BRILL Insect Systematics & Evolution 45 (2014) 303–350 brill.com/ise

Taxonomic delimitation in color polymorphic species of the South American grasshopper genus *Diponthus* Stål (Orthoptera, Romaleidae, Romaleini)

Martina E. Pocco[a,b,*], M. Celeste Scattolini[c], Carlos E. Lange[a,d] and María Marta Cigliano[a,b]

[a]Centro de Estudios Parasitológicos y de Vectores (CEPAVE), CCT La Plata, CONICET,
La Plata, Argentina
[b]División Entomología, Museo de La Plata, Universidad Nacional de La Plata, Argentina
[c]Facultad de Ciencias Veterinarias, Universidad Nacional de La Plata, Argentina
[d]Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CICPBA),
Buenos Aires, Argentina
*Corresponding author, e-mail: martinapocco@fcnym.unlp.edu.ar

---

Abstract

The South American genus *Diponthus* Stål comprises species with cryptic and probably aposematic colorations. It belongs to a group of grasshoppers, tribe Romaleini, where color polymorphism is common. Morphometric techniques were used to clarify the taxonomic limits and status of six nominal species of *Diponthus*: *D. permistus* (Serville), *D. argentinus* Pictet & Saussure, *D. pycnostictus* Pictet & Saussure, *D. communis* Bruner, *D. pictus* (Bolivar) and *D. schulzi* Bruner. Results of cluster (CA) and principal component (PCA) analyses showed that *D. pycnostictus* can be defined by a unique combination of characters, while the remaining nominal species represent different color morphs of a single taxon, here recognized as *D. argentinus*. We also used statistical analyses to examine whether the discontinuities in body coloration of the polymorphic *D. argentinus* could be explained by geographic variation. The distribution patterns of body coloration of *D. argentinus* do not appear to be restricted to any particular biogeographic region and no character correlation resulted with latitude. Furthermore, the results show that color morphs display high levels of overlap across the geographic range, as well as intra-population variation. We conclude that in *D. argentinus* body coloration varies considerably across the geographic distribution range but without any noticeable color gradient correlated with the latitude. According to the phylogenetic species concept (PSC) we consider *D. pycnostictus* Pictet & Saussure and *D. argentinus* Pictet & Saussure as valid species. The following synonymies are proposed under *D. argentinus*: *D. communis* Bruner **n. syn.**, *D. schulzi* Bruner **n. syn.**, *D. pictus* (Bolivar) **n. syn.**, and *D. permistus* (Serville) **n. syn.** We declare *D. permistus* (Serville) a *nomen oblitum*.

Keywords

Color polymorphism; grasshoppers; species delimitation; cluster analysis; principal component analysis

DOI 10.1163/1876312X-45012108

Introduction

Intraspecific variation in body coloration is frequently found among insects. In grasshoppers the occurrence of different color morphs is a commonly observed phenomenon. In this group of insects, chromatic polymorphism may be determined genetically or by environmental factors (Rowell 1970; Pener 1991; Colvin & Cooter 1995; Lecoq & Pierozzi 1996; Tanaka 2008), or may be influenced by a combination of genetic and environmental cues (Rowell 1971; Dearn 1990; Hochkirch et al. 2008).

Regarding environmentally controlled chromatic polymorphism in grasshoppers, at least three factors have been shown to affect coloration (Rowell 1971; Dearn 1990). Humidity can influence coloration in species with green-brown color dimorphism (Rowell 1971; Rowell & Cannis 1972). In some grasshoppers high humidity and fresh grass favor the green morph (Okay 1956; Rowell 1970, 1971; Rowell & Cannis 1972; Otte & Williams 1972). In other grasshoppers the change from brownish to increasingly green coloration varies with season and sexual maturity, the latter coinciding with the rainy season (Lecoq & Pierozzi 1996). Temperature also can affect the coloration in some grasshopper species (Colvin & Cooter 1995; Key 1954; Key & Day 1954; Tanaka 2008). In others the microhabitat/substrate coloration appears to be the most important environmental factor influencing body coloration (Rowell 1970, 1971; Dearn 1990; Hochkirch et al. 2008). An extreme case of homochromic response has been found in some grasshoppers, where the frequency of black individuals increases when they inhabit previously burnt areas (Rowell 1971; Karlsson et al. 2008; Forsman et al. 2011).

In locusts, phase polymorphism (polyphenism) has been extensively studied (Uvarov 1966; Pener 1991; Pener & Yerushalmi 1998; Simpson et al. 1999, 2002; Sword et al. 2000), and it is considered to constitute density-dependent phenotypic plasticity (Pener 1991; Pener & Yerushalmi 1998; Simpson et al. 1999, 2002, 2005; Simpson & Sword 2008). Sword (1999) demonstrated the first case of density-dependent warning coloration, in the grasshopper *Schistocerca lineata* Scudder. Nymphs of this species also exhibit a host plant association; they are associated with specific host plants in different geographically and genetically distinct populations (Sword & Dopman 1999). Nymphs of *Ptelea trifoliata*-associated populations are green at low densities, but become yellow and black at high density, deriving gut-content mediated toxicity to predators by consuming the host plant (Sword 2001). According to Sword et al. (2005), host plant ecological divergence and genetic differentiation was also found in the grasshopper *Hesperotettix viridis* (Thomas).

