WORLD HEALTH ORGANIZATION

ORGANISATION MONDIALE DE LA SANTE

LEISH/WP/82.34

ENGLISH ONLY

INDEXED

EXPERT COMMITTEE ON LEISHMANIASES

Geneva, 10-16 November 1982

Draft agenda item 8.4

Sandflies - Classif

"ECOLOGICAL ANALYSIS". APPLICATION TO THE STUDY OF MIXED POPULATIONS OF THE SANDFLY VECTORS OF LEISHMANIASES

by

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1. Definitions. General considerations of method

The term mixed population is taken to mean a characteristic grouping of species (biotic community) belonging to the same systematic unit (taxocoenosis). A mixed population is defined in relation to an "ecological space" (biogeographical region, bioclimatic zone, biotope, station). This concept, worked out by botanists at the end of the last century, is currently applied to many zoological groups. The analysis of mixed populations is thus one of the main preoccupations of ecology (synecology).

Although the strategies developed for this analysis are numerous, which strategy to select is always a difficult decision. The one known as the progressive method,[1] which is used in the main for rural planning purposes (agriculture, sylviculture, animal husbandry, aquaculture, nature conservancy, etc.), would seem to be the best adapted to the study of zoonoses and, in particular, metazoonoses.[2] We are of the opinion that, by permitting a statistical approach to populations of vectors and reservoirs, it should lead to a better understanding of intricate epidemiological situations and, by the same token, should enable the most effective strategies to be worked out for investigation or intervention.

More specifically, the ecological analysis of mixed populations successively involves sampling by station, global species-station analysis, the production of ecological profiles and the statistical individualization of groupings of species (nomocoenoses, ecological groups). It is in this sense that we propose to apply this method to mixed populations of the sandfly vectors of leishmaniases.

2. Sampling

2.1 The sampling equipment (trap) should satisfy the following conditions:

- it should avoid any bias stemming from trophic, phototactic or anemochorous behaviour (rejection of baited traps and light traps);
- it should be possible to handle it (manufacture, transportation, installation) without excessive difficulty so as to make possible simultaneous operation at several stations;
- it should remain effective for long enough to dampen short-term climatic fluctuations in as far as possible.

The only one of the many traps that have undergone full-scale trials that satisfies these conditions is the sticky trap. It is an interception trap consisting of a 20 x 20 cm sheet of glossy paper impregnated with castor oil and left in position for at least four nights in cavities or cracks.[3] The recommended number of traps per station is at least 30.[4] Figures for the abundance of the various species are arrived at by relating the number of individuals captured to unit area of the catching surface (e.g., per square metre).

2.2 Sampling proper consists in the taking of homogeneous and representative samples. Representivity is dependent not only on the sampling technique, but also on the types of station selected. In general, this choice is made the easier by preliminary stratification, the object of which is to reduce the "effect of contagiousness". What is involved is the particularization within the area under investigation of a certain number of zones or strata that are, at one and the same time, different one from the other and relatively homogeneous in relation to the phenomenon under investigation.

In epidemiology, the area involved is generally divided up on the basis of "noso-ecological determinants" that are known or highly probable (indicators). The criteria adopted in relation to sandflies are dependent on how good the analysis must be and on the level of perception desired: bioclimates, geomorphological and pedological units, spontaneous or cultivated vegetation types, biotopes of vertebrate reservoirs, human habitats, etc. Several interlocking stratifications may be effected in the same zone, for example houses and gardens within the same phyto-ecological zone. A provisional typological map is then produced with the aid of various records and aerial photographs. A quick run through the area under examination is indispensable at this stage ("ground check"). When this has been done, the stations are designated in each stratum, either by random selection or (most often) by regular selection. The use of a carefully selected transect itinerary enables all the strata identified to be sampled. In this case, the interval between each station is calculated having regard to the extent of the stratum.

Having applied this method for several years now in a number of countries (Fig. 1) in the Western Mediterranean, we are in a position to vouch for its heuristic value and its effectiveness.

3. Global species-station analysis

In this phase the raw data are processed by multi-dimensional analysis techniques.[5] The groupings to be noted on the diagrams implicitly reflect the degrees of species-species, station-station and species-station ecological affinity (Fig. 2). The hierarchization technique enables these groupings to be more clearly particularized within the continuum. Thus, analysis of 339 samples spaced out along three transect itineraries in Morocco reveals three species-station subsets following a bioclimatic gradient from north to south (dendrogram, Fig. 3).

