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Relationships within the *Hyles euphorbiae*-complex: a numerical taxonomy approach (Lepidoptera: Sphingidae)

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Introduction

Hyles euphorbiae is a highly variable species. It is distributed widely across the Palaearctic region and a large number of subspecies have been described. Various authors (e.g. Ebert, 1969; Derzhavets, 1979, 1980; Pittaway, 1983) assign full species rank to some of these taxa. Most are geographically well separated although a few seem to occur in the same geographical area but are then, apparently, ecologically separated (e.g. *mauretanica* and *deserticola* in NW. Africa). All taxa have in common the fact that their caterpillars feed on various species of *Euphorbia* (Euphorbiaceae).

Larval characters are generally neglected in Lepidoptera taxonomy, usually because the larval stages are unknown or even ignored. It is of the author's opinion that larval characters are highly important in the study of the phylogenetic relationships within the *H. euphorbiae*-complex. After having reared and studied large numbers of *H. euphorbiae* from several different populations belonging to several different taxa, an attempt was made to construct a phenogram of the *H. euphorbiae*-complex based on numerical taxonomy.

Material and methods

For the purpose of this study a total of 350 adults and 150 caterpillars was examined. These specimens were grouped into 17 operational taxonomic units (OTUs) according to recognized taxa (Table 1) or locality. Only those taxa/populations from which a full set of characters was available were taken into consideration. Some taxa/populations such as subsp. *filapjewi* (Bang-Haas, 1936) from the T'ien Shan, Central Asia, subsp. *orientalis* (Ebert, 1969) from the Pamirs, Central Asia, subsp. *solida* Derzhavets, 1979, from eastern Siberia, Russia, subsp. *sinensis* (Closs, 1917) from Kanton, China, and the populations from La Palma, Canary Islands (see Harbich, 1989), southern Italy, the Aegean Islands, Greece and the Asir, Saudi Arabia (see Wiltshire, 1986), are therefore not represented in this study.

From each OTU, 14 characters were examined. As larval characters were considered to be of equal importance to adult characters, seven are based on larvae (mostly last instar, L5) and seven on adults. The characters used are as follows.

Adults

1) Width of the forewing subterminal fascia at the inner margin in relation to the total width of the inner margin. Corresponding with Quotient Q4 of Harbich (1988).

2) Number of black spots on the abdomen.
3) Appearance of white rings at the end of the abdominal segments.
4) Darkening of the forewing costa, completely, partly or not obscuring costal spots C1, C2 and C3.
5) Veins running through subterminal fascia coloured white or not.
6) Tegulae bordered white or not.
7) Colour of underwings.

Caterpillars

8) Shape of ocelli in the dorsolateral (upper) row.
9) Shape of ocelli in the lateral (lower) row, if present.
10) Intensity of white speckling in the black dorsal and lateral bands.
11) Appearance of the coloured dorsolateral band, if present.
12) Colour of caudal horn.
13) Colour of dorsolateral band.
14) Colour of freshly hatched L1 larva.

The data were processed using numerical phenetic techniques (Sneath & Sokal, 1973) with the aid of the NTSYS-pc (1990) program by F. J. Rohlf (Applied Biostatistics Inc.), giving a phenogram representing taxonomic distance on the similarity coefficients.

Results and discussion

The results are presented in Fig. 1. The taxa *peplidis* and *robertsi* are so close that it is probably best to consider *peplidis* a synonym (**syn. n.**) of *robertsi*. In the same manner, *balearica* is best considered a synonym (**syn. n.**) of *dahlii* while the Cape Verde population is best placed within *tithymali*. Whether the taxon *vandalusica* is to be considered a synonym of *euphorbiae* as suggested by de Freina & Witt (1984) is open to debate; they argued that *vandalusica* presented just one of the many differently coloured morphs that occur in most *H. euphorbiae* populations. The phenogram presented here, based on characters other than colour alone, suggests that the Iberian population, although very close to nominate *euphorbiae*, does deserve subspecific status and the taxon *vandalusica* should therefore be recognised as valid.

Furthermore the phenogram places the taxon *nervosa* in a very isolated position and it is therefore best considered a full species (**stat. n.**). The taxon *costata* is also set apart but still close enough to be considered a subspecies of *H. euphorbiae*. More study is definitely needed to define the exact status of this Far East taxon.

For the remainder of the taxa/populations, there is a '*euphorbiae*' group with a cluster of the subspecies *euphorbiae, vandalusica* and *conspicua* and a separate branch formed by *robertsi*. Then there is the '*tithymali*' group with three main branches. The most important one is formed by the subspecies *tithymali, desertícola, himyarensis, mauretanica* and *gecki*. The last two taxa are clearly very close but also distant enough to be recognized as separate subspecies. The second branch is formed by the populations on Malta and Crete, that are quite distinct

and definitely deserve subspecific status. The third branch is formed by the single subspecies *dahlii*.

This result is largely in concordance with earlier views of the author (Meerman, 1991), which were largely based on 'intuition'. The most noticeable difference between the phenogram presented in this study and the author's earlier 'intuitive phenogram' is the placement of the *mauretanica, gecki* pair within the main '*tithymali*' branch.