Within the tribe Romaleini, several species exhibit intraspecific variation in body color. Carbonell (2007) highlights the existence of color gradients in *Zoniopoda tarsata* (Serville); specimens from central Argentina, the southernmost of its geographic range, are lighter-colored while northern specimens from Bolivia and Brazil are darker and more brightly colored; he also observed an east to west coloration gradient. *Chromacris speciosa* (Thunberg), widely distributed in South America, also exhibits geographical variation of body color, and coloration also varies within local populations (Roberts & Carbonell 1982). *Tropidacris collaris* (Stoll) is also a highly color variable species, and this variation is determined mostly by ecological conditions which in turn may have geographical causes; individuals from humid places are green while those from drier areas are brown (Carbonell 1986).

Most of the Romaleini genera distributed in South America have been revised (Roberts & Carbonell 1982, 1992; Carbonell 1984, 1986, 1996, 2004, 2007; Descamps & Carbonell 1985) except for the genus *Diponthus*, whose species, aside from *D. argentinus*, are known only from their original descriptions. The genus *Diponthus* Stål, one of the largest within the tribe, comprises species with cryptic colorations and most of them exhibit contrasting patterns of stripes and spots, while their nymphs usually show striking (probably aposematic) coloration. It is endemic to southern South America, distributed across central and northern Argentina, Uruguay, southern Brazil, south-eastern Paraguay and south-eastern Bolivia. Nineteen species have been recognized for the genus. Of the twelve species occurring in Argentina, six cannot be easily distinguished: *D. permistus* (Serville), *D. argentinus* Pictet & Saussure, *D. pycnostictus* Pictet & Saussure, *D. communis* Bruner, *D. pictus* (Bolivar) and *D. schulzi* Bruner. They lack differences in the morphological characters from tegmina venation, male terminalia and genitalia, and color pattern that are useful to identify the remaining *Diponthus* species. Most of the characters used to distinguish members of this group are either quantitative and show considerable overlap, or consist of differences in coloration. However, coloration varies geographically as well as within local populations, as recent surveys revealed.

The aim of this study is to clarify the limits and status of the six nominal species mentioned above by using morphometric techniques. We also analyze the geographic variation of body coloration within the group.

Materials and methods

Specimens

A total of 303 specimens (197 males and 106 females) were examined, including type specimens of all nominal species except for *D. permistus*, the type of which is lost. Specimens were tentatively assigned to each nominal species (*D. permistus*, *D. argentinus*, *D. pycnostictus*, *D. communis*, *D. pictus* and *D. schulzi*) and to one chromatic morph that did not match any of the original species descriptions of *Diponthus*. The examined specimens covered the entire distribution range of the group.

Most material examined originated from several collecting trips (surveys) conducted recently by the authors in Argentina, deposited at Museo de La Plata, Argentina (MLP). Other specimens examined were deposited at the following institutions: Museo de La Plata, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Argentina (MLP); Facultad de Ciencias, Universidad de la República, Montevideo, Uruguay (FCMU); Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Argentina (MACN); Instituto Fundación Miguel Lillo, Argentina (IFML); Instituto de Investigación de Zonas Áridas, Argentina (IADIZA); Instituto de Biología

Subtropical, UNaM-CONICET, Misiones, Argentina (IBS); Museu de Zoologia da Universidade de São Paulo, Brazil (MZSP).

Specimens were relaxed in a humid chamber and male terminalia moistened with ammonia. Genitalia then were pulled off from the body using a finely hooked pin, cleared in potassium hydroxide and stored in glycerine. Photographs of morphological characters were captured with a Canon EOS Rebel digital camera. Images of tegmen and male genitalia were captured with a Micrometrics digital camera attached to a Nikon SMZ1000 stereomicroscope. The program Combine Z5.3 (Hadley 2006) was used for focus stacking.

Morphological characters and data matrices

Character screening was based on the original descriptions of the six nominal species of *Diponthus* (*D. permistus*, *D. argentinus*, *D. pycnostictus*, *D. communis*, *D. pictus* and *D. schulzi*) and own observations. Data matrices consisted of 197 male specimens (Table B1 in Appendix B, which can be viewed in the online edition of this journal, accessible via http://booksandjournals.brillonline.com/content/journals/1876312x, Matrix A) and 106 female specimens (Table B2 in Appendix B, Matrix B) by 19 morphological characters (Appendix A); from which 5 were quantitative continuous and the remaining 14 characters correspond to qualitative chromatic characters. Morphometric characters were measured by the same person with high precision calipers. Coloration of specimens was recorded in the field and/or from photographs of live specimens. Discolored specimens were disregarded for the analysis.

