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EVOLUTION AND DIVERSITY OF AUCHENORRHYNCHA IN ATLANTIC ISLAND BIOTAS

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ABSTRACT

After present available data, a synoptic view on the diversity of Atlantic Auchenorrhyncha is given. Statistical analyses of different diversity parameters and several influencing parameters were done, proving the importance of island areas, their habitat diversity, and the diversity of vascular plants as a key resource for Auchenorrhyncha. Multivariate plots show some of these factors acting together. Species-genera quotients were calculated to examine contributions of evolutionary events resulting in speciation to species richness. Species numbers of archipelagos are also influenced by their island numbers offering possibilities for allopatric growths of island taxa. Continental distances of biotas shelter a filter function in taxonomic diversity.

KEY WORDS

Auchenorrhyncha, diversity, Atlantic islands, island areas, ecological diversity, resource diversity, speciation.

INTRODUCTION

Research on Auchenorrhyncha in Atlantic island biotas was done already at the beginning of this century, and was intensified during its second half. To supplement a short review of papers in SERGEL 1986b, here are added the publications of FRISTRUP 1945, LINNAVUORI 1974, QUARTAU 1975,1979,1981, 1982, R. REMANE & ASCHE 1986, R. REMANE & HOCH 1986.

The investigation on Atlantic Auchenorrhyncha taxa and their communities is far from being complete. But nevertheless, the present knowledge enables to give a synopsis of the Auchenorrhynchous diversity in these biotas and factors influencing it, as well as of some evolutionary patterns.

DIVERSITY OF AUCHENORRHYNCHA

The Filter Function of Continental Distance

The taxonomic diversity of Atlantic Auchenorrhyncha is influenced by the filter function of the continental distance of the different biotas. This is illustrated in fig. 1 for three Auchenorrhyncha families, where their spread potentials are related to the continental distances of colonized archipelagos. For calculating mathematical values of spread potentials, the formula presented by LESTON 1957 was used: $SP_t = 100 \sum(s_{it}+s_{pt})n_k \; / \; \sum(s_{ik}+s_{pk})n_i$, where s = number of

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species, n = number of islands / archipelagos, t = taxon under investigation, k = standard taxon, i = immigrant species, p = prototype species. By this, the diversity of higher taxa of e.g. family levels decreases in the Macaronesian archipelagos with continental distance: the Canaries are colonized by 8 Auchenorrhyncha families, whereas the Azores by 5.

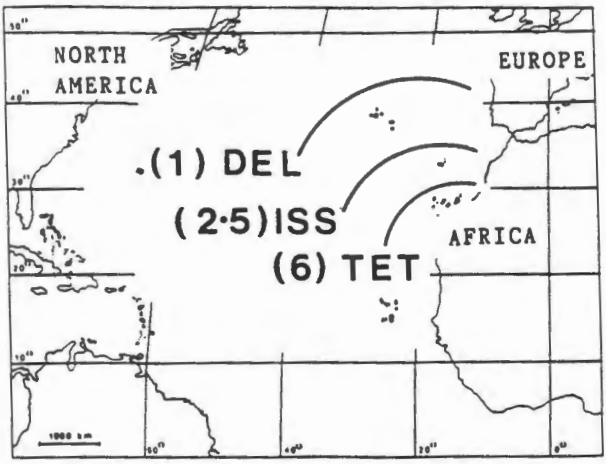

Fig. 1 - The filter function of continental distance in taxonomic diversity of Atlantic Auchenorrhyncha in relation to their spread potential: for three fulgoroid families, the reached one of the central Macaronesian archipelagos is marked. In parentheses, spread potential ranks of the families are given (as mean values for central Macaronesian archipelagos). Groups showing the highest spread potential have colonized the archipelagos situated most distantly from continents.
DEL - Delphacidae, ISS - Issidae, TET - Tettigometridae.

