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VARIABILITY OF MORPHOLOGICAL CHARACTERS AND ITS USE IN THE SYSTEMATICS OF MEALYBUGS (HOMOPTERA: PSEUDOCOCCIDAE)

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ABSTRACT

Intraspecific variations in morphological characters are common in mealybugs. Their incorrect or superficial interpretation has often led to proliferation of synonyms and neglect of studies on the possible existence of cryptic or sibling species. Intraspecific variation was studied in three species of *Puto* Signoret, namely *P. superbus* (Leonardi), *P. tauricus* (Borchsenius) and *P. pilosellae* (Sulc). *Puto superbus* is distributed in the Mediterranean region and Central Europe. Adult females are considered to differ from those of *P. tauricus* only by the absence of dorsal tubular ducts on or near the cerarian plates. Populations of supposedly both species have been collected at several localities in Central and Southern Italy and found to cohabit the same niche at four collecting sites. At one locality, near Potenza (Southern Italy), these species were collected systematically from 1989 to 1993, being found on the same host plant and exhibiting the same phenology. A taxonomic discrimination between these species was possible only after a study of adult females mounted on microscope slides. Among 315 adult female specimens the number of dorsal tubular ducts varied from 0 to 38. Only 26% of the specimens possessed more than 18 dorsal ducts, which is regarded as the lower range of this character in *P. tauricus.* These findings suggest that the use of morphological characters alone is not reliable enough for discrimination between *P. superbus* and *P. tauricus*, and further biological studies are required to assess their effective degree of evolutionary divergence.

P. pilosellae is a polyphagous mealybug, widely distributed in the Palearctic region. The presence of a single circulus on the fourth abdominal segment of the adult female was regarded as characteristic of this species. However, a study of 34 females from Southern Italy revealed the presence of a second circulus in two specimens. The second circulus is circular, very small and situated on the fifth abdominal segment. The occurrence and number of circuli and their use as a fundamental taxonomic character is critically discussed.

KEY WORDS: Coccoidea, Pseudococcidae, *Puto*, intraspecific variation, tubular ducts, circulus.

INTRODUCTION

"The Pseudococcidae are extremely diverse, and such make the work of systematists truly challenging, forcing us to often use such qualifying terms as almost, normally, most, often, usually, etc." (Kosztarab and Kozar, 1988). The use of these equivocal terms is often a consequence of the strong intraspecific variation of morphological characters currently used in the taxonomy of mealybugs.

The taxonomy of mealybugs (Homoptera: Pseudococcidae) is fundamentally based on external morphology, particularly of the adult female, whereas nymphal stages and adult males have rarely been considered. The occurrence of cerarii as well as the shape and distribution of different types of external orifices of wax-producing ducts and pores are commonly used characters. These characters are conventionally drawn on a map-like illustration, that is a main tool used traditionally for mealybug identification.

During recent years, intraspecific variability in mealybugs has been evaluated by comparing specimens from different geographical regions or living on different host plants.

This paper presents a study on intraspecific morphological variation in three species of *Puto* Signoret, namely *P. superbus* (Leonardi) and *P. tauricus* (Borchsenius) on the one hand and *P. pilosellae* (Šulc) on the other.

MATERIAL AND METHODS

Puto superbus (Leonardi) and *P. tauricus* (Borchsenius) were collected at several localities in Central and Southern Italy, cohabiting the same niche at four collecting sites. At one locality, near Potenza (Southern Italy), both species were collected systematically from 1989 to 1993, being found on the same host plant and exhibiting the same phenology.

The collecting area, Monte li Foi (1200 m above sea level) extends for about 600 m^2 along the borders of a *Quercus cerris* forest. The specimens were collected only on *Arrhenatherum elatius*. Following the first record in June 1988, about 100 specimens were collected annually in June. A total of 513 specimens were collected during five years and mounted on microscope slides. Only 315 specimens collected in 1989–1991 have been examined so far. In 1992, a study on the life history, with bimonthly or monthly sampling, was also carried out.