Multivariate analyses

The data matrices were analyzed by a cluster analysis using the unweighted pair-group average method (UPGMA) and general similarity coefficient of Gower. Cluster Analysis (CA) was conducted in PAST v. 2.17b software (Hammer et al. 2001). Specimens assigned to the six nominal species and to one undescribed greenish-brown color morph of *Diponthus* analyzed in this study that did not cluster together in the CA, were then analyzed by Principal Components Analysis (PCA) using the Pearson correlation coefficient, in order to discover groups of specimens with unique combination of character states. PCA analyses were conducted using XLSTAT v. 2008 7.03. Missing data was replaced by the mean values.

Multivariate statistical methods were used to delimit groups of specimens, including morphological and chromatic characters that would represent all the variation observed in the specimens. Groups of specimens defined by unique combinations of qualitative character states were identified according to the phylogenetic species concept (PSC) of Nixon & Wheeler (1990) as modified in population aggregation analysis (PAA) by Davis & Nixon (1992) and Henderson (2004, 2005).

Geographic distribution

To analyze the geographic variation of the nominal species, the biogeographic province where each specimen was collected was indicated in the dendrograms and in the PCA plots. The biogeographic provinces considered in this study, following Cabrera & Willink's (1973) scheme (Fig. 13), were: Chaqueña (Ch), Espinal (Es), Monte (Mo), Pampeana (Pm) and Yungas (Yu).

Species distributions were mapped with ArcGis10.1 (ESRI) using latitude and longitude data for each specimen. Information from those museum specimens lacking locality records could not be included in the geo-referenced maps.

Statistical analyses of the geographic variation of body coloration

A two-way ANOVA (on arcsine transformed variable) was conducted to test differences between the proportions of each color morph of *D. argentinus* in each biogeographic province. Levene's test ($p > 0.05$) was used to evaluate the homogeneity of variance. For the analysis of variance, we considered only those color morphs that were represented by more than 10 specimens.

The association between character values or the PCA components and latitude and longitude was evaluated using the Pearson correlation coefficient (r), as implemented in Salariato et al. (2012).

Electronic content and hyperlinks

This study includes hyperlinks to the Orthoptera Species File (OSF) online (http://orthoptera.speciesfile.org) (Eades et al. 2013) following procedures described in Cigliano & Eades (2010). It also implements Life Science Identifiers (LSIDs), which are globally unique identifiers used for biodiversity data and provide a way to track and find metadata of taxa entities on the internet. Taxon LSIDs provided by OSF have been included in this study.

Results

Morphometric analyses

The dendrogram resulting from the cluster analysis (CA) conducted on Matrix A splits the male specimens into seven groups at an arbitrary distance level of 0.24 (Fig. 1). Only one group (Group V) comprised all the specimens assigned to the nominal species *D. pycnostictus*. The remaining groups (G) included specimens from different nominal species: GI included three specimens of the nominal species *D. argentinus* and *D. pictus*; GII grouped most of the specimens of the nominal species *D. schulzi*; GIII clustered specimens of the greenish brown morph F; GIV included specimens of the greenish brown morph and one specimen identified as *D. pictus*; GVI consisted of specimens identified as *D. permistus*, *D. argentinus* and two specimens of *D. schulzi*; and GVII consisted of two subgroups: one (SGVII1) included specimens of *D. argentinus* and *D. pictus*, and the other one (SGVII2) grouped specimens assigned to *D. argentinus*, *D. pictus*, *D. communis* and specimens identified as *D. permistus*.

The Principal Component Analyses (PCA) conducted on all specimens other than *D. pycnostictus* that did not conform homogeneous groups in CA, showed that only some specimens assigned to the nominal species *D. schulzi* were separated from the big