4. Production of "ecological profiles"

The term ecological profile is applied to diagrams of the frequency of a species as a function of the classes of a factor. By producing the profile it is possible to bring out the discriminant (or explanatory) factors and, consequently, to particularize the one (or more) species indicative of such a factor. In Morocco the spatial distribution of *Phlebotomus papatasi*, *P. alexandri* and *P. ariasi* is explained by the bioclimates, whereas *P. sergenti* and *P. perniciosus* are relatively indifferent to this factor (Fig. 4). In Corsica, "altitude" is a descriptor that clearly distinguishes *P. sergenti* from *P. perniciosus*. Within these variables (species) and the parameters (stations) discrimination is achieved by the application of various correlation tests. Godron[6] has adapted information theory for such an analysis: calculation of the species entropy and the factor entropy, mutual species-factor information.

In practice, two types of profiles are used in the main, the corrected profile and the indexed profile. The latter, in particular, takes into account the differences between the observed frequencies and their expected values for the various classes of a factor in the case of random distribution (Fisher's test). In the southern Moroccan foci of zoonotic leishmaniasis (L. major), indexed profiles (Fig. 5) reveal a significant difference between the distribution of P. papatasi, a host of human habitations, and P. alexandri, present in the main in biotopes of Gerbillidae (Meriones, Psammomys).

5. Particularization of nomocoenoses and ecological groups

5.1 Nomocoenosis is a term designating a mixed population characterized by its diversity, its richness in species and its density per unit of surface.[7] Specific abundance distributions are sufficiently close to log-linear[8] or log-normal[9] models to be likened to them. Although nomocoenoses are not as interesting in practice as are ecological groups, they do correspond theoretically to a homogeneous and stable environment, and may be used as indicators of "ecological alteration". The comparison of sandfly nomocoenoses in the Congo reveals that the sandfly populations of cleared zones are impoverished by comparison with those of forest zones.[10]

5.2 The term "ecological group" denotes a statistical set of species exhibiting the same behaviour vis-à-vis a given factor. This definition is in fact applied to the elementary ecological group or auto-ecological group.[1] Such a group is constructed on the basis of indexed profiles. The validity of the "provisional group" thus formed is then statistically tested with the help of corrected profiles. Although the ecological group is less synthetic than the nomocoenosis, it is however more explanatory because it takes discriminant factors into consideration. In the case of sandflies, the ecological group may be an effective descriptor of given epidemiological situations. For example, preliminary investigations undertaken in southern Morocco suggest that at least two ecological groups are characteristic of L. major zoonotic foci: P. papatasi and P. sergenti in the inhabited zone, P. alexandri, S. antennata and S. fallax in the wild zone.

6. Conclusions

Although we do not regard the approach set out above as the only effective approach to the structural analysis of mixed sandfly populations, we are of the opinion that it can make a real contribution to the better understanding of foci of leishmaniasis. At a time when the techniques of information science and statistics are becoming accessible, and when the multidisciplinary approach is recognized as an operational necessity, it would be a pity to neglect what "ecological analysis" has to offer.

"Landscape epidemiology" may be used, pro parte, during this stage.*

* There is no indication in the French text of the intended position of this footnote - Translator.