The specimens of *P. pilosellae* (Šulc) were collected in June 1988, on the Tyrrhenian Sea coast, at Capo Palinuro (Salerno Province, Southern Italy), on two heavily infested plants of *Daucus carota*.

Body segmentation is designated according to Ferris (1950) and McKenzie (1967). The system of cerarii numbering used here follows that of De Lotto (1975, 1977) and Tranfaglia (1981) in beginning from the anal lobes. A diagrammatic illustration showing the morphological characters of the adult female of the *P. superbus* group used in this work is given in Marotta and Tranfaglia (1993).

RESULTS

Tubular ducts in *Puto superbus* (Leonardi, 1907) and *P. tauricus* (Borchsenius, 1948)

Adult females of *P. superbus* differ from those of *P. tauricus* only by the absence of dorsal tubular ducts on or near the cerarian plates (Borchsenius, 1948, 1949; Tereznikova, 1975; Marotta and Tranfaglia, 1993). The two species can not be distinguished from each other either by the external appearance of the adult female and male, or by the young mobile instars and by their phenology (Marotta, unpublished data).

The frequency distribution of dorsal tubular ducts (Fig. 1) varied from 0 in 221 specimens (70%), which are here regarded as *P. superbus*, to 38 ducts.

The lectotype and paralectotype of *P. tauricus* have 29 and 18 dorsal tubular ducts,

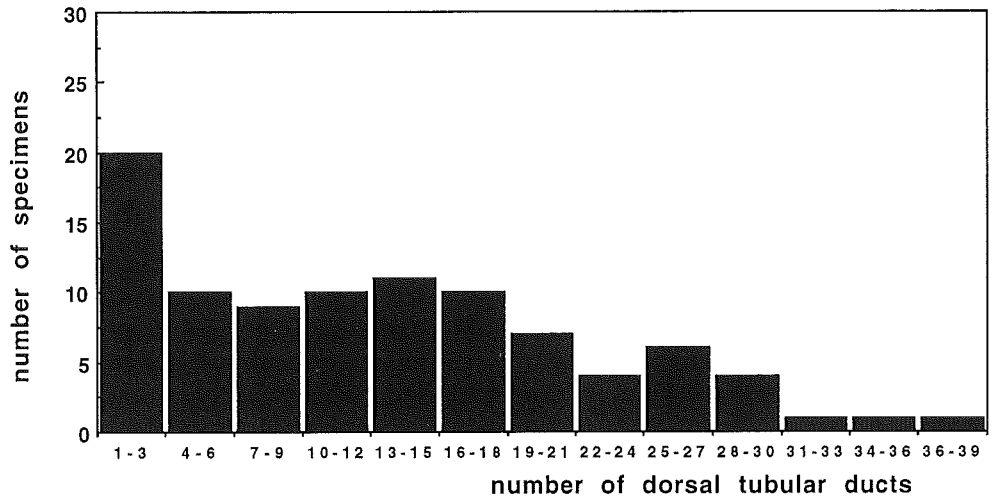

Fig. 1. *Puto* spp. (Potenza, Italy): frequency distribution of dorsal tubular ducts on main marginal cerarii of both sides.

respectively (Marotta and Tranfaglia, 1993). The latter figure was regarded as the lower range of tubular ducts in *P. tauricus*. Consequently, among the 94 specimens with tubular ducts from Potenza, Italy, only 26% possessed more than 18 ducts and are here identified as *P. tauricus*. They represent 7.6% of the total (24 out of 315). The remaining 70 specimens could not be included morphologically in any species.

We also observed a remarkable asymmetry in the bilateral distribution of the tubular ducts on each specimen (Fig. 2). There were few specimens in which the ducts were present on

