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

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INTRODUCTION

FISCHER ~~et al~~ *(23)* were the first ones to investigate faunistic diversity creating an α 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 Δ 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 problems, led RIBEIRO to investigate *(52)* and to apply *(53)* a new δ index, calculated by the formula

$$\delta = \frac{E - 1}{\log_e(A + 1)}$$

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" archipelogoes (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 δ' 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:

$$\delta' = \frac{E - 1}{\log_e\left(\frac{A + A'}{2} + 1\right)}$$

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 MICROCORYPHIA 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: $\delta'M$, the modified RIBEIRO index to the total MICROCORYPHIA which number of species is EM; $S'M1$, the modified RIBEIRO index to the probably autochthon MICROCORYPHIA, which number of known species is E'M; $S'Z$, the modified RIBEIRO index to the ZYGENTOMA, being its number of species EZ and $S'Z1$, the modified RIBEIRO index to the non introduced ZYGENTOMA, which number of species is E'Z.

RECULTC

Subsquently, the known thysanuran faunas of MICROCORYPHIA and ZYGENTOMA in the eactern atlantic islands are presented (TABLES 1 and 2).

	ICELAND	IRELAND	GREAT BRITAIN	AZORES	MADEIRA (1)	SALVAGES	CANARIES	CAPE VERDE	FERNANDO POO	PRINCIPE	S. THOME	ST. HELENA
Machilinus ?kleinenbergi	-	-	-	-	-	-	-	B	-	-	-	-
Machilinus portosantensis	-	-	-	-	A*	-	-	-	-	-	-	-
Machilinus rupestris ssp.	-	-	-	-	-	-	A	-	-	-	-	-
?Neomachilellus? gestroi	-	-	-	-	-	-	-	-	-	-	A*	-
Pseudomeinertellus feae	-	-	-	-	-	-	-	-	-	-	A*	-
Pseudomeinertellus gradweli	-	-	-	-	-	-	-	-	-	-	A*	-
Pseudomeinertellus snowi	-	-	-	-	-	-	-	-	-	-	A*	-
Oilta altenai	-	-	-	-	-	-	A	-	-	-	-	-
Dilta hybernica	-	A	A	-	-	-	-	-	-	-	-	-
Dilta insulicola	-	-	-	-	A	-	A	-	-	-	-	-
Dilta littoralis	-	-	A	-	-	-	-	-	-	-	-	-
Dilta saxicola	-	A	-	?A	-	-	-	-	-	-	-	-
Janetschekilis dolichopsis	-	-	-	-	-	-	-	-	-	A*	-	-
Janetschekilis grandipalpus	-	-	-	-	-	-	-	-	A*	-	-	-
Lepismachilis ssp.(?)	-	-	-	?A	-	-	-	-	-	-	-	-
Metagraphitarsus doriae	-	-	-	-	-	-	-	-	A*	-	-	-
Parapetrobius aroricus	-	-	-	A*	-	-	-	-	-	-	-	-
Petrobius brevistylis	A	A	A	-	-	-	-	-	-	-	-	-
Petrobius maritimus	-	A	A	-	-	-	-	-	-	-	-	-
Trigoniophthalmus alternatus	-	-	A	-	-	-	-	-	-	-	-	-
TOTAL	1A	4A	5A	?3A	2A	-	3A	?1B	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 t Desertas).

None data are available from the following islands, where no thysanurological prospections have been camed: Ano Bom (=Pagalu), in the Guinea Gulf, where some speciec muct 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 beiieve quite probably that none species (with the eventual exception of synanthropic introduced po