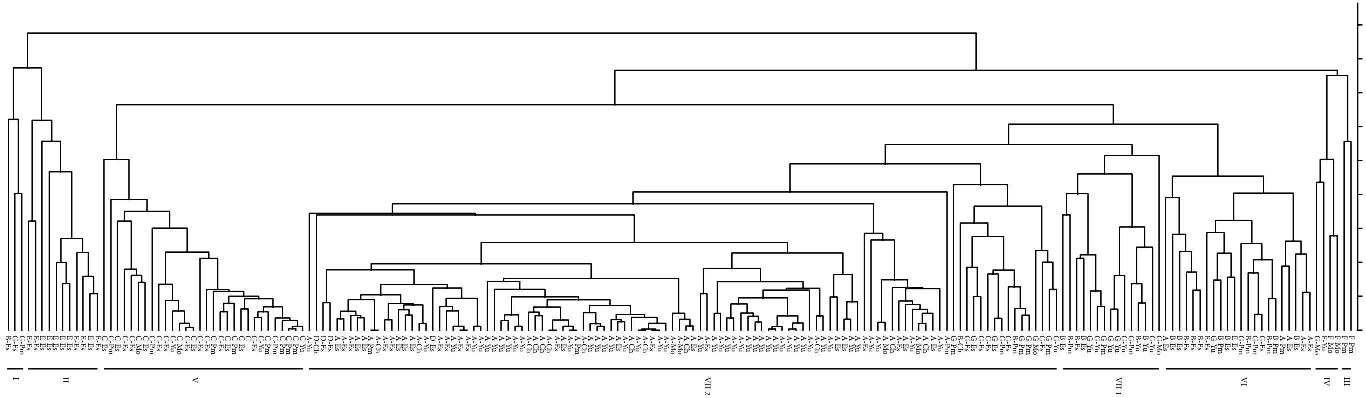

Fig. 1. Dendrogram showing the results of the CA of matrix A (males). A: *D. permistus*; B: *D. argentinus*; C: *D. pycnostictus*; D: *D. communis*; E: *D. schulzi*; F: greenish-brown specimens; G: *D. pictus*. The biogeographic region from where each specimen was collected is indicated as follows: Chaqueña (Ch), Espinal (Es), Monte (Mo), Pampeana (Pm), and Yungas (Yu).

cloud constituted by most of the analyzed specimens (Fig. 3). The first two components accounted for 38.11% of the total variation (20.92 and 17.19%, respectively). Principal Component I had significant representation from characters “middle legs color pattern”, “anterior legs color pattern” and “body color”. In principal component II the characters “presence of red markings on posterior edge of pronotum”, “hind tibiae color pattern” and “femur III length” were the variables that most contributed to the variation.

The cluster analyses on female specimens (Matrix B, Fig. 2) showed five groupings at an arbitrary distance level of 0.29. Results were quite similar to those obtained in the analysis of male specimens in recovering all specimens of *D. pycnostictus* in one group (GIII). Each of the remaining groups included specimens of different nominal species/color morph: specimens of greenish brown color morph were included into two different groups (GI and GII); GIV consisted of specimens previously identified as *D. argentinus*, *D. pictus* and three specimens of *D. schulzi*; and GV consisted of specimens of *D. permistus*, *D. communis*, *D. argentinus*, *D. schulzi*, *D. pictus*, and one specimen of the greenish brown color morph.

The PCA conducted on those nominal species (*D. argentinus*, *D. schulzi*, *D. pictus*, *D. permistus*, *D. communis*) and the undescribed greenish brown color morph that did not conform homogeneous groups in CA, showed that all specimens were plotted into the same cloud in the multivariate space, except for some specimens of the greenish brown color morph that were separated from this major group (Fig. 4). The first two components accounted for 35.75% of the total variation (20.49 and 15.26%, respectively). Component I had significant representation from characters, “body length”, “femur III length” and “body color”. In component II the characters “bands of pronotum color”, “tegmen length” and “pronotum length” were the variables that most contributed to the variation.

Geographic variation of body coloration

The morphometric analyses (cluster and PCA) for males and females, showed that the specimens did not group according to their geographic distribution (Figs. 1-4). On the contrary, there was high intra-population variation of body coloration.

The ANOVA conducted on the nominal species (*D. argentinus*, *D. schulzi*, *D. pictus*, *D. permistus*) and the undescribed greenish brown color morph that did not form homogeneous groups in CA, indicated that their proportions among the biogeographic regions were not significantly different ($F_{4,20} = 1{,}85; p = 0{,}159$). However, each nominal species showed higher proportions in certain areas: *D. permistus*, appeared to be particularly common in Yungas province, *D. schulzi* in Espinal, *D. argentinus* and *D. pictus* in Espinal and Pampeana provinces and the greenish brown color morph was associated with Monte province (Fig. 5).

No character correlation with latitude or longitude was found. However, the first and second component of PCA for females and the first component for males showed weak but significant correlation with latitude ($R = -0.43$, 0.33 and –0.27, respectively) (Table 3).