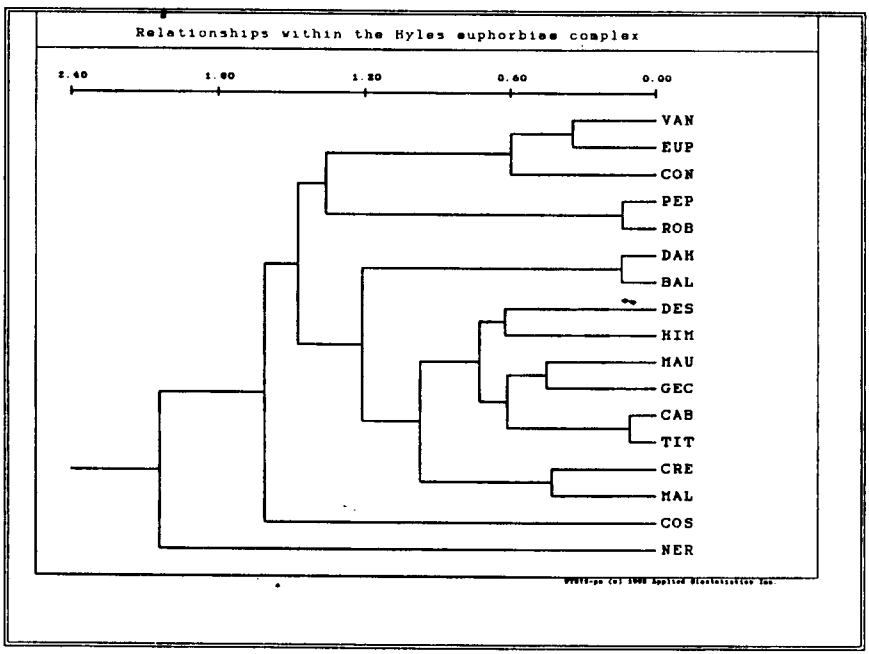

Fig. 1. Phenogram showing relationships within the *Hyles euphorbiae*-complex. At the X-axis taxonomic distance, at the Y-axis the 17 OTUs. VAN = taxon *vandalusica*, representing all specimens from the Iberian peninsula. EUP = taxon *euphorbiae* s. str., representing specimens from France, Germany, Poland, Switzerland, northern Italy, Bosnia, Austria, Hungary and Russia. CON = taxon *conspicua*, representing specimens from Turkey, Syria, Lebanon and Israel. PEP = taxon *peplidis*, representing specimens from NE. Iran and Turkmenistan. ROB = taxon *robertsi*, representing specimens from Iran, Afghanistan, Pakistan and Turkmenistan. DAH = taxon *dahlii*, representing specimens from Corsica and Sardinia. BAL = taxon *balearica*, representing specimens from Mallorca. DES = taxon *deserticola*, representing specimens from Tunisia and Algeria. HIM = taxon *himyarensis*, representing specimens from Yemen. MAU = taxon *mauretanica*, representing specimens from Algeria and Morocco. GEC = taxon *gecki*, representing specimens from Madeira. CAB = population from the Cape Verde Islands representing specimens from Fogo and Santo Antao. TIT = taxon *tithymali*, representing specimens from Tenerife, Gran Canaria, Hierro and Fuerteventura (all Canary Islands). CRE = population from Crete. MAL = population from Malta. COS = taxon *costata*, representing specimens from NE. China (taxon *exilis* sensu Derzhavets, 1979). NER = taxon *nervosa*, representing specimens from Himachal Pradesh (India) and NE. Afghanistan.

Obviously this result is influenced by the choice of characters. In this study every character has the same significance and the external habitus of the larva weighs just as strongly as the external habitus of the adult. Had unequal numbers of characters been used for larval and adult stages, the results would have been somewhat different. The choice of the characters used was determined by availability in dead (museum) specimens or in literature. Some characters such as character 14 are rarely available in the literature or in museum specimens and usually could be obtained only through breeding experiments. These are also the only source of other possibly important characters that could not be used here, such as size and colour of the egg, as suggested by de Freina (1991), or colour changes during the moult from L4 to L5. The caterpillars of the taxa *vandalusica, euphorbiae* and *conspicua* change colour after the moult from L4 to L5, but those belonging to the Crete population and the taxa *dahlii, himyarensis, tithymali* do not (Meerman & Smid, 1988). Also differences in mating behaviour of the adult are probably important. Of the Crete population it is known that mating takes place at a different time of night compared to the few other taxa/populations of which the mating time is known. This difference in mating time actually forms an effective reproductive barrier (Meerman & Smid, 1988). An important morphological character not used here might be the configuration of spines on the first tarsal segment of the front legs in the adult, as suggested by Ebert (1969). Electrophoresis studies have never been conducted but the results of such research would obviously be very helpful in fine-tuning the present phenogram. The male genitalia of the various taxa are very similar and of little use in the taxonomy of the *H. euphorbiae*-complex (Meerman, 1988).

Table 1. List of taxa within the *Hyles euphorbiae*-complex represented in this study.

euphorbiae (Linnaeus, 1758)
vandalusica (Rebel, 1910)
conspicua (Rothschild & Jordan, 1903)
dahlii (Geyer, [1828])
balearica (Rebel, 1926). Placed in synonymy (**syn. n.**) with *dahlii*.
tithymali (Boisduval, 1834)
himyarensis Meerman, 1988
deserticola (Bartel, 1899)
gecki De Freina, 1991
mauretanica (Staudinger, 1871)
robertsi (Butler, 1880)
peplidis (Christoph, 1894). Placed in synonymy (**syn.n.**) with *robertsi*.
nervosa (Rothschild & Jordan, 1903). Raised to full species rank (**stat. n.**).
costata (Nordmann, 1851)

The southern Italian populations have not been considered in this study mainly because there is hardly any material from the early stages available. Based on descriptions and on the little material that is available (Meerman & Smid, 1988), it has to be assumed that the southern Italian or at least the Sicilian populations represent a separate subspecies, which would mean reviving the subspecies *strasilai* (Stauder, 1921) or *rothschildi* (Stauder, 1928). This subspecies would

then probably have to be placed in the Crete, Malta branch of the '*tithymali*' group. Similar populations may be expected in the Aegean. Breeding experiments involving material from these areas are needed to establish the exact status of these populations.

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