	ICELAND	IRELAND	GREAT BRITAIN	AZORES	MADEIRA (1)	SALVAGES	CANARIES	CAPE VERDE	FERNANDO POO	PRINCIPE	S. THOME	S. HELENA
Acrotelsa collaris	-	-	-	-	-	-	-	B*	-	-	B*	-
Afrolepisma wygodzinskyi	-	-	-	-	-	-	-	-	-	-	-	A*
Ctenolepisma ciliata	-	-	-	-	-	-	A	?A	-	-	-	-
Ctenolepisma diversisquamis	-	-	-	-	-	-	-	?A	-	-	-	-
Ctenolepisma dubitalis	-	-	-	-	-	-	-	B	-	-	-	-
Ctenolepisma feae	-	-	-	-	-	-	-	A	-	-	-	-
Ctenolepisma lindbergi	-	-	-	-	-	-	-	A*	-	-	-	-
Ctenolepisma 1ineata	-	-	-	-	-	A	A	A	-	-	-	-
Ctenolepisma longicaudata	-	-	-	B*	B*	B*	-	B*	-	-	-	B*
Ctenolepisma sanctaehelenae	-	-	-	-	-	-	-	-	-	-	-	A*
Ctenolepisma unistila	-	-	-	-	-	-	-	A*	-	-	-	-
Ctenolepisma vieirai	-	-	-	-	A*	-	-	-	-	-	-	-
Ctenolepisma sp. 1	-	-	-	-	-	-	-	-	-	-	A*	-
Lepisma saccharina	B*	-	B*	B*	B*	-	B*	B*	-	-	-	B*
Monachina stylifera ssp.	-	-	-	-	-	-	-	B*	-	-	-	-
Neosterolep. myrmecobia	-	-	-	-	A	-	A	A	-	-	-	-
Neosterolep. pelagodromae	-	-	-	-	-	A*	-	-	-	-	-	-
Neosterolepisma sp. 1	-	-	-	-	-	-	-	-	-	-	A*	-
Prolepismina pulchella	-	-	-	-	-	-	-	?B	-	-	-	-
Thermobia aegyptiaca	-	-	-	-	-	-	-	B	-	-	-	-
Therbobia domestica	-	-	B	-	-	-	-	-	-	-	-	-
Gastrotheus seticeps	-	-	-	-	-	-	-	A	-	-	A	-
Gastrotheus brachyurus	-	-	-	-	-	-	-	-	-	-	A	-
Gastrotheus nanus	-	-	-	-	-	-	-	B	-	-	B	B
Grassiella modesta	-	-	-	-	-	-	-	-	A	-	A	-
Luratea aequatorialis	-	-	-	-	-	-	-	-	-	-	A*	-
Olarthrocera brevicauda	-	-	-	-	-	-	-	-	A*	-	-	-
Proatelurina pseudolepisma	-	-	-	B	-	-	-	-	-	-	-	-
Santhomesiella thomensis	-	-	-	-	-	-	-	-	-	-	A*	-
Hematelura gestroi	-	-	-	-	-	-	-	-	A	-	A	-
Subnicoletia feae	-	-	-	-	-	-	-	-	-	-	A*	-
TOTAL	1B		2B	3B	2A+ 2B	2A+ 18	3At 18	8A+ 8B	3A		9A+ 2B	2A+ 38

TABLE 2 - Known distribution of the species of ZYGENTOMA in the eastern atlantic islands. A, A*, B, B* and HAOEIRA (1) as in TAELE 1.

pulations) would occur. The faunas of the remaining archipeiagoes are more or less well known, with the exceptions of those from Fernando Poo and Principe.

20 species of MICROCORYPHIA (fam. Meinerteiiidae and Machilidae) 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)(18)(63); to GREAT BRITAIN (3)(5)(8)(12)(13)(14)(15)(17)(18)(19)(22)(27)(28)(42)(45)(50)(51)(62)(63); to the AZORES (26)(31)(41)(56)(64)(69); to MADEIRA+PORTO SANTO+DESERTAS

(1)(4)(29)(31)(45)(47); to the SALVAGES (29)(31)(36); to the CANARIES (2)(3)(31)(43)(44)(45)(46)(54)(64)(65)(68); to CAPE VERDE (21)(31)(32)(33)(34)(35)(44)(57)(67); to FERNANDO POO *(57);* to PRINCIPE *(57);* to S. THOME (37)(38)(39)(40)(57)(66); and to ST. HELEKA (30)(70)

In TABLE *3* are exposed the values of terra firme 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, IRELAND and GREAT BRITAIN excluded as these islands are part of the eurasian shield and have been, in quite recent times, in direct connection with