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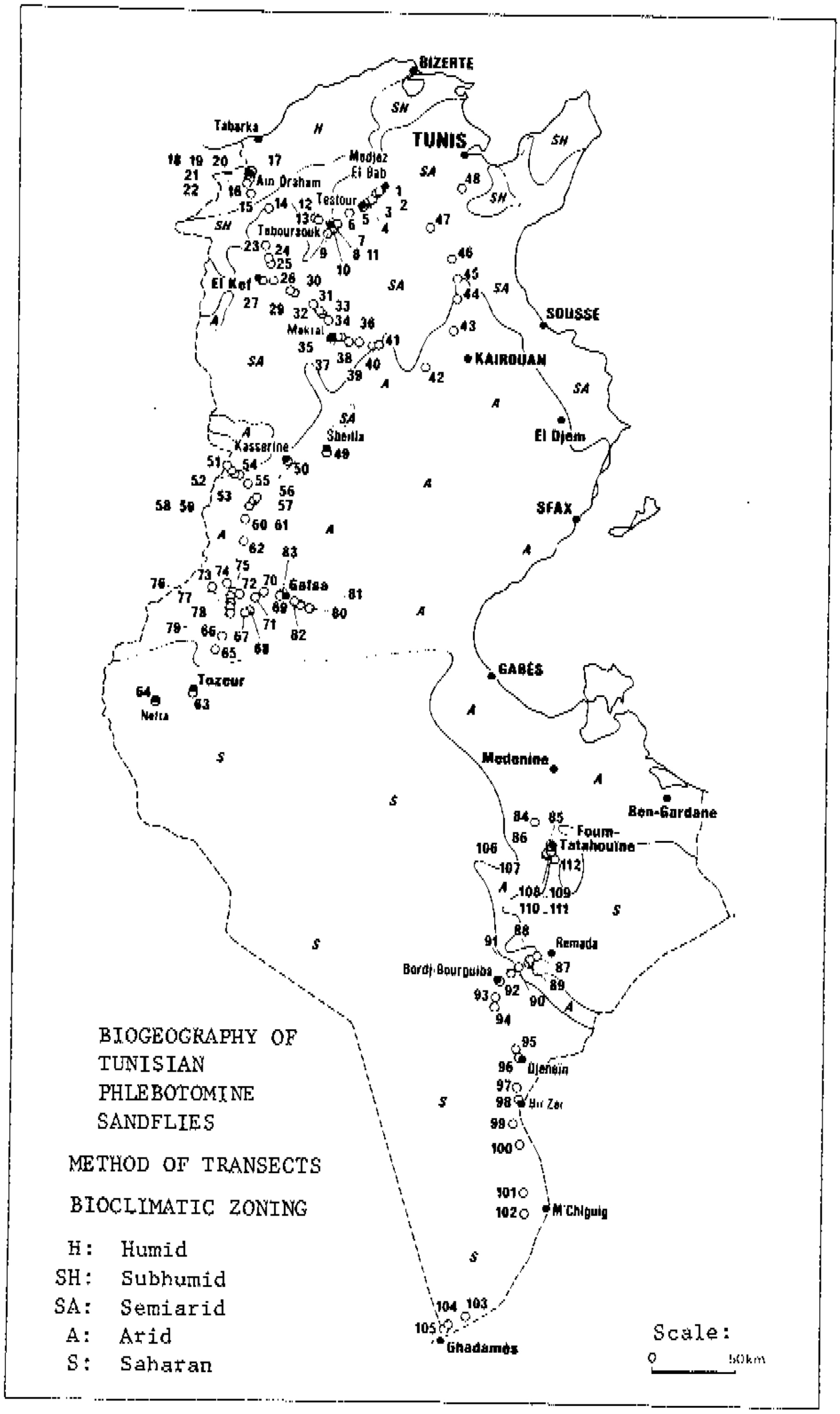
BIZERTE
Tabarka
TUNIS
Medjez El Bab
Ain Draham
Testour
Tebourso uk
El Kef
Makthar
KAIROUAN
SOUSSE
Kasserine
Sbeitla
El Djem
SFAX
Gafsa
GABÈS
Tozeur
Nefta
Medenine
Ben-Gardane
Foum-Tatahouine
Remada
Bordj-Bourguiba
Djeneïn
Bir Zar
M'Chiguig
Ghadamès
BIOGEOGRAPHY OF TUNISIAN PHLEBOTOMINE SANDFLIES
METHOD OF TRANSECTS
BIOCLIMATIC ZONING
H: Humid
SH: Subhumid
SA: Semiarid
A: Arid
S: Saharan
Scale:
0 50km

Figure 1.