Species Richness of Biotas and Its Statistics

A synoptic summary of recorded species numbers is given in fig. 2, showing clearly the differences in species richness of the Atlantic islands. To prove the obvious influence of latitudinal gradients in species diversity of Palaearctic Auchenorrhyncha (SERGEL, in press) also on island biotas, Iceland was added to the data of the other archipelagos belonging to the Macaronesian region.

Considered the Macaronesian islands, statistical analyses show different environmental factors to influence the species richness of Auchenorrhyncha (table 1).

The species numbers of Auchenorrhyncha (SAUC) in the island biotas are related to sizes of areas (a). Statistical support is given by regressions for the Macaronesian archipelagos ($r=0.94$) and the Western Canary Islands ($r=0.93$, $r=0.88$), also for the Azores ($r=0.98$, QUARTAU 1982). For the Canaries, this

Table 1 - Some diversity parameters of Atlantic Auchenorrhyncha as function of different parameters and its statistics, stand 1987. Data after several authorities. Abbrevations explained in text.

function	biogeographic unit	r	p
log SAUC = f (log a)	Canaries without L,F	0.88	2.5
log SAUC = f (log a)	Canaries with L,F	0.51	12
SAUC = f (a)	Canaries without L,F	0.93	1
SAUC = f (a)	Canaries with L,F	0.64	6
log SAUC = f (log a)	Macaronesian archipelagos + Selvage Is.	0.94	1
SAUC = f (SAUC/GAUC)	Canaries	0.77	2
SAUC = f (ed)	Canaries	0.71	3.5
SAUC/GAUC = f (a)	Canaries without L,F	0.77	6
SAUC/GAUC = f (a)	Canaries with L,F	0.69	4
SAUC/GAUC = f (ed)	Canaries	0.47	15
SAUC = f (SVP)	Canaries	0.93 (rank)	<0.001
SIS = f (ed)	Canaries	0.97	<0.01
SAUC = f (a)	Azores	0.98	0.01

function loses significance if the ecologically poor two Eastern Islands (L,F) are included (r=o.64, r=o.51). For the West Canarian island group, the available data in this relation are better fitted by a non-log function than by a log-function.

There is also some evidence for species numbers being related to ecological diversity (ed) of the biotas, for the all Auchenorrhyncha level (r=0.71), as well as for a tested generic level (issid planthopper genus Issus (SIS), r=0.97) on the Canary Islands, and for Auchenorrhyncha species numbers being related to the number of vascular plant species (SVP, r=0.93).

Moreover, some relation of species richness to the species number/genera number quotient is supported by the data (r=0.77). There can be found some tendency for this quotient to be related to areas (Canaries without L,F: r=o.77, whole archipelago: r=0.69), whereas a plot against ecological diversity of islands shows an r-value of 0.47.

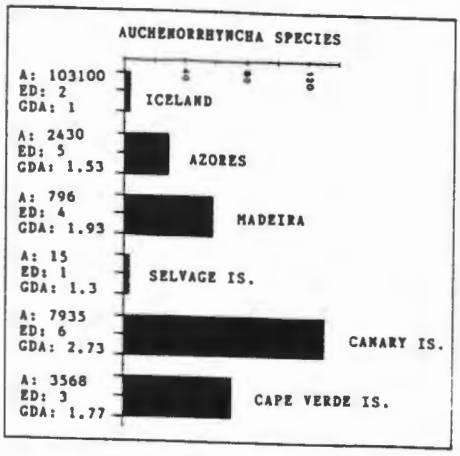

Fig. 2 - Species richness of Auchenorrhyncha in several Atlantic island biotas. Given also values of biotas' areas (A)*, ecological diversity (ED), and species/genera quotients of Auchenorrhyncha (GDA). *km^2

