)(42)(45)(50)(51)(62)(63);
to the AZORES (26)(31)(36)(36)(56)(64)(69); to MADEIRA+PORTO SANTO+DESERTAS
(Q4X39X30X45X47); to the SALVAGES (29X31X36); to the CANARIES (2X31X43) (44X45X65X64X65X68); to CAPE VERDE (21X31X32X33X34X35X44X57X67); to FERNANDO POO (57); to PRINCIPE (57); to S. THOME (37X38X39X40X57X66); and to ST. HELENA (30X70).

In TABLE 3 are exposed the values of terra firma area (A) and of the total area (A') of each one of the archipelagoes (or isolated islands) and also the result of the natural logarithm calculated upon these two surfaces. The approximate distance to the nearest mainland and the probable age are also presented. RELAND and GREAT BRITAIN excluded as these islands are part of the eurasian shield and have been, in quite recent times, in direct connection with

<table>
<thead>
<tr>
<th>Island</th>
<th>A (km²)</th>
<th>A' (km²)</th>
<th>( \log_e \frac{A+e}{2} )</th>
<th>Age (MY)</th>
<th>Distance to mainland</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICELAND</td>
<td>102 828</td>
<td>102 828</td>
<td>4.633</td>
<td>20</td>
<td>400 Km (Greenland)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>800 Km (N.England)</td>
</tr>
<tr>
<td>IRELAND</td>
<td>84 419</td>
<td>84 419</td>
<td>11.344</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GREAT BRITAIN</td>
<td>230 000</td>
<td>230 000</td>
<td>12.346</td>
<td></td>
<td>1 650 (Portugal)</td>
</tr>
<tr>
<td>AZORES</td>
<td>2 304</td>
<td>53 704</td>
<td>12.824</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MADEIRA (1)</td>
<td>781</td>
<td>5 170</td>
<td>7.998</td>
<td>90</td>
<td>600 (Marocco)</td>
</tr>
<tr>
<td>CANARIES</td>
<td>8</td>
<td>45</td>
<td>3.211</td>
<td>32</td>
<td>345 (Marocco)</td>
</tr>
<tr>
<td>SALVAGES</td>
<td>7 484</td>
<td>97 500</td>
<td>10.868</td>
<td>32</td>
<td>115 (Marocco)</td>
</tr>
<tr>
<td>CAPE VERDE</td>
<td>4 023</td>
<td>63 112</td>
<td>10.421</td>
<td>120</td>
<td>600 (Senegal)</td>
</tr>
<tr>
<td>FERNANDO POO</td>
<td>2 017</td>
<td>2 017</td>
<td>7.610</td>
<td>120</td>
<td>30 (Nigeria-Kameroo)</td>
</tr>
<tr>
<td>PRINCIPE</td>
<td>114</td>
<td>114</td>
<td>4.695</td>
<td>120</td>
<td>215 (Rio Muni-Kameroo)</td>
</tr>
<tr>
<td>S. THOME</td>
<td>857</td>
<td>857</td>
<td>6.755</td>
<td>120</td>
<td>280 (Gaboon)</td>
</tr>
<tr>
<td>ST. HELENA</td>
<td>123</td>
<td>123</td>
<td>4.416</td>
<td>20</td>
<td>1 850 (Namibia-Angola)</td>
</tr>
</tbody>
</table>

TABLE 3: Areas, ages and distances to nearest mainland of the eastern atlantic islands. A, A' and e according to the text. (MADEIRA (1) = Madeira+Porto Santo+Desertas)

<table>
<thead>
<tr>
<th>Island</th>
<th>( E_M )</th>
<th>( E'_M )</th>
<th>( \delta'_M )</th>
<th>( \delta'_M )</th>
<th>( E_Z )</th>
<th>( E'_Z )</th>
<th>( \delta'_Z )</th>
<th>( \delta'_Z )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICELAND</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IRELAND</td>
<td>4</td>
<td>4</td>
<td>0.265</td>
<td>0.265</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GREAT BRITAIN</td>
<td>5</td>
<td>5</td>
<td>0.324</td>
<td>0.324</td>
<td>2</td>
<td>0</td>
<td>0.080</td>
<td>0</td>
</tr>
<tr>
<td>AZORES (*)</td>
<td>3</td>
<td>3</td>
<td>0.195</td>
<td>0.195</td>
<td>3</td>
<td>0</td>
<td>0.195</td>
<td>0</td>
</tr>
<tr>
<td>MADEIRA (1)</td>
<td>2</td>
<td>2</td>
<td>0.125</td>
<td>0.125</td>
<td>4</td>
<td>2</td>
<td>0.375</td>
<td>0.125</td>
</tr>
<tr>
<td>SALVAGES</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0.610</td>
<td>0.305</td>
</tr>
<tr>
<td>CANARIES</td>
<td>3</td>
<td>3</td>
<td>0.184</td>
<td>0.184</td>
<td>4</td>
<td>3</td>
<td>0.276</td>
<td>0.184</td>
</tr>
<tr>
<td>CAPE VERDE</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>8</td>
<td>1.439</td>
<td>0.672</td>
</tr>
<tr>
<td>FERNANDO POO</td>
<td>2</td>
<td>2</td>
<td>0.131</td>
<td>0.131</td>
<td>3</td>
<td>3</td>
<td>0.263</td>
<td>0.263</td>
</tr>
<tr>
<td>PRINCIPE</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. THOME</td>
<td>4</td>
<td>4</td>
<td>0.444</td>
<td>0.444</td>
<td>11</td>
<td>9</td>
<td>1.480</td>
<td>1.184</td>
</tr>
<tr>
<td>ST. HELENA</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>0.831</td>
<td>0.208</td>
</tr>
</tbody>
</table>