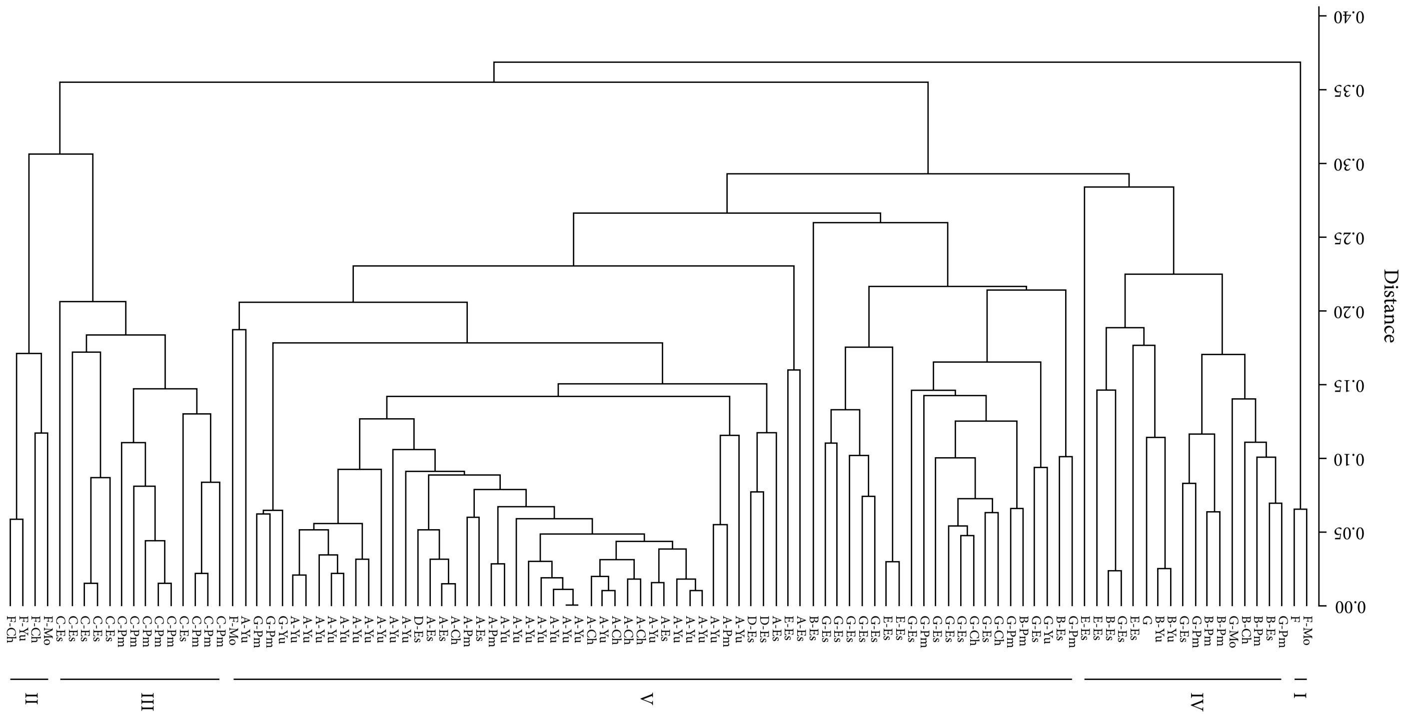

Fig. 2. Dendrogram showing the results of the CA of matrix B (females). A: *D. permistus*; B: *D. argentinus*; C: *D. pycnostictus*; D: *D. communis*; E: *D. schulzi*; F: greenish-brown morph; G: *D. pictus*. The biogeographic region from where each specimen was collected is indicated as follows: Chaqueña (Ch), Espinal (Es), Monte (Mo), Pampeana (Pm), and Yungas (Yu).