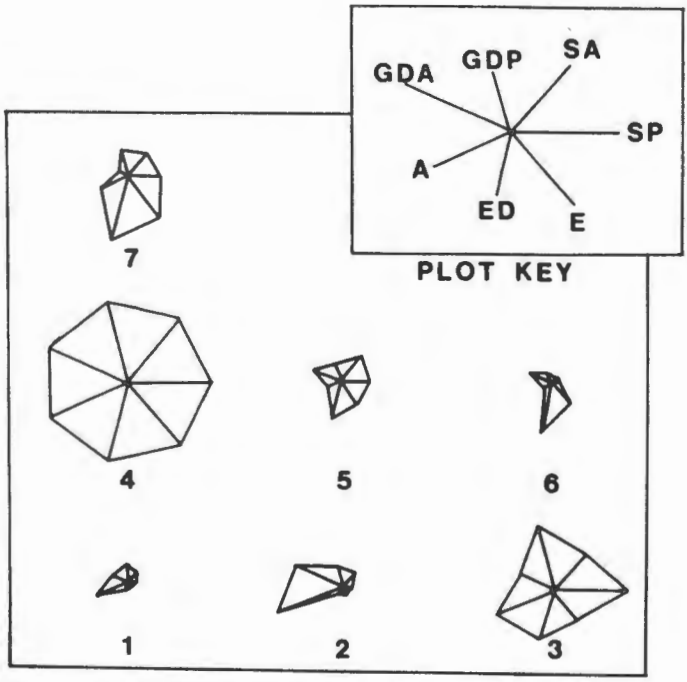

Fig. 3 - Parameters inluencing the diversity of Auchenorrhyncha on the Canary Islands: multivariate star symbol computer plot considering 7 data vectors. SA - species richness Auchenorrhyncha; SP - species richness vascular plants; GDA - species / genera quotient Auchenorrhyncha; GDP - species / genera quotient vascular plants; A - island areas; ED - ecological diversity; E - elevation.

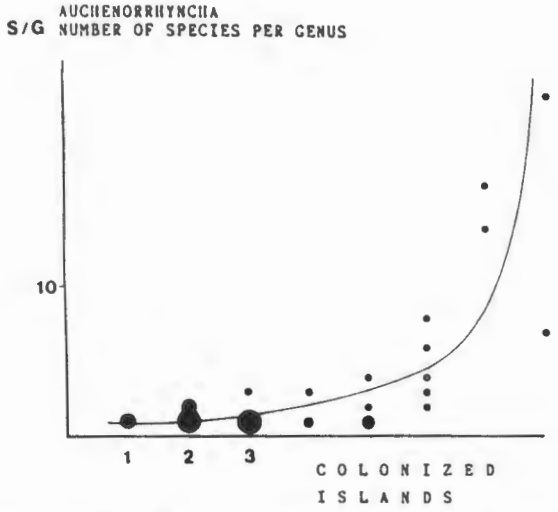

Fig. 4 - Species richness of Auchenorrhyncha genera of Macaronesian island biotas plotted against number of islands colonized by the genera.

A multivariate computer plot done with data for the Canary Is. shows relations of some parameters influencing the diversity of Auchenorrhyncha to each other (fig. 3).