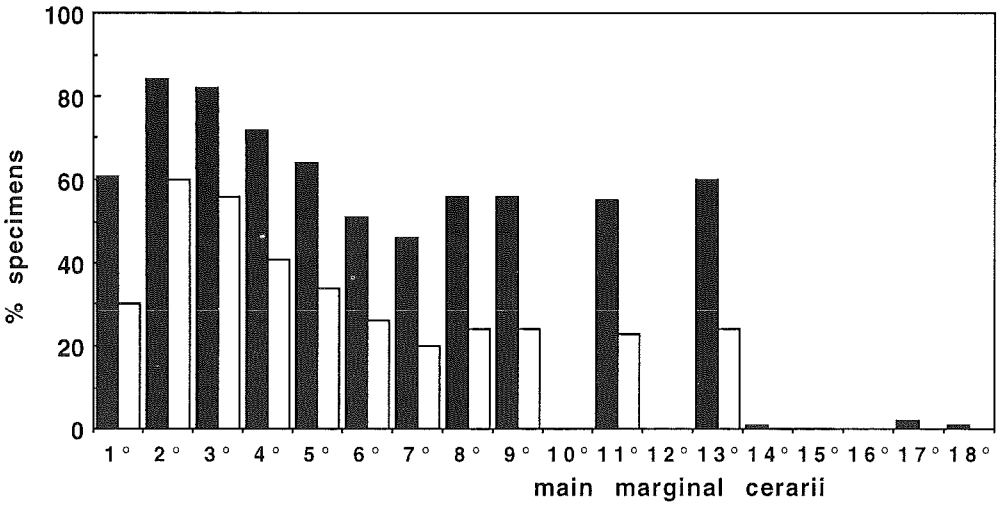

Fig. 2. *Puto* spp. (Potenza, Italy): percentage of specimens with dorsal tubular ducts on both margins (black) and within each pair of cerarii (white).

corresponding cerarii of both margins. It should be noted that no ducts were present on cerarii X, XII, XV and XVI.

All the ducts were of the simple tubular type, without a sclerotized oral collar, but varied in size. Their length varied from 0.015 to 0.026 mm and their width from 0.004 to 0.009 mm. The length/wide ratio ranged from 2.14 to 4.0.

A second circulus in *Puto pilosellae* (Šulc, 1898)

The presence of a single circulus on the fourth abdominal segment of the adult female of *P. pilosellae* is generally regarded, in available taxonomic redescriptions, as characteristic of the species. We studied 34 females of *P. pilosellae* from Southern Italy, collected on *Daucus carota*, and found that a second circulus was present in two specimens. The second circulus is circular, very small, about 0.025 mm in diameter and situated on the fifth abdominal segment.

DISCUSSION

Puto superbus is a polyphagous giant mealybug, distributed in the Mediterranean region and Central Europe. It is common on grasses in Central and Southern Italy, mainly in shaded area. Its life history and taxonomic features were described recently (Marotta, 1992; Marotta and Tranfaglia, 1993). *P. tauricus* is a poorly known species, reported from the Ukraine, China, Greece and Italy. Its taxonomic redescription was given recently (Marotta and Tranfaglia, 1993).

P. pilosellae is a polyphagous mealybug, widely distributed in the Palearctic region. Its occurrence in Italy, taxonomy and new data on morphological variability were recently reported (Pellizzari Scaltriti, 1989; Marotta and Tranfaglia, 1993).

The separation between closely related species in mealybugs was based on quantitative morphological differences, such as the number of the various types of pores and ducts in different positions on both body sides. The extent of phenotypic variation was established by using specimens from different countries living on the same and on different host plants. For example, the number of circuli in *Phenacoccus aceris* (Signoret) varies from two to five. This was assessed on specimens from different regions of its Transpalearctic distribution (Danzig, 1970). The study revealed an individual and clinal variation in the number of circuli (Danzig, 1970). The examined material also included type specimens of other described species, which proved to be synonyms of *Ph. aceris*.

Cox and Ben-Dov (1986) showed that the number of modified dorsal tubular ducts present on the abdomen of *Planococcus vovae* (Nassonov) specimens from different geographical areas varied from 13 to 110. Specimens from northern Europe had the highest number of this kind of ducts, while those from eastern Mediterranean countries possessed a lower number.

Williams (1987) reported unique morphological variations (i.e. distribution of multilocular pores, number of cerarii), in several *Phenacoccus* species characterized by the presence of dorsal multilocular pores. The examined specimens were from different regions.