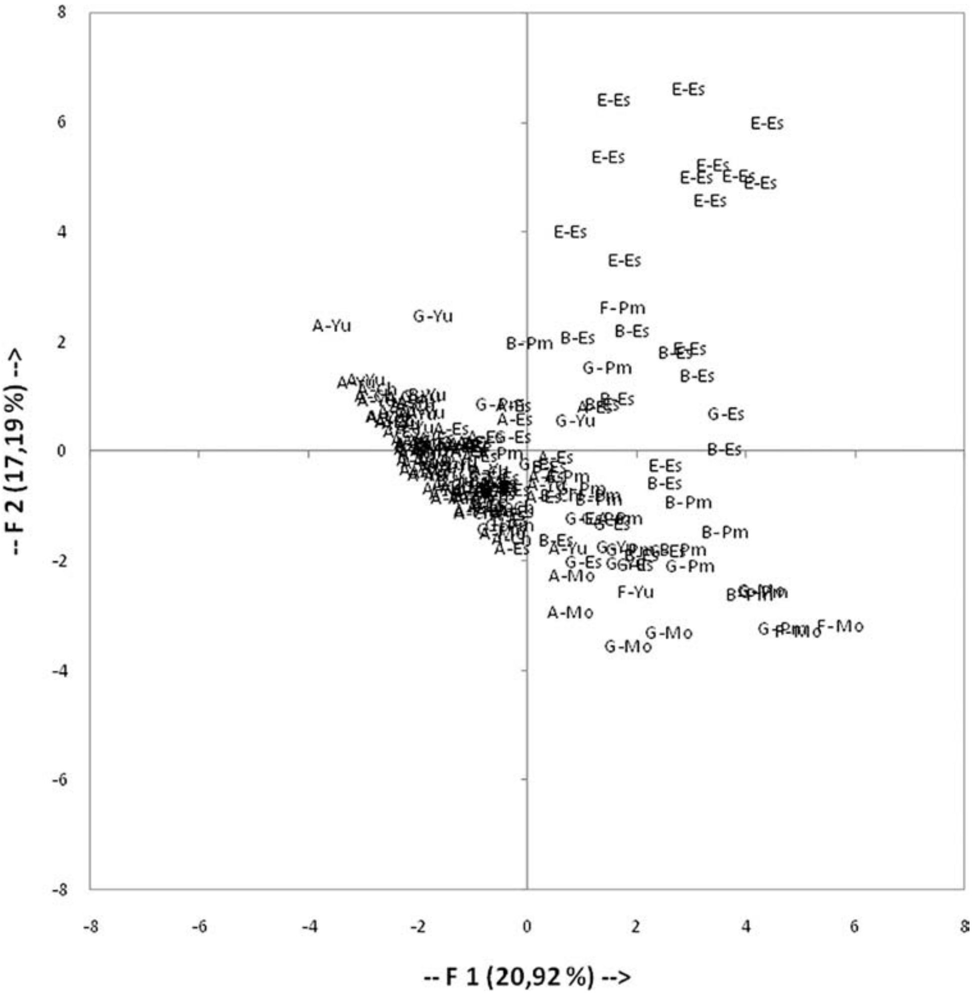

Fig. 3. Scatterplot showing the results of the PCA of matrix A without *D. pycnostictus* (males). A: *D. permistus*; B: *D. argentinus*; D: *D. communis*; E: *D. schulzi*; F: greenish-brown morph; G: *D. pictus*. The biogeographic region from where each specimen was collected is indicated as follows: Chaqueña (Ch), Espinal (Es), Monte (Mo), Pampeana (Pm), and Yungas (Yu).

Discussion

Species delimitation constitutes a complex and extensively discussed issue. Several species concepts have been defined (Mayden 1997; de Queiroz 1998, 2005, 2007), based on different biological properties (de Queiroz 2007), and different methods have been proposed to determine species boundaries (Davis & Nixon 1992; Marshall & Sites 2003; Sites & Marshall 2003, 2004; Knowles & Carstens 2007; Wiens 2007; de Queiroz 2007), including some based exclusively on DNA data (Sites & Marshall 2003). However, in most groups of organisms, new species are still described and taxonomic revisions are undertaken mainly based on morphology (Wiens & Servedio

