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THE ODONATE COMMUNITIES ASSOCIATED WITH DISTINCT AQUATIC ENVIRONMENTS OF THE SIERRA MORENA (ANDALUSIA), SPAIN

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Abstract — The physical and chemical features of various aquatic environments were studied in relationship to their odon. fauna. On the basis of mathematical considerations, 4 aquatic biotopes and 3 odon. community types are defined.

Introduction

In recent years, studies revealing the importance of Odonata as indicators of the nature of aquatic environments have been numerous (e.g. AGUESSE, 1955, 1960, 1964; JARRY & VIDAL, 1960; MACAN, 1962; FURTADO, 1969; FERNET & PILON, 1970; DUMONT, 1971; PILON & LEBUIS, 1976; LEBUIS & PILON, 1976; PILON et al., 1978). The aim of this study was to establish a relationship between the different aquatic biotopes in an odonate community in southeastern Spain by a physical characterization of the waters and their associated odonate fauna. The proposed objective of relating dragonfly species with their respective environments was realized by the preferential capture of larvae (AGUESSE, 1964); the simultaneous collection of imagines added greater security to determination of the larval samples. The information was analyzed by computer.

Localities and methods

The study was carried out (Feb. 1977-Oct. 1978) in the portion of the Sierra Morena in the province of Cordoba (38° 00'-38° 40'N, 0° 30'-1° 50'E). The climate is mesomediterranean (BAGNOULS & GAUSSEN, 1957). The vegetation consists of an old, yet regenerating sclerophilic mediterranean forest.

Thirteen sites were selected (5 streams and 8 river locations) and explored at regular intervals on ten occasions, viz. Arroyo Parrilla-La Granjuela (30S TH 925498; alt. 550 m), — Arroyo Albardado (30S UH 106362; 480 m), — Arroyo del Molino (30S UH 336010; 280 m), — Arroyo El Patriarca (30S UG 409971; 160 m), — Arroyo Pedroches (30S UG 443986; 130 m), — Rio Guadiato-Belmez (30S UH 067372; 480 m), — Rio Guadiato- Villanueva del Rey (30S UH 146334; 470 m), — Rio Guadiato-Los Arenales (30S UH 361044; 300 m), — Rio Guadiato-Castro y Picón (30S UH 277026; 200 m), — Rio Guadalmellato (30S UH 564015; 120 m), — Rio Guadiato-Almodovar (30S UH 194875; 80 m), — Rio Bembezar (30SUG 056832; 60 m), — Rio Retortillo (30S TG 966768; 60 m).

The abiotic characterization of the aquatic environment was made by considering its permanency or intermittency and current state, and by measuring, on each visit, the temperature, total alkaline reserve, pH, chloride (Cl^-), silicate (SiO_2), sulfate ($SO_4^{=}$), nitrate NO_3^-), nitrite (NO_2^-), phosphate ($PO_4^{\equiv}$) and oxygen-dissolved levels. The chemical data were processed by principal components analysis in order to obtain an arrangement of samples with respect to trends in independent variation (HARMAN, 1967).

A total of 1,896 larvae, representing 21 species, were studied. Adult *Calopteryx haemorrhoidalis* (Vander L.), *C. xanthostoma* (Charp.), *Platycnemis acutipennis* Sel. and *P. latipes* Ramb. were captured in the zone. However, these larvae could be identified to the genus level only.

A two-data matrix (presence-absence) was established considering successively the annual inventory of each site and the species as variables. A parallel mathematical treatment was applied whose purpose was, first, to determine the similarity between the sites in relation to the Odonata community associated to each site and, second, to estimate the similarity between species paying attention to the biotopes utilized. The BARONI-URBANI & BUSER (1976) similarity index was chosen. Its formula is

$$S = \frac{\sqrt{A.D} + A}{\sqrt{A.D} + A + B + C}$$

with A equalling the number of species present in the two lists compared, B and C the number of species present in each one of the lists and absent in the other, and D the number of species present in other lists and absent in the two lists compared. The results of the anterior calculations were formulated into two similarity matrices, to which a BMDP 1M classification analysis (DIXON, 1975) was applied in order to group the variables (inventory or species) according to their degree of similarity.

Biotope classification

Principal components analysis revealed the first five axes absorbing 89.2% of the variance. Axis I had a eutrophic direction, possibly owing to the inclusion in this analysis of entries taken all year long and axis II discriminated against mineralized samples.

The study and statistical interpretation of the data obtained (FERRERAS, 1980) revealed the existence of four principal aquatic biotope types, whose most outstanding characteristics are discussed below, together with details of their associated vegetation.

— (Type A) The Stable streams (sites 3, 5) where those which always had a current and temperatures never surpassing 20° C. Their alkaline reserve oscillated between 3 and 3.5 meq/l, representing well buffered waters with a pH of approximately 8 which experienced slight daily variations. The oxygen concentration was always equal to or greater than 5 mg/l. Aquatic vegetation was scarce, yet the greenery along the bank abundant.