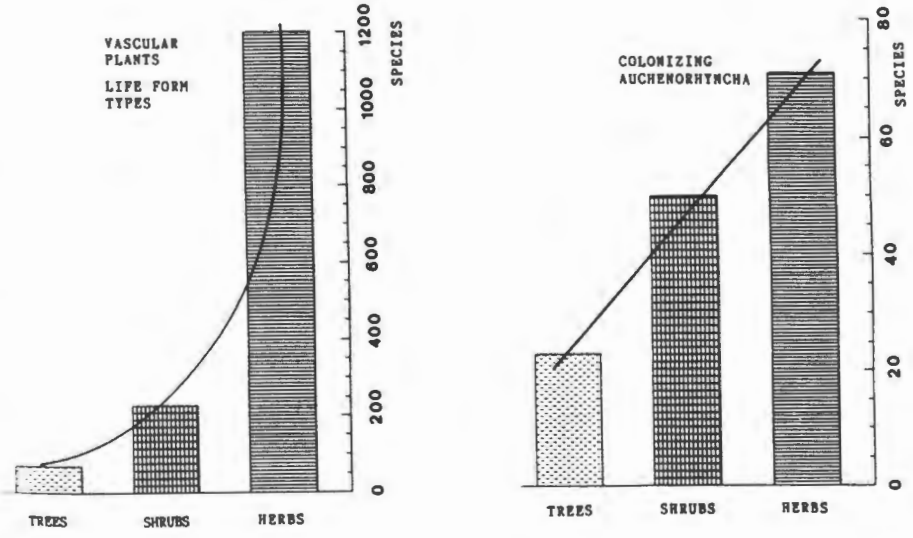

Fig. 5 - Composition of The Canarian vascular plant flora after life form types (left) and species numbers of associated Auchenorrhyncha faunas. Data after several authorities.

The species richness of Atlantic Auchenorrhyncha genera is also inlfuenced by the number of islands colonized by the genera. A plot for central Macaronesian island biotas shows a power function (fig. 4).

Plant Architecture and Auchenorrhyncha Faunas

For possible relations, plants and Auchenorrhyncha of the Canary Islands were counted after life form types and associated Auchenorrhyncha species (fig. 5). The vascular plant flora of the Canary Islands consists mainly of herbacous plants, followed by shrubs and trees in decreasing order. The decrease is characterized by a non-linear curve. Ranks of species richness of associated Auchenorrhyncha faunas correspond with the plant species richness of the life form types. But their decrease from herbs to trees can be characterized by a linear fitting.

DISCUSSION

As known, areas are an importent parameter of island biotas influencing species richness, as shown by McARTHUR & WILSON (1963, 1967), and others. Beside their influence on immigration and extinction probabilities of invading organisms, areas have also a meaning for resource quantities: for primary producers e.g. of geological resources, for consumers e.g. of consumed plants. Ecological diversity of biotas is in bigger islands often higher than in smaller ones. The contribution of habitat diversities is considered to be often an important factor in species-area curves (e.g. BOECKLEN 1986, JOHNSON & SIMBERLOFF 1974). In the Macaronesian islands, this can also be seen if in species-area plots of the Canary Is. the ecologically poor two Eastern islands are added to the group of the ecologically richer Western islands.

In the Canaries with their high level of endemic taxa, speciation events contribute to the species richness of biotas as shown in SERGEL 1986a, SERGEL & BAEZ in press. For phytophages, more diverse islands support higher possibilities for non-allopatric speciation events than less diverse, and probably bigger ones higher than smaller ones. Thereby, abundances and ranges of possible host plants could be important.

Considered species richness of archipelagos, island numbers are clearly relevant giving possibilities for allopatric speciation events. As known, adaptive radiation and growth of island taxa were also driving forces in the evolution of Atlantic (Macaronesian) Auchenorrhyncha. The possible relevance of other patterns (taxon cycle hypothesis) is dealt with in SERGEL & BAEZ, in press.

The species diversity of vascular plants as primary produders is also related to island areas (SERGEL 1984d, 1986a, SERGEL & BAEZ in press), influencing resource diversities for exploiting phytophages. As shown in previous papers, the species richness of Auchenorrhynchous insects corresponds with the species richness of vascular plants in investigated island biota. Obviously, also plant architecture influences the species richness of associated Auchenorrhyncha faunas if considered the deminishing of a non-linear decrease in plant species diversity of the life forms of herbs, shrubs, and trees to a linear decrease in species diversity of corresponding Auchenorrhyncha faunas examined for the Canarian islands. That plant architecture

can influence the species richness of associated insect faunas is known (for examples and discussions see e.g. LAWTON & SCHRÖDER 1977, LAWTON 1983, STRONG et al. 1984).

