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OF BALKAN AND ADJACENT REGIONS**

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Structure organization and dynamics of Hemiptera-Plant communities of a mediterranean area: preliminaries and methodology

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There are several quantitative studies that compare Hemiptera with various types of plant communities in northern Europe and north America (Kontkanen 1950; Murdoch et. al., 1970; Raatikainen, 1972; Wallof & Solomon, 1973; Claridge & Wilson, 1976, 1981; Drosopoulos, 1977; Moris & Lakhani, 1979, Morris, 1982).

In the Mediterranean region this type of studies are lacking, except a few recent biogeographic attempts (Drosopoulos, 1982, 1985; Asche & Remane, 1982; Asche & Hoch, 1982; Drosopoulos & Asche, 1983; Drosopoulos et. al., 1983; D'Urso et. al., 1983; Gogala et. al., 1983; Klein & Raccach, 1983; Abdul-Nour, 1983, 1985).

On the other hand, qualitative ones give very little information on the structure and organization of Hemiptera populations on community level. In addition, simultaneous analysis of both plants and Hemiptera components are difficult to be combined since investigators focus their interest on the first or the second component according to their specialization (Claridge & Singhrao, 1978). A plant ecologist always uses the insect component under the term «biotic factor». Insect ecologists are usually more detailed confined to a record of dominant tree species, shrub species, or - in the case of grassland communities - of the dominant graminaceous species or the «mean height of vegetation», although it is generally accepted that such simple considerations are basically and largely inadequate to explain the observed variations (Claridge and Wilson, 1978, 1981; Morris, 1982;

Morris and Lakhani, 1979).

This is a result of the fact that a plant ecologist approaches the community diversity from a spatial point of view and insect, or generally, animal ecologists from a temporal point. Combined approaches would be among others mathematically elaborated and sophisticated, but they are necessary if we are aiming to explore and analyze efficiently plant-insect communities data. Actually, questions semantics and necessities in community ecology emerge more often than powerful sampling schemes, experimental designs and efficient statistical techniques. Many authors on the topic have mentioned this necessity in other words (Morris, 1982; Claridge and Singhrao, 1978), but they usually attribute this to the inadequacy of the existing theories (Strong, 1979; Southwood, 1985) and to the restricted available information on individual species preferences, host plants biochemical differences (Claridge and Wilson, 1976, 1978, 1981) and complicated presocial type behavioural interactions (Claridge and Singhrao, 1978).

Others have emphasized that observational studies can not yield conclusive insights into pattern generative processes irrespective of what mathematical technique has been used to extract information from the collected data body (Cody, 1974; Diamond, 1975; Connor and Simberloff, 1979; Wilbur and Travis, 1984). The point has been also realized by our team, nevertheless our approach is somewhat differentiated. The second point is an issue of much debate in contemporary ecology. We assess that in the

majority of formulated realistic problems, observational studies are fruitful answer seeking methods provided that we have properly evaluated the type of information gained through statistical analyses of the submitted data. It is a tradition in this discipline, an investigator to expect too much from a mere application of a statistical technique whatever it is its appropriateness sophistication or efficiency, a tendency usually generated by the great investment of time and efforts always involved in data gathering. On the other hand it may be premature to initiate a project by designing experiments in which we have focused our interest on a small set of variables disregarding the others either by eliminating them or by randomizing their occurrences over the values of the «relevant» variables (Wilbur and Travis 1984; Rathcke pers. com.). This strategy of choosing a solution seeking approach, assumes that we already know all the variables, that we have control over their entire set and that we are able to decompose their plexus into single measurable and reproducible elements. Instead of this strategy, it seems more logical and methodologically more formal to us to submit the set of collected data to a component analysis. To date this is the only objective way to select from an unknown (and perhaps indefinite) set of variables the possibly most important subset which is worth to investigate further (Greig Smith 1983).

We assess that much more attention must be paid on small scale pattern of vegetation (in a few centimeters) which represents an insect fitted scale, before any correlation between plant and insect components begins. But the data on plant component must not only cover an annual cycle of vegetation changes, but also long term changes related to successional trends. Objective successional trends seeking methods adopted from information theory are used with good results for such analyses (Orloci 1968, 1971, 1981). After the first stage in which plant data will be analyzed, a second stage will be initiated in which the whole body of Hemiptera data will enter. The following is a symbolic

matrix representation of community data after the entering of insect data body.

$M = (\text{plant sp.} \times \text{area} \times \text{time} \times \text{Hemiptera sp.})$
under the term area, which is used in the sense of a quadrat score, other alternatives can serve as input, such as environmental data specific to each quadrat or soil parameters.