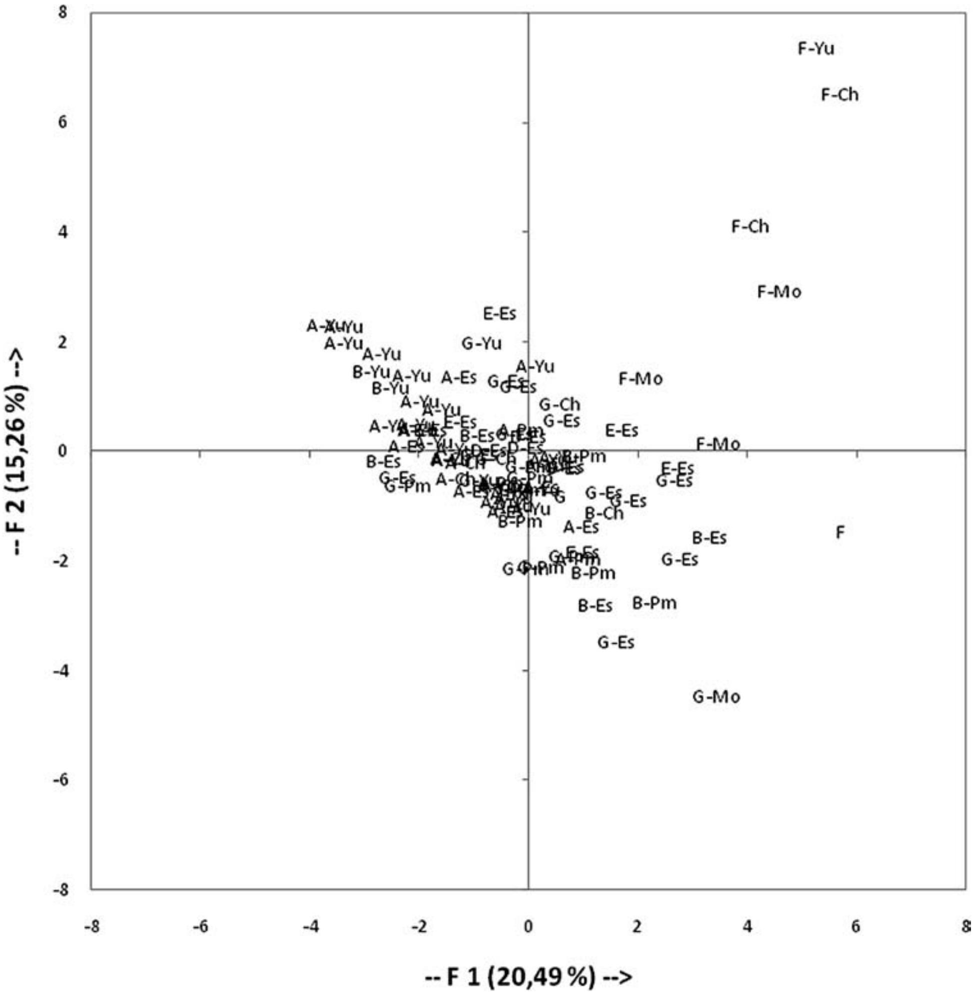

Fig. 4. Scatterplot showing the results of the PCA of matrix B without *D. pycnostictus* (females). A: *D. permistus*; B: *D. argentinus*; D: *D. communis*; E: *D. schulzi*; F: greenish-brown morph; G: *D. pictus*. The biogeographic region from where each specimen was collected is indicated as follows: Chaqueña (Ch), Espinal (Es), Monte (Mo), Pampeana (Pm) and Yungas (Yu).

2000; Alstrom et al. 2008; Zapata & Jimenez 2012). Conventionally, species are recognized by discontinuous, non-overlapping patterns of variation in characters of individuals from geographically circumscribed populations (Mayr 1942; Davis & Nixon 1992; Wiens & Servedio 2000; Sites & Marshall 2004). This operational criterion, gaps in the morphological variation, is based on the idea that morphological discontinuities are due to some evolutionary force (e.g., lack of gene flow, natural selection) that prevents two distinct lineages from homogenizing (Wiens & Servedio 2000; Wiens & Penkrot 2002; Mallet 2008). Among the different species concepts, the Phylogenetic Species Concept (PSC) seems to be the most appropriate that can be

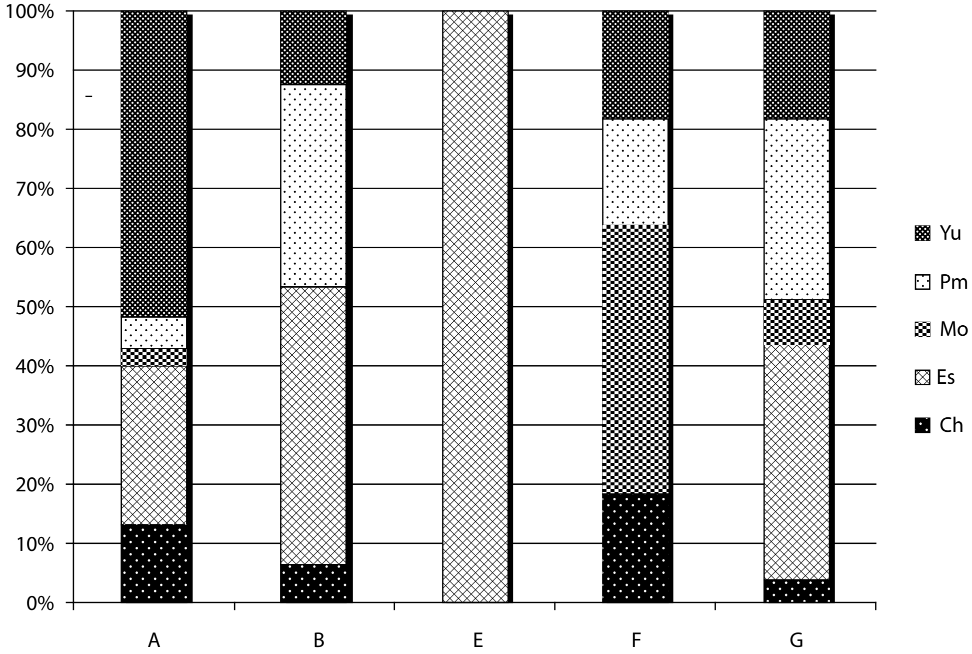

Fig. 5. Proportion of the nominal species *D. permistus* (A); *D. argentinus* (B); *D. schulzi* (E); *D. pictus* (G); and undescribed greenish-brown color morph (F) in each biogeographic region: Chaqueña (Ch), Espinal (Es), Monte (Mo), Pampeana (Pm), and Yungas (Yu).

applied to groups of specimens delimited by the data used here. This species concept was defined as “the smallest aggregation of populations (sexual) or lineages (asexual) diagnosable by a unique combination of character states in comparable individuals” (Nixon & Wheeler 1990) and modified later by Davis & Nixon (1992).

Diponthus pycnostictus always constituted an isolated group in the morphometric analyses, and it is characterized by a unique combination of character states (entire body black mottled, prozona and metazona of pronotum dark grey; in phallic complex valves of cingulum with anterior margin curved and distal portion oblong). Therefore, according to the PSC, we consider it as a valid species (see below).