Island areas can also influence host plant ranges of possible parasitic insects which is also known to be a relevant factor for the species richness of parasites.

REFERENCES

BOECKLEN, J.W. (1986) Effects of habitat heterogeneity on the species-area relationship of forest birds. J. Biogeogr. 13,59 - 68.

FRISTRUP, B. (1945) Hemiptera 1: Heteroptera and Homoptera Auchenorrhyncha. In: The Zoology of Iceland. Eds. A. FRIDRIKSSON & S.L. TUXEN, Copenhagen, Reykjavik, Vol.3, 1-21.

JOHNSON, M.P. & D.S. SIMBERLOFF (1974) Environmental determinants of island species numbers in the British Isles. J. Biogeogr. 1, 149-154.

LAWTON, J.H. (1983) Plant architecture and the diversity of phytophagous insects. Ann. Rev. Entomol. 28, 23-39.

LAWTON, J.H. & D. SCHRÖDER (1977) Effects of host plant type, size of geographic range and taxonomic isolation on number of insect species associated with British plants. Nature 265, 137-140.

LESTON, D. (1957) Spread potential and the colonisation of islands. Syst. Zool. 6, 41-46.

LINNAVUORI, R. (1974) A Hemipterous material from the Selvage Is. Bocagiana Mus. munic. Funchal 34, 1-3.

QUARTAU, J.A. (1975) On the origin of two flatids (Homoptera, Auchenorrhyncha) of the Selvage Islands. Bocagiana Mus. munic. Funchal 37, 1-8.

QUARTAU, J.A. (1981) On a new species of the genus Brachypterona LINDBERG from the Selvage Islands (Homoptera, Cicadellidae). Arq. Mus. Boc. (Ser. B) 1 (10), 129-132.

QUARTAU, J.A. (1979) An annotated check-list of the species of leafhoppers known to occur in the Azores (Homoptera, Cicadellidae). Arq. Mus. Boc. (Ser. 2A) 7 (45), 1-6.

QUARTAU, J.A. (1982) A preliminary faunistic analysis of the Cicadellidae (Homoptera, Auchenorrhyncha) of the Azores. Bolm. Soc. port. 7 (Suppl. A), 145-149.

REMANE, R. & M. ASCHE (1986a) Makarorysa n.g. - a new genus for the Canaro-Madeiran Eurysa ribauti LINDBERG-group with remarks on speciation, distribution and phylogenetic relationship within this taxon (Homoptera, Delphacidae). Marb. ent. Publ. 2 (3), 217-258.

REMANE, R. & H. HOCH (1986) Sechs neue Arten der Gattung Hyalesthes SIGNORET, 1865 (Homoptera, Cixiidae) von den mittelatlantischen Inseln und aus dem Irak. Marb. ent. Publ. 2(3), 123-154.

SERGEL, R. (1984d) Evolution of a fulgoroid genus in the Macaronesian region: overlapping of growth of island taxa and ecological differentiation? (Homoptera, Issidae). Cour. Forsch.-Inst. Senckenberg 71, 61-78.

SERGEL, R. (1986a) Aspects in island biogeography of Canarian Auchenorrhyncha. Biol. Z. 1 (1), 5-27.

SERGEL, R. (1986b) Occurence of the Auchenorrhyncha family of Kinnaridae in the peripheric Palaearctic region on the Canary Islands (Homoptera, Fulgoroidea). Biol. Z. 1 (1), 28-39.

SERGEL, R. (in press) Inselfaunenmuster kanarischer Homopteren. Nat. Mus.

SERGEL, R. & M. BAEZ (in press) On the biotic diversity of Eastearn Atlantic islands and its implication for the theory of island Biogeography. Cour. Forsch.-Inst. Senckenberg.
STRONG, D. R., J.H. LAWTON & T.R.E. SOUTHWOOD (1984) Insects on Plants. Community Patterns and Mechanisms , Oxford, Blackwell Publ.