The explanation of matrix M is our objective. By the word explanation is meant the detection and description of multivariate trends of responses of various species. The usefulness of multivariate methods in this process is obvious. Obvious is also the necessity of more informative and formal terms in a statistical sense, for the representation of Hemiptera and plants responses; so terms as «monophagous», «oligophagous», «polyphagous», «different types of vegetation» will be excluded in the stage of detailed description of community components interaction.

Our efforts are concentrated on this basic although inaccessible problem. One approach is that adopted by Claridge & Wilson (1978) who believe that studies on individual species may reveal several discrete types of host-plant specificity within the ecosystem. Such an approach, although feasible, assumes the independence of autecological processes, an assumption introducing a certain risk. In addition autecological studies need a trigger such as special weight attributed to the species in question. We need thus a basis to assess and extract information on the special role of each species in the integrated community. The study of individual species preferences may serve as an addendum which elucidates some very specific aspects of their biology and may give answers to the questions concerning the possible mechanisms affecting specialization on the population level. The patterns which might appear at a final stage of these studies, must be evaluated in the context of community components interaction.

Our data, though not yet completed, support these ideas. In the sequel we shall try to outline the basic procedures and our methodological framework through an

example concerning two Hemiptera species and we'll emphasize the need for autecological and synecological studies to be tightly bound.

On the basis of sweep net samples taken at various transect positions and on detailed vegetation data on plant performances, we have attempted two parallel component analyses of transect segments ordinating them in a plant species and a Hemiptera species abstract space respectively using two basically different algorithms, a principal component extracting algorithm (Orloci & Kenkel, 1985) and a multidimensional scaling one (Kruskal, 1964a,b). Two out of 20 transect positions were separated from the clusters of the remaining others in the scattergram of the ordination in a Hemipteran species space (Fig. 1 and 2). Usually these disjunct points, in the ordination techniques, are deleted prior to data analysis with the sceptic that their position is determined from information not extractable from the submitted data set (Gauch et. al., 1977; Gauch, 1982). Because of the special nature of the project and the bifid scheme of our analysis, we need more rigid ecological arguments to justify the deletion of these points. These two transect positions in the scattergram of the ordination in a plant species space are not discriminated from the clusters formed by the transect positions containing annual herbs and/or perennial grasses. Additionally these two transect positions are characterized by high numbers of the Myridae *Tuponia tamaricicola* (53 m+f) - the first - which never occurred in other positions and of the leafhopper *Melillaia matsumuri* (16 m+f) - the second - which was the only species in this position, a situation never met elsewhere. All transect positions containing *Melillaia matsumuri* also contain at least 3 additional Hemipteran species and often one or two Curculionid species in relatively high numbers. Among Hemiptera species *M. matsumuri* was the most abundant species on the samples taken after the first half of May when all annual herbs are desiccated and juiceless except the fairly abundant grass *Brachypodium*

distahyon an important element of the late summer flora, and perennial herbs, mainly the grass *Dactylis glomerata*. The second transect position is representative of these samples. An attempt to explain this pattern without knowledge of the autecology of the two Hemipterans would be a priori unsuccessful. But also, the explanation of the observed pattern on an autecological basis would be an equally reckless attempt. *D. glomerata* is a perennial grass obviously associated with *M. matsumuri* and exhibits a very complicated slow growth pattern with unsynchronized phenological responses. This is the result of competition among perennial and annual grasses and is clearly clarified for two Californian perennial grasses *Stipa pulchra* and *Poa scabrella*, and for some Mediterranean grasses (Jackson, 1985). It is certain that the accumulation of

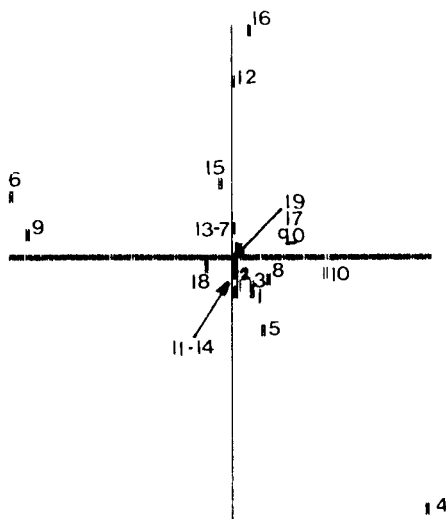


Fig. 1. Scattergram of 20 transect positions on two axes. The dimensionality of the original data is reduced in these two axes. The reduction achieved with a multidimensional scaling algorithm (see text for explanations), after 200 iterations. The characterization of the 4th and 16th transect positions as outliers is decided after the inspection of another ordination (see fig. 2). In this ordination the variables are numbers of Hemipteran species.