	A (Km^2)	A' (Km^2)	$\log_e(\frac{A+A'}{2}+1)$	AGE (MY)	Oistance to mainland
ICELANO	102 828	102 828	4.633	20	400 Km (Greenland) 800 Km (N.England)
IRELAND	84 419	84 419	11.344	---	• continental isl. •
GREAT BRITAIN	230 000	230 000	12.346	---	• continental isl. •
AZORES	2 304	53 704	10.240	20	1'650 (Portugal)
MAOEIRA (1)	781	5 170	7.998	90	600 (Marocco)
SALVAGES	8	45	'3.211	32	345 (Marocco)
CANARIES	7 484	97 500	10.868	32	115 (Marocco)
CAPE VERDE	4 023	63 112	10.421	100	600 (Senegal)
FERNANDO POO	2 017	2 017	7.610	120	30 (Nigeria-Kameroon)
PRINCIPE	114	114	4.745	120	215' (Rio Muni-Kameroon
S. THOME	857	857	6.755	120	280 (Gaboon)
ST. HELENA	123	123	4.816	20	1 850 (Namibia-Angola)

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

	E_M	E'_M	δ'_M	δ'_{M1}	E_Z	E'_Z	δ'_Z	δ'_{Z1}
ICELANO	1	1	0	0	1	0	0	0
IRELANO	4	4	0.265	0.265	0	0	0	0
GREAT BRITAIN	5	5	0.324	0.324	2	0	0.080	0
AZORES (*)	3	3	0.195	0.195	3	0	0.195	0
MAOEIRA (1)	2	2	0.125	0.125	4	2	0.375	0.125
SALVAGES	0	0	0	0	3	2	0.610	0.305
CANARIES	3	3	0.184	0.184	4	3	0.276	0.184
CAPE VERDE	1	0	0	0	16	8	1.439	0.672
FERNANDO POO	2	2	0.131	0.131	3	3	0.263	0.263
PRINCIPE	1	1	0	0	0	0	0	0
S. THOME	4	4	0.444	0.444	11	9	1.480	1.184
ST. HELENA	0	0	0	0	5	2	0.831	0.208

TABLE 4 - Number of knoun species of total and autochthon HICROCORYPHIA (E_M and E'_M) and of ZYGENTOMA (E_Z and E'_Z) in the eastorn atlantic islands and δ' diversity fndexes. (*) If Oilta and Lepismachilis ssp. are considered os introduced, the δ indexes will be reduced to 0. MAOEIRA (1) = Madeira+Porto Santo+Desertas

the neighbouring continental areas. These values are based in (7)(20)(55)(58) and (60).

DISCUCSION

TABLE *4* shows the calculated values of δ' to the total and to the probably autochthon species of MICROCORYPHIA and of ZYGENTOMA in the analysed insular entities. With the exception of CAPE VERDE where the unique signalized Meinertellidae (Machilinus ? kleinenbergi), 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, $\delta'M$ and $\delta'M1$ are identical. Among the ZYGENTOMA, only FERNANDO POO (poorly prospected, only once) shows both δ' 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 δ' indexer nule, 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 substream, 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 this islands, only S. THOME is more or less well prospected.ST. 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 δ' indexes (see TABLE *4)* show quite low values (particularly those concerning the PIICROCORYPHIA with the exception of S. THOME, with *4* endemic Meinertellidae). CANARIEC, with $\delta'M$ *= 0.184,* is certainly much more diverse as shown by non-published material.

In what the ZYGENTOPIA are concerned, ICELAND, GREAT BRITAIN, IRELAND and AZORES -the most northern insular entities- show nule values of δ'; the same happens in PRIKCIPE island where further studies shall show the occurrence of several further species, albeit they have never been studied.

The maximal obtained $\delta'Z$ values, are attained in two different insular entities, though due to quite distinct reasons: the indexes of *1.439* (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 $\delta'Z1$ to these islands is reduced to *0.672* only; in S. THOME, with very few introduced species, this last index attains *1.184.*

For comparation only, it must be said that the maximum values obtained to the MICROCORYPHIA have been calculated to SPAIN. with $\delta'M$ = $\delta'M1$ = *4.727* and that the maximum values to the ZYGENTOMA have been calculated to SOUTHERN AFRICA (NAMIBIA included), with $\delta'Z$ = 5.125 and with $\delta'Z1$ = *4.990;* all these values seem clearly lower than those calculated, for instance, to the mosquitoes (52)(53).

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