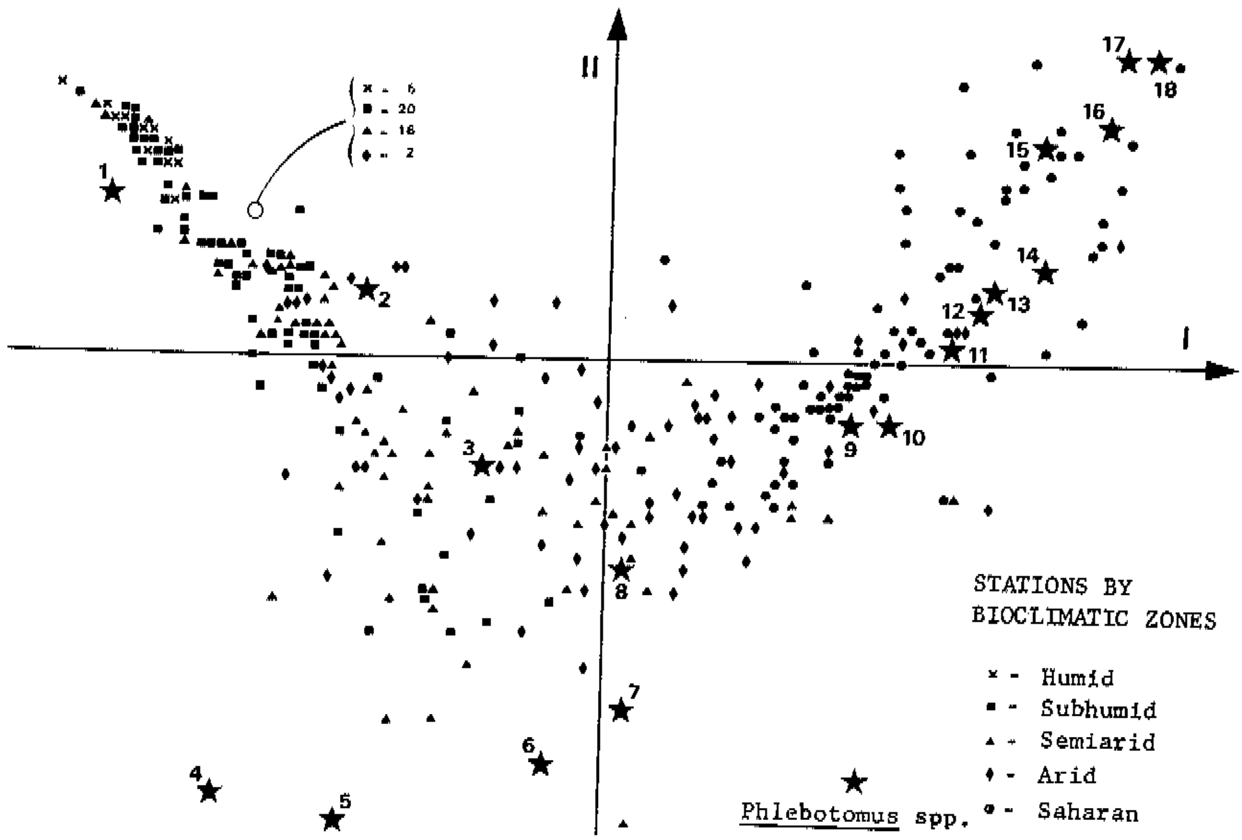

Figure 2: Phlebotomine sandflies of Morocco. Processing of data on stations and species. In general appearance the graph is a continuum. Nevertheless, the upper left quadrant contains most of the "humid" and "subhumid" stations, the upper right quadrant the "Saharan" stations. The "semiarid" and "arid" stations occupy the lower quadrants. The sandflies are distributed in accordance with their bioclimatic affinity: the most diversified Saharan group is placed, along with the corresponding stations, in the upper right quadrant.

1: Phlebotomus ariasi. 2: Sergentomyia minuta. 3: P. longicuspis.
4: P. perfiliewi. 5: P. chadlii. 6: P. mariae. 7: P. chabaudi.
8: P. sergenti. 9: S. fallax. 10: S. dreyfussi.
11: P. alexandri. 12: P. papatasi. 13: S. lewisi.
14: S. christophersi. 15: P. bergeroti. 16: S. clydei
17: S. antennata. 18: S. africana.