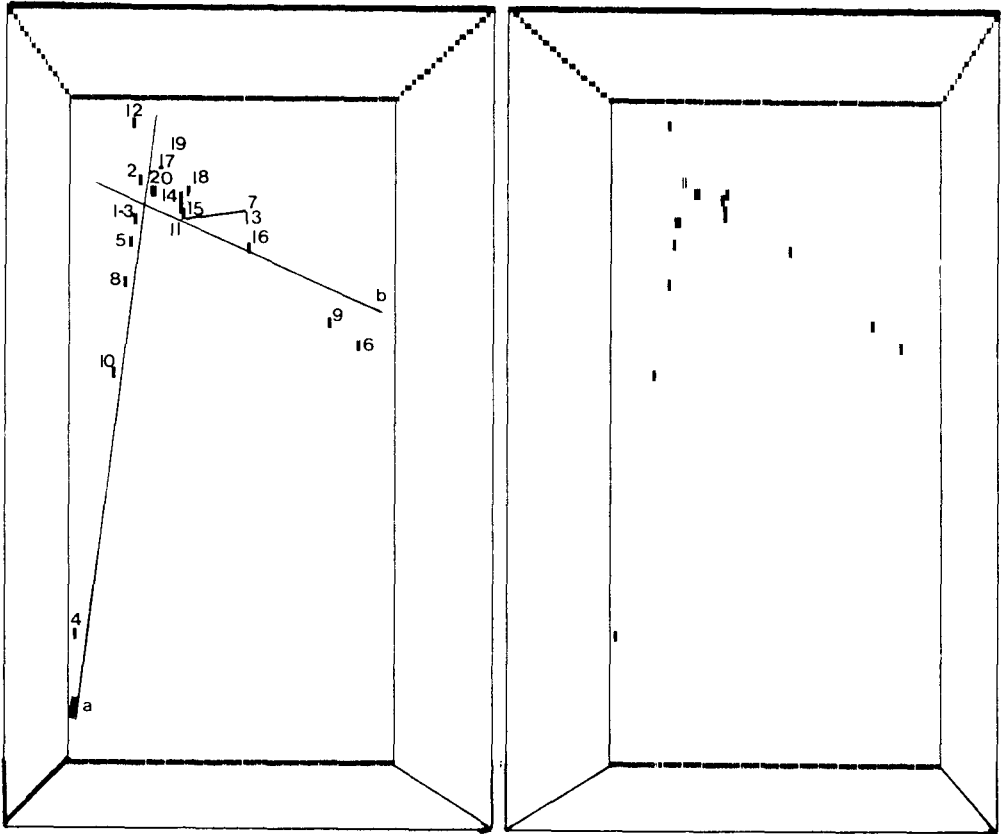


Fig. 2. Ordination stereogram of the same transect positions. A principal component analysis on a variance-covariance matrix applied of the same original data as in fig. 1. With this stereogram the characterization of the 4th and 16th transect positions is justified. These three axes explain the 93.43% of the trended variation. Two clear trends are revealed in this figure; axis a is associated with *Tuponia tamaricicola* and axis b is associated with *Melillaia matsumuri* and codominant annual and perennial grasses (for more explanations see in the text).

carbohydrate reserves occur at the end of the annual cycle of *D. glomerata* as a result of competition with annual grasses. These reserves define the apparency - sensu Feeny (1976) - of this particular plant to *M. matsumuri*. The growth of *D. glomerata* in other sites stopped quite early in the summer, but in sites with mixed populations of annual and perennial grasses the growth is much slower and the availability of the plant to the insects lasts longer. This is a feasible explanation of

the observed pattern but additional autecological studies are needed to clarify the association of *M. matsumuri* with the annual *B. distahyon*. Generally it is recognized that explanations based on phenological patterns may have a very complicated obscured basis, especially these concerning recently radiated plant taxa such as Graminae. As has been thoroughly reviewed by Rathcke & Lacey (1985) asynchronization of phenological events is common in herbaceous plants

and synchrony in shrubs and trees of temperate climates. These patterns are selected in the majority of the cases to reduce herbivory, to escape from parasitism, to regulate intraspecific competition for pollinators, to increase dispersal rates in the case of autumn fruiting shrubs and trees or to establish a mimic-model relation.

Scanning our data, pooled over all sampling dates, we have found a more or less clear association of *M. matsumuri* with these two grasses but it is not known the food and oviposition plant. There is some evidence that this species is univoltine overwintering as an egg and emerges in the late autumn on *D. glomerata* and its annual competitors such as *Bromus intermedius*, *B. mollis*, *Trifolium stellatum*, *T. angustifolium*, *T. scabrum* and *Allysum minutum*.