(Type B) The Intermittent highly mineralized streams (sites 1, 4) were those lacking water during the second half of summer and the first of autumn. In those in which there was no current the water temperature surpassed 20° C. There was an elevated alkaline reserve between 6 and 9 meq/l, an approximate pH of 8 and a relatively elevated winter silicate level of 200 μgr-at Si/l which decreased in the remaining months of the year due to its utilization by diatoms. The chloride concentration was between 30 and 60 mg/l. The oxygen levels were normally greater than 5 mg/l. These waters had aquatic vegetation (*Ranunculus* sp., *Lemna* sp.), yet lacked greenery along the banks.

— (Type C) The Intermittent slightly mineralized streams (site 2) were similar to the type B ones, however with noticeable differences in chemical composition. The alkaline reserve oscillated between 1 and 3 meq/l, representing slightly buffered waters with marked daily pH variations. This site registered the highest chloride (189 mg/l) and sulfate (48.1 μgr-at S/l) levels. The oxygen concentration was equal or superior to 4.5 mg/l.

— (Type D) The Rivers (sites 6-13) were permanent, receiving water periodically from nearby dams. The temperature reached a maximum of 25° C and the alkaline reserve oscillated between 1 and 4 meq/l. Silicate and sulfate levels varied with respect to the various sites and the time of year, with chloride levels remaining relatively uniform between 10 and 30 mg/l. The oxygen concentration was generally superior to 4 mg/l, however in site 10 levels of about 2.5 mg/l were registrated in the summer and autumn. The aquatic vegetation consisted fundamentally of *Myriophyllum* sp., *Ranunculus* sp., *Alisma* sp., *Scirpus* sp. and *Cynodon* sp. There was no vegetation along the banks.

Independent of the types of aquatic biotopes, there were maximum nitrate levels of between 60 and 100 μgr-at N/l in December and January. Minimum levels which varied with respect to the various sites were registered between April and October; sites 2, 6 and 10 lacked nitrate in the summer. Maximum nitrite concentrations were registered during dry season in the intermittent highly mineralized streams, reaching levels superior to 13 µgr-at N/l. The rivers registered superior to 13 µgr-at N/l. The rivers registered maximum levels of orthophosphate (superior to 5 µgr-at P/l), which were concomitant with elevated concentrations. In the majority of the sites, in the summer, the orthophosphate acted as a factor limiting productivity.

Table I — Similarity index between sites with respect to their respective associated odonate community

Station													
1	1.000												
2	.625	1.000											
3	.223	.000	1.000										
4	.675	.625	.000	1.000									
5	.384	.400	.805	.154	1.000								
6	.783	.496	.223	.783	.270	1.000							
7	.653	.864	.000	.653	.457	.537	1.000						
8	.609	.673	.248	.609	.537	.499	.820	1.000					
9	.458	.625	.223	.567	.497	.350	.653	.721	1.000				
10	.631	.579	.199	.526	.458	.526	.609	.458	.736	1.000			
11	.653	.726	.000	.537	.457	.420	.751	.579	.653	.832	1.000		
12	.496	.692	.342	.364	.673	.364	.726	.805	.751	.579	.726	1.000	
13	.609	.673	.248	.497	.537	.497	.820	.769	.721	.675	.700	.805	1.000

Habitat characterization with respect to usage by Odonata

Faunistic data analysis, taking as variables the annual inventories of the distinct sites, revealed those sites with similar odonate communities as manifest by the similarity matrix (Tab. I). Posterior classification (Fig. 1) revealed the existence of three site groups:

Group 1 — site 3 and 5 (stable streams);

Group 2 — sites 7-13 (rivers) and site 2 (intermittent slightly mineralized stream);

Group 3 — sites 1 and 4 (intermittent highly mineralized streams) and site 6 (one river location).

A similarity matrix (Tab. II) was formulated using the distinct species as variables. The highest index corresponded to those pairs of species that occupied similar biotopes. A posterior classification showed the existence of three community types whose species, encompassing 71.5% of those analyzed (Fig. 2) are discussed below.

— Type 1 contained three Anisoptera, *Onychogomphus uncatus* (Charp.), *Boyeria irene* (Fonsc.) and *Cordulegaster boltoni* (Don.), species in which larval development takes several years.

— Type 2 included four Zygoptera and two Anisoptera: *Platycnemis acutipennis*, *P. latipes*, *Ischnura graellsi* Ramb., *Coenagrion lindeni* (Sel.), *Gomphus pulchellus* Sel. and *Crocothemis erythraea* (Brullé).