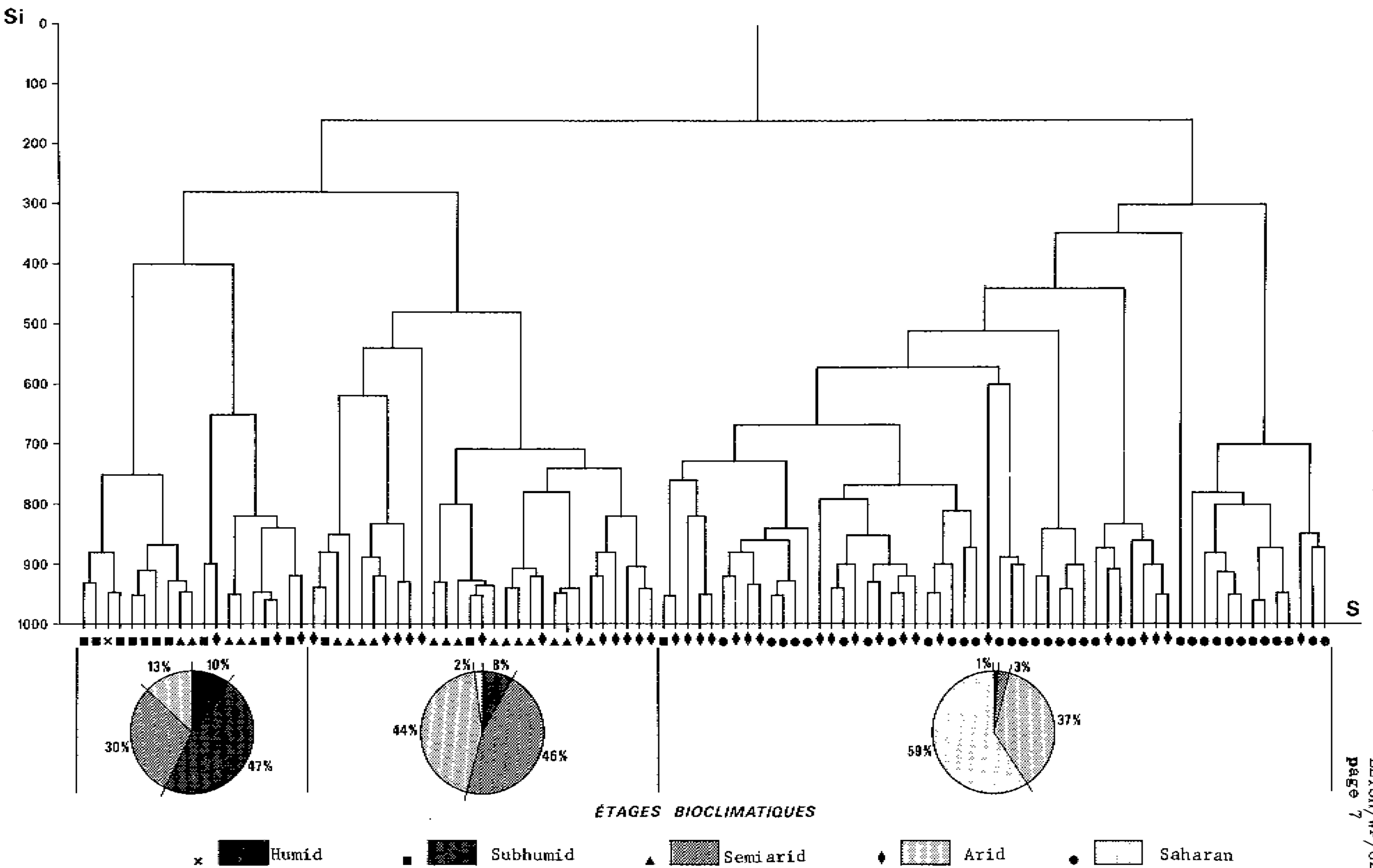

Figure 3. Phlebotomine sandflies of Morocco. Station dendrogram based on sandfly abundance. Three bioclimatic subsets, humid, arid and saharan, may be distinguished from left to right.

PHLEBOTOMUS SANDFLIES OF MOROCCO
CORRECTED ECOLOGICAL PROFILES
(DESCRIPTION: BIOCLIMATIC ZONES)