More examples of intraspecific variation were reported in *Planococcus citri* (Risso) and *Pl. minor* (Maskell), *Pl. ficus* (Signoret) and *Pl. halli* Ezzat and McConnell, *Phenacoccus manihoti* Matile Ferrero and *Ph. herreni* Cox and Williams, *Pseudococcus affinis* (Maskell) and *Ps. maritimus* (Ehrhorn), *Euripersia tomlini* (Newstead) and *Chorizococcus rostellum* (Lobdell).

The intraspecific variability in some of the above-mentioned species has been studied by multivariate analysis using field-collected specimens from different host plants and locations and specimens obtained from single-female line cultures and reared under different controlled environmental conditions (Cox, 1981, 1983; Cox and Williams, 1981; Cox and Wetton, 1988). Rearing the cultures at a range of temperatures corresponding to different geographical and environmental conditions, it was possible to induce considerable morphological variation, such as a tendency of the number of several structures, e.g. pores and ducts, to decrease with increasing temperature. In this way, the limits of the environmentally induced variation are found, enabling a better appreciation of genetic variation (Cox and Williams, 1981).

In many species the morphological variation had also overlapping areas, so that the separation between two species was possible only by examining many specimens. Often the extent of variation within a given species could not be demonstrated in a single illustration: the differences were so striking, that it was necessary to illustrate different specimens.

The identification of cryptic or sibling species has been achieved by using non-conventional taxonomic methods, such as cytology, sperms, chemotaxonomy and serological and electrophoretic techniques. Works with these methods were briefly reviewed by Miller and Kosztarab (1979) and Williams (1985). The use of species-specific parasites has been another helpful non-conventional method (Rosen and De Bach, 1977).

Our study raises the question whether *P. superbus* and *P. tauricus* are two distinct species or represent sampled populations of a highly polymorphic species. In the first case, the samples that we have studied probably include specimens from two sympatric populations and the individuals showing a fewer or higher number of tubular ducts than that in the parent population could be sterile F1 hybrids. In the second case, all the 315 specimens would be ascribable to *P. superbus*, and *P. tauricus* would be considered its junior synonym.

These findings suggest that morphological characters alone are not reliable enough to discriminate between *P. superbus* and *P. tauricus*, as well as between other closely related species, and further biosystematic studies are required to assess their degree of evolutionary divergence.

These results also indicate that the taxonomic significance of tubular ducts in mealybug taxonomy should be critically re-evaluated. How many genera and species are simply separated by the presence/absence of tubular ducts? How many species are differentiated only by little numerical differences of this character?

The occurrence of a second circulus in a species that was supposed to possess normally one is not rare in mealybugs. There are species that have specimens with or without circulus (*Anisococcus ephedrae* McKenzie, *Dysmicoccus hypogaeus* Williams, *Erium globosum* Williams and *Saccharicoccus penium* Williams), whereas other species (*Balanococcus boratynskii* Williams, *Chorizococcus socialis* Brain, *Euripersia tomlini* Newstead and *Phenacoccus aceris* Signoret) have a variable number of circuli. The use of the circulus has been emphasized in the past and it may be a double-edged weapon when we utilize this character in keys to genera and species. A key that uses "Circulus absent/Circulus present" or "One circulus/Two or more circuli" might be misleading. In addition this study indicates that a key developed on morphological characters of specimens from a certain country should be critically employed when studying specimens from another country.

CONCLUSIONS

The ideas presented here may also be extended to other morphological characters and therefore to other taxa of mealybugs. Intraspecific variability studies and experiments on field-collected specimens and on populations reared in a controlled environment have shown that there is a correlation between environmental conditions and morphological characters. Generally, in specimens from warmer regions or reared at high temperatures there is a reduction in the number of pores and ducts. Our studies as well as others have shown that there is a remarkable variability in specimens collected in the same area.

Is it sufficient to utilize only morphological discrimination to establish that two morphologically close populations are really two distinct biological entities? How many taxa are now only morphologically regarded as separate species and are awaiting further biological investigations? How many closely related genera are regarded as distinct, although it is very likely that their discrimination is not based on a sound scientific approach?

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