After the desiccation of the annual vernal flora the insect continued its development feeding on *B. distachyon* too. Adults were found on *D. glomerata* after the desiccation of *B. distachyon* but their numbers were very small for individuals occurring in pure stands with other perennial grasses such as *Poa bulbosa* and *Agrostis capillaris*. It is likely that the preference is not exhibited on a range of plant species, but on certain specific combinations of competing individuals, a situation elucidated only by the careful designing of interconnected autecological and synecological studies. The above extends the view that Hemiptera associated with grasslands are generally less plant specific, as reported by Waloff & Solomon (1973) and Claridge & Wilson (1978), and closes the rift between contrasting views based on detailed field studies on Auchenorrhyncha of grasslands which showed some considerable specificity (Drosopoulos, 1977). Additionally it introduces the possibility that evolutionary radiation in auchenorrhyncha has occurred at least twice in environments rich in tannins and lignins - Carboniferous or Permian - and in later environments rich in higher plant groups - Graminae, Compositae, Umbelliferae, Cruciferae etc - as has been suggested for Orthoptera and

Coleoptera (Bernays 1978). On the other hand *Tuonia tamaricicola* is generally accepted as a monophagous species - sensu Claridge & Wilson - on *Tamarix*. The respective transect position does not contain any *Tamarix* individual. In the area two species of this tree genus exist, *T. smyrnensis* and *T. parviflora* in a salt marsh. The closest *T. parviflora* is approximately 300 m far from the transect. Individual samples of equal size on *T. parviflora* contain fewer individuals than those taken on the transect position. Dominant herbs and low chamaephytes on this particular position are *Teucrium frutescens*, *Urginea maritima*, *Bromus hordeaceus*, *Dactylis glomerata* and *Asparagus aphyllus*. Except the grasses and Liliaceae, all the species are not only taxonomically very different but exhibit different phenologies and have unrelated chemistries and growth forms. In addition *Tamarix* is a taxonomically isolated genus of shrubs and small trees in spite of its superficial resemblance with *Salicaceae* (Hutchinson, 1969) and it is unlikely to share common insect visitors, especially Hemiptera, with typical plants of degraded mediterranean ecosystems. The necessity of a higher resolution level is clear and autecological research is a promising approach to this problem of which the only clear cut datum is the long history of the plants in the mediterranean sandy coasts and the nearby rocky soilless hills respectively.

An alternative - or rather complementary - approach would be the consideration of plants, not in a taxonomic framework but in other classificatory systems, such as the monocharacter system of growth forms. Growth forms of plants are better correlated with nutrient levels such as N and H₂O; the latter is frequently overlooked but it might have a decisive influence on the growth of larvae, as has been reported by Scriber & Feeny (1979) and Scriber & Slansky (1981). We have worked out a monocharacter system of growth forms, compatible with the system proposed by Orshan (1984) for international use and we now attempt to incorporate it into our database (Petrakis,

1986). The only impression so far is the huge amount of gaps in our knowledge on this particular theme.

Finally we decided to delete these two disjunct transect positions and we are now investigating correlations between the components of the two separated component analyses by using the theoretically promising approach of «canonical correlation analysis», a powerful technique due to Hotelling (1935, 1936), reviewed by McKeon (1965) and extended to three or more sets of variates by Kettenring (1971). The method is the multivariate analogue of the case in which correlations are sought between the amounts of one plant species and one insect species in a set of sampling units. It has been previously used for correlations between plant and Coleoptera species quantities by Tselepatioti-Petrakis (1985 unpubl.) with satisfactory results and for plant species and soil properties by Barkham & Norris (1970). In addition it has been assessed in detail, for use in ecological work, by Gittins (1979). We have not yet results to report from such analyses since that would require data covering an at least annual period.

The interpretation of the output of the analyses demands some additional studies on the biology of the most principal components of Hemiptera fauna. Special sampling methods will be devised for each under study component and its biology will be probed under field conditions.

The area of Schoenias-Cynosura, near Marathon village, favours such a research because it possesses a remarkable set of characters listed below.

- a. An extremely rich and well known flora; often more than 50 tracheophyta species per m² recorded and annotated by Petrakis (1984 unpublished).
- b. A largely unknown Hemiptera fauna initially sampled by Drosopoulos and Phardella (1984 unpublished) with some new species records for Greece, the Mediterranean and science.
- c. Peculiar topoclimatic conditions and a dramatic history documented by paleogeographical data (Creutzburg 1963) often in contrast with botanical data (Petrakis, 1984 unpublished).
- d. The area included a salt marsh with distinct zonation of vegetation with zones gradually mingled with the vegetation of neighbouring hills.
- e. The microtopography of the area is extremely heterogenous and microhabitats well differentiated exist throughout, perhaps as a result of the complex plant cover-slope process interactions.
- f. Parts of the area where subjected to many types of disturbance in various intensities, in contrast with parts accessible by flocks of sheep and goat and by men.
- g. The history of the area is well known and the main impact is more or less well documented since 2500 years ago.

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