TABLE 4: Number of known species of total and autochthon MICROCHORDATA (\( E_M \) and \( E'_M \)) and of ZYGENTOMA (\( E_Z \) and \( E'_Z \)) in the eastern atlantic islands and \( \delta'_Z \) diversity indexes. (*) If Olita and Lepismachilis spp. are considered as introduced, the 8 indexes will be reduced to 6. MADEIRA (1) = Madeira+Porto Santo+Desertas
the neighbouring continental areas. These values are based in \((7 \times 20) / (55 \times 58)\) and (60).

**DISCUSSION**

TABLE 4 shows the calculated values of \(\sum^i\) to the total and to the probably autochthon species of MICROCRYPHIA and of ZYGENTOMA in the analysed insular entities. With the exception of CAPE VERDE where the unique signalized Meinertellidae (Machilinus \(\text{?} kleinenbergii\)), noticed only once (57) correspond, if correctly determined, to an obvious introduction, all the remaining data corresponding to the other islands show the PIICROCORYPHIA as almost certainly autochthon species and, so, \(\sum^i\) and \(\sum^j\) are identical. Among the ZYGENTOMA, only FERNANDO PÔO (poorly prospected, only once) shows both indexes with the same value.

The calculated faunistic diversities seem, moreover, quite low in the great majority of the analysed situations and three different cases can be considered: 1) ICELAND, with all the calculated \(\sum^i\) index, is a volcanic isolated young island which has been linked with the northern Holoarctic mainlands by an ice cap during the last glaciations. 2) IRELAND and GREAT BRITAIN, also partially connected with continental Europe during the ice ages, are continental islands and have been —as noticed— connected by dry land with central—northern Europe; none ZYGENTOMA is autochthon and the local PIICROCORYPHIA are the same of the neighbouring continental areas. 3) All the remaining islands are oceanic, with volcanic origin and, with the eventual exception of the most oriental CANARIES, have never been connected to mainland. Those globally known as Macaronesia, are situated in the way of the Gulf Stream; AZORES, in its northern area, the younger and the most isolated islands, are associated with the NW–SE main stream which comes from Labrador and Newfoundland. MADEIRA, SALVAGES, CANARIES and CAPE VERDE are in the way of a special sub-stream, the N–S cold Canaries Stream. The Guinea Gulf islands, quite distinct each other on the faunistic point of view, are part of the Cameroon Ridge and appear as the tops of several submarine mountains. Among these islands, only S. THOME is more or less well prospected. S. HELENA, isolated and young, lies in the SE–NW course of the cold Benguela Stream. The probably autochthon thysanuran faunas of all these islands (considered under point 3) seem more or less clearly related to those from the continental areas close to the origin of the marine streams which flow around the islands.

The obtained \(\sum^i\) indexes (see TABLE 4) show quite low values (particularly those concerning the PIICROCORYPHIA with the exception of S. THOME, with 4 endemic Meinertellidae). CANARIES, with \(\sum^i = 0.184\), is certainly much more diverse as shown by non-published material.

In what the ZYGENTOMA are concerned, ICELAND, GREAT BRITAIN, IRELAND and AZORES—the most northern insular entities—show nule values of \(\sum^i\); the same happens in PRÍNCIPE island where further studies shall show the occurrence of several further species, albeit they have never been studied.

The maximal obtained \(\sum^j\) values, are attained in two different insular entities, though due to quite distinct reasons: the indexes of 1.493 (CAPE VERDE) and of 1.480 (S. THOME), are the result of the presence of 16 and 11 species (total number) in each one of these geographical entities; however, in CAPE VERDE most of the species are non-autochthon and, so, the calculated \(\sum^j\) to these islands is reduced to 0.672 only; in S. THOME, with very few introduced species, this last index attains 1.184.

For comparison only, it must be said that the maximum values obtained to the MICROCRYPHIA have been calculated to SPAIN, with \(\sum^i = 4.727\) and that the maximum values to the ZYGENTOMA have been calculated to SOUTHERN AFRICA (NAMIBIA included), with \(\sum^j = 5.125\) and with \(\sum^j = 4.990\); all these values seem clearly lower than those calculated, for instance,
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