— Type 3 contained five short-cycle Anisoptera: *Anax imperator* Leach, *Orthetrum coerulescens* (Fabr.), *O. chrysostigma* (Burm.), *Sympetrum striolatum* (Charp.), *S. fonscolombei* (Sel.), and one zygopteran,

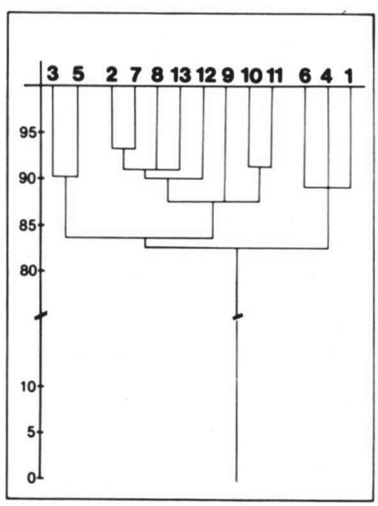

Fig. 1. Association groups between distinct sample sites.

Table II — Similarity index between species with respect to the habitats they occupy

Species																				
Calopteryx spp.	1.000																			
L. viridis	.408	1.000																		
Platycnemis spp.	.703	.461	1.000																	
I. graellsi	.384	.508	.730	1.000																
I. pumilio	.000	.421	.000	.254	1.000															
C. lindeni	.307	.576	.658	.934	.302	1.000														
C. mercuriale	.408	.000	.307	.307	.421	.23	1.000													
G. pulchellus	.576	.493	.865	.868	.000	.80	.344	1.000												
O. forcipatus	.522	.365	.578	.344	.000	.40	.36	.461	1.000											
O. uncatus	.569	.000	.272	.076	.000	.000	.666	.194	.000	1.000										
B. irene	.589	.000	.272	.076	.000	.000	666	.194	.000	.1.000	1.000									
A. imperator	.357	.578	.405	.584	.589	.654	.408	.428	.316	.000	.000	1.000								
C. boltoni	.589	.000	.272	.076	.000	.000	.666	.194	.000	1.000	1.000	.000	1.000							
O. chrysostigma	.232	.462	.461	.508	.421	.576	.462	.493	.589	.000	.000	.408	.000	1.000						
O. coerulescens	.272	.522	.357	.428	.757	.493	.522	.254	.666	.000	.000	.462	.000	.716	1.000					
C. erythraea	.076	.461	.428	.730	.462	.800	.461	.584	.408	.000	.000	.703	.000	.615	.518	1.000				
S. striolatum	.272	.522	.194	.428	.757	.493	.522	.254	.000	.000	.000	.822	.000	.522	.589	.518	1.000			
S. fonscolombei	.000	.000	.000	.254	.675	.307	.666	.194	.000	.000	.000	.589	.000	.421	.489	.462	.757	1.000		
T. annulata	.000	.000	.462	.254	.000	.307	.421	.357	.571	.000	.000	.000	.000	.666	.489	.462	.000	.000	1.000	

Ischnura pumilio (Charp.).

With respect to the remaining species, field observations indicated that *Calopteryx haemorrhoidalis* and *Coenagrion mercuriale* (Charp.) were associated with medium and highly mineralized streams (types A and B). *Lestes viridis* (Vander L), an opportunistic species, occupied the rivers and intermittent streams during the spring, their existence being independent of the existing of mineralization levels. *Trithemis annulata* (P. de Beauv.) and *Onychogomphus forcipatus* (L.) larvae were collected in a few of the river sites.

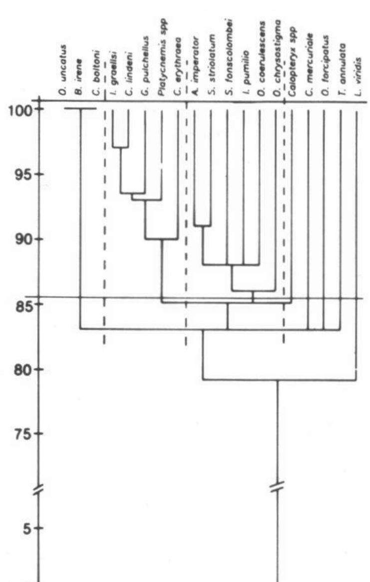

Fig. 2. Association groups between species with similar distribution.

Discussion

These mathematical considerations served as the basis for the interpretation of the odonate distribution in a segment of the Sierra Morena pertaining to the province of Cordoba and possibly other zones of this mountain range.

The river and intermittent, slightly mineralized streams (types C and D) were exploited by the type-2 communities in which there was a predominance of Zygoptera. Anisoptera communities with larval development lasting several years (type 1) were associated with stable streams (type A), while those Anisoptera communities with rapid larval development (type 3) were associated with intermittent, highly mineralized streams (type B).

An interesting observation was the preferential utilization of stable and intermittent streams by Anisoptera, while the Zygoptera preferred the rivers. The explanation of this phenomenon lies in the evident size, mobility and microhabitat differences of their respective larval forms. In the rivers, the larger, less mobile anisopteran larvae are dislodged by the sudden increase in current caused by water released from the dams. On the other hand, the zygopteran larvae, being more mobile and habitually hidden amongst the aquatic vegetation, are less likely to be dislodged by sudden current changes.

Finally it should be pointed out that in a study in the French region of Montpellier (JARRY & VIDAL, 1960) an odonate community identical to type 1 was found, utilizing biotopes with characteristics similar to type A: live, fresh and permanent water streams.

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