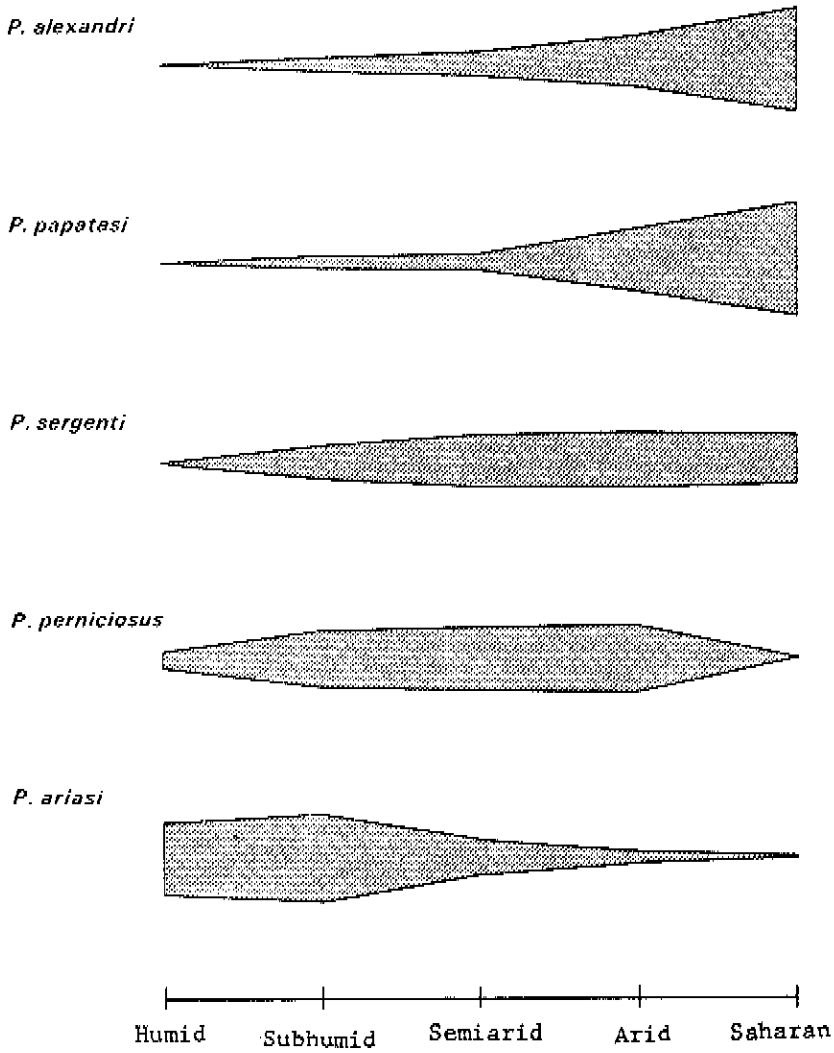

Figure 4. Ecological profiles produced for five Moroccan phlebotomine sandfly species employing a bioclimatic descriptor (Emberger's indices). The upper two profiles (P. alexandri and P. papatasi) correspond to saharan elements. The lower profile places P. ariasi in humid and subhumid strata. P. perniciosus reaches the arid zone.

REGROUPEMENT
CLASSES ANNUELLES 11 ..24 ..51 ..
CLASSES D'ACCUEIL 12 ..23 ..52 ..
SORTIE TRIEE SUR NUMEROS D ESPECES

NO. 4 CODES DES ETAGES BIOCLIMATIQUES DE SAUVAGE 12 CLASSES. ENTROPIE FACTEUR= 3.32591NB. REL= 354.
MOYENNES DES HIM 0.14629 POUR 21 ESPECES 0.14629 POUR 21 ESPECES.

PROFIL D ENSEMBLE 69 14 17 27 27 43 12 33 15 63 12 22

CODES DES CLASSES				N			12	13	21	22	23	31	32	33	41	42	43	52
12	1	PHLEBOTOMUS	BERGEROTI.	17	0.27794	0.08203	392	297	122	0	0	0	0	0	0	33	0	0
3	2	PHLEBOTOMUS	PAPATASI.	106	0.88060	0.41404	246	310	157	210	111	31	83	10	0	0	0	0
1	3	PHLEBOTOMUS	ALEXANDRI.	117	0.91544	0.53250	271	259	71	257	33	21	151	18	20	4	0	0
13	4	PHLEBOTOMUS	CHARAUDI.	54	0.61616	0.07930	104	93	154	339	97	76	163	119	43	41	0	0
6	5	PHLEBOTOMUS	SERGENTI.	158	0.99167	0.16346	133	112	131	174	99	88	205	101	134	42	56	0
5	6	PHLEBOTOMUS	ARIASI.	101	0.86238	0.21043	15	0	20	38	25	130	58	84	233	211	204	175
17	7	PHLEBOTOMUS	CHADLII.	16	0.26563	0.03785	0	0	0	249	163	205	164	201	147	70	0	0
8	9	PHLEBOTOMUS	LONGICUSPIS.	205	0.98107	0.13452	110	24	121	115	153	100	129	88	149	87	115	7
19	10	PHLEBOTOMUS	MARIAE.	5	0.10703	0.02486	0	0	416	524	0	164	0	214	0	0	0	0
20	11	PHLEBOTOMUS	PERFILIEWI.	1	0.02799	0.01056	0	0	0	0	999	0	0	0	0	0	0	0
10	12	PHLEBOTOMUS	PERNICIOSUS.	45	0.54948	0.11461	0	0	185	174	145	164	65	238	0	37	393	35
4	14	SERGENTOMYIA	ANTENNATA.	48	0.57258	0.24422	342	526	43	54	0	17	0	0	0	23	0	0
21	15	SERGENTOMYIA	BEDFORDI.	1	0.02799	0.00669	513	0	0	0	0	0	0	0	0	0	0	0
2	16	SERGENTOMYIA	FALLAX.	155	0.98882	0.43225	205	179	80	203	126	54	209	27	91	18	0	0
14	17	SERGENTOMYIA	MINUTA.	322	0.43779	0.07326	100	78	84	109	109	94	91	109	102	104	109	79
11	19	SERGENTOMYIA	AFRICANA.	16	0.26563	0.08278	384	316	130	0	0	0	184	0	0	0	0	0
18	20	SERGENTOMYIA	LEWISI.	7	0.14017	0.03495	366	361	0	187	0	0	0	0	0	0	0	0
9	21	SERGENTOMYIA	DREYFUSSI.	36	0.47434	0.12322	256	70	115	364	72	22	81	0	65	0	0	0
7	22	SERGENTOMYIA	CHRISTOPHERSI.	26	0.37865	0.14133	394	291	0	151	0	0	0	0	0	0	0	0
15	23	SERGENTOMYIA	CLYDEI.	12	0.21358	0.06816	427	0	0	218	0	0	0	0	0	0	0	0
16	99	PAS DE	PHLEBOTOME.	14	0.24021	0.06103	36	0	0	0	0	235	0	0	168	80	0	689

0.21138	0.28007	0.05498	0.18137	0.07875	0.05975	0.11507	0.10076	0.11107	0.12728	0.19760	0.26023
0.05487	0.01161	0.00279	0.01514	0.00051	0.00802	0.00401	0.01008	0.00512	0.02625	0.00688	0.01763
2.35907	4.66024	4.38013	3.71271	3.71271	3.04133	4.80263	3.42320	4.56070	2.49032	4.88263	4.00816
0.71164	0.24021	0.27794	0.38890	0.38890	0.53357	0.21358	0.44713	0.25307	0.67561	0.21358	0.33591

SORTIE TRIEE SUR SIGNE
NO. 5 QUOTIENT PLUVIOMETHERMIQUE D'EMBERGER 13 CLASSES. ENTROPIE FACTEUR= 3.55053NB. REL= 354.
MOYENNES DES HIM 0.14456 POUR 21 ESPECES 0.14456 POUR 21 ESPECES.

PROFIL D ENSEMBLE 30. 63. 25. 26. 16. 22. 37. 37. 25. 24. 15. 26. 8.

CODES DES CLASSES				N			005	010	015	025	035	045	055	065	080	100	140	160	190
2	16	SERGENTOMYIA	FALLAX.	155	0.98882	0.47869	+++	+++	+++	+	.	+	---	---	--	---	---	---	-
3	2	PHLEBOTOMUS	PAPATASI.	106	0.88060	0.46288	+++	+++	+++	+	.	---	---	---	---	---	--	---	
1	3	PHLEBOTOMUS	ALEXANDRI.	117	0.91544	0.50347	+++	+++	+++	.		--	---	---	---	---	--	---	
6	5	PHLEBOTOMUS	SERGENTI.	158	0.99167	0.14790	+	+	++	.	.	.	.	-	.	--	--	--	.
4	14	SERGENTOMYIA	ANTENNATA.	48	0.57258	0.25063	+++	+++						--	-			-	
7	22	SERGENTOMYIA	CHRISTOPHERSI.	26	0.37865	0.13386	++	+++											
9	21	SERGENTOMYIA	DREYFUSSI.	36	0.47434	0.10866	+	+++	.	.				-					
11	1	PHLEBOTOMUS	BERGEROTI.	17	0.27794	0.08512	+++	+											
10	19	SERGENTOMYIA	AFRICANA.	16	0.26563	0.09879	+++	+											
13	23	SERGENTOMYIA	CLYDEI.	12	0.21358	0.07813	+++												
17	20	SERGENTOMYIA	LEWISI.	7	0.14017	0.03400	+												
8	4	PHLEBOTOMUS	CHARAUDI.	54	0.61616	0.11111		.	+++	.		.	.	-		-		-	
5	6	PHLEBOTOMUS	ARIASI.	101	0.86250	0.23557	---	---	--	-		.	+++	.	.	.	+++	+++	.
16	7	PHLEBOTOMUS	CHADLII.	16	0.26563	0.03796		.					+						
14	12	PHLEBOTOMUS	PERNICIOSUS.	45	0.54948	0.07743	-	--	.			.	.	++		.			
12	9	PHLEBOTOMUS	LONGICUSPIS.	205	0.98107	0.08315	.	.	.	.	.	.	.	.	.	.	-	---	.
15	99	PAS DE	PHLEBOTOME.	14	0.24021	0.04757													
18	17	SERGENTOMYIA	MINUTA.	322	0.43779	0.02361	.	.	.	.		.	.	.	.	.		.	
19	10	PHLEBOTOMUS	MARIAE.	5	0.10703	0.01777													
20	15	SERGENTOMYIA	BEDFORDI.	1	0.02799	0.01012													
21	11	PHLEBOTOMUS	PERFILIEWI.	1	0.02799	0.00925													

SORTIE TRIEE SUR SIGNE
NO. 11 CODE DU BIOTOPE 12 CLASSES. ENTROPIE FACTEUR= 3.15894NB. REL= 346.
MOYENNES DES HIM 0.06238 POUR 21 ESPECES 0.06238 POUR 21 ESPECES.

PROFIL D ENSEMBLE 14. 41. 37. 101. 10. 28. 14. 10. 43. 14. 26. 8. 5. 2. 1.

CODES DES CLASSES				N			11	12	13	21	23	24	30	41	42	43	44	53	14	22	45
1	3	PHLEBOTOMUS	ALEXANDRI.	113	0.91140	0.20422	.	+++	.	---	.	.	+++		.	++	.				
3	16	SERGENTOMYIA	FALLAX.	322	0.98934	0.12929	.	+++	.	---		.	.	.	+	.	.				
5	5	PHLEBOTOMUS	SERGENTI.	155	0.99217	0.09696	.	+	.	---	.	+			+++	.	.	.			
6	4	PHLEBOTOMUS	CHARAUDI.	52	0.61056	0.09730	.	+++	.	---	.				.						
13	22	SERGENTOMYIA	CHRISTOPHERSI.	25	0.37428	0.03447			++	-											
2	6	PHLEBOTOMUS	ARIASI.	97	0.85592	0.13802		--	.	+++		-	-		.	-	.				
15	99	PAS DE	PHLEBOTOME.	14	0.24441	0.02873						+									
7	14	SERGENTOMYIA	ANTENNATA.	46	0.56547	0.08770		.	.	---		.	+++		.	.					
14	20	SERGENTOMYIA	LEWISI.	7	0.14274	0.03850								+							
4	2	PHLEBOTOMUS	PAPATASI.	103	0.87844	0.11124	.	.	.	---		.	.	.	++	+++	.				
8	21	SERGENTOMYIA	DREYFUSSI.	34	0.46347	0.05503		.		--					+						
9	9	PHLEBOTOMUS	LONGICUSPIS.	201	0.98102	0.05139	.	.	.	.	.	.	.		++		.				
10	12	PHLEBOTOMUS	PERNICIOSUS.	45	0.55759	0.04474		-	.	.					.		.				
11	19	SERGENTOMYIA	AFRICANA.	16	0.27022	0.04295		.							.						
12	7	PHLEBOTOMUS	CHADLII.	14	0.24441	0.04021				.											
16	1	PHLEBOTOMUS	BERGEROTI.	17	0.28270	0.02705															
17	17	SERGENTOMYIA	MINUTA.	316	0.42537	0.01921		.	.	.		.			.		.				
18	23	SERGENTOMYIA	CLYDEI.	12	0.21735	0.01857															
19	10	PHLEBOTOMUS	MARIAE.	4	0.09097	0.01509															
20	15	SERGENTOMYIA	BEDFORDI.	1	0.02854	0.01352															
21	11	PHLEBOTOMUS	PERFILIEWI.	1	0.02854	0.00874															

Figure 5. Corrected ecological profiles (upper list) and indexed ecological profiles (middle and lower lists) based on samples of phlebotomine sandflies collected throughout Morocco. The indexed profiles of the lower list exhibit good correlation with some species and some biotopes. Phlebotomus alexandri is primarily linked with rural biotopes: with stony zones (class 12) and with the burrows of Gerbillidae (class 30). Phlebotomus papatasi is linked with human habitats: ksars (class 43) and douars (class 42).

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