There are no differences in tegmina venation, male terminalia or in phallic structures that separate the nominal species *D. permistus*, *D. communis*, *D. argentinus*, *D. pictus* and *D. schulzi*. However, differences in these structures are useful to separate the remaining species of *Diponthus*. The morphometric analyses also revealed that except for *D. pycnostictus*, the remaining groups delimited in the analyses are not homogeneous. Although some consistency can be found, these groups include specimens assigned to different nominal species revealing the existence of individuals with intermediate attributes, and thus they cannot be separated by an unambiguous character combination. Therefore, we consider that the five nominal taxa represent different color morphs of a single species here recognized as *D. argentinus* (see below).

Table 3. Factor loadings on the first two principal components for characters of matrix A (males) and B (females), and values of the Pearson correlation coefficient (*r*) obtained between the coordinate values of the first two components of the PCA and latitude.

Character	Males		Females	
	F1	F2	F1	F2
BL	0.2849	−0.2470	0.3806	−0.2160
PL	0.2827	−0.2858	0.3189	−0.3062
TL	0.2475	−0.2990	0.3212	−0.3111
FL	0.2044	−0.3216	0.3759	−0.1898
MW	0.2764	−0.2307	0.3379	−0.2220
BC	0.3177	−0.0112	0.3622	0.2055
BCP	0.0290	−0.0828	0.1803	0.2910
HC	0.0603	0.1180	0.1693	0.2739
AC	0.1867	0.1935	0.0380	−0.0838
PC	−0.0471	−0.1190	0.2098	0.3037
MC	0.0743	0.0945	0.1628	0.1886
BPC	0.0889	0.2555	0.1737	0.3673
SP	0.2329	0.3035	0.0524	−0.1286
RMP	0.1875	0.4188	−0.0154	−0.0370
OBP	0.2815	0.2085	0.1384	−0.0274
ALC	0.3750	−0.0058	0.1642	0.2931
MLC	0.3835	−0.0183	0.2049	0.2073
HFC	−0.0713	−0.0533	−0.0813	−0.2376
HTC	0.2050	0.3879	0.0515	−0.0414
r	−0.2745*	0.0816	−0.4275*	0.3257*

* $p < 0.01$.

Within *D. argentinus*, the variation observed in PCA results was explained by different types of characters in the different sexes. In males, characters from coloration contributed mostly to the total variation, while variation in females appeared to be mostly related to body size.

No character correlation with latitude or longitude was found. However, the first and second principal components for females and the first principal component for males showed weak but significant correlation with latitude. As mentioned above, in females, characters from the body size contributed mostly to the total variation of the PCA.

Our results showed that variability in females' body size tended to increase with latitude, coincident with the ecological Bergmann's rule (Bergmann 1847) that states that among populations of endotherm species, larger individuals are found at higher latitudes. However, general application of this rule is uncertain, especially in ectotherms. Bidau & Marti (2007a,b) studied the geographical body size variation in populations of two species of Melanoplinae grasshoppers (*Dichroplus pratensis* Bruner and *Dichroplus vittatus* Bruner) in Argentina, with similar geographic distribution ranges than *Diponthus argentinus*, and found an inversion pattern to what we observed, where body size of these two species decreased with increasing latitude. According to Whitman (2008) some Orthoptera follows Bergmann's rule, but most Orthoptera follow the converse Bergmann's rule (Mousseau 1997; Blanckenhorn & Dermont 2004; Berner & Blanckenhorn 2006; Ciplak et al. 2008; Remis 2008). Several factors such as season length, temperature, population densities, forage, local pathogens, and interspecific competition have been mentioned as causes that drive insect size clines (Ciplak et al. 2008; Lehmann & Lehmann 2008; Whitman 2008). Further studies on the ecology of *D. argentinus* are needed to be able to confirm the tendency that we found in this study.

Since phenotypic discontinuities can result from geographic differentiation within a single species (e.g., McGowen et al. 2001; Olson et al. 2004), we examined whether the discontinuities in body color observed in *D. argentinus* could be explained by geographic variation. In grasshoppers, environmental factors (e.g., humidity, temperature, background coloration), phenotypic plasticity (density-dependent warning coloration) and host plant association have been mentioned to be related to changes in body coloration (Rowell 1970, 1971; Rowell & Cannis 1972; Dearn 1990; Colvin & Cooter 1995; Key 1954; Key & Day 1954; Sword 1999, 2001; Sword & Dopman 1999; Tanaka 2008; Hochkirch et al. 2008).

In other insect groups, color polymorphism has also been explained by host specific differentiation, e.g. in populations of a polymorphic walking-stick insect species, divergence of color and color pattern and frequency of different cryptic morphs, body size and shape, and behavior is related to host plant adaptation (Sandoval 1994a,b; Nosil et al. 2002; Nosil & Crespi 2004, 2006; Nosil 2007; Sandoval & Crespi 2008).

However, within Romaleini, host plant preference has been related to chemical defense (Whitman & Orsak 1985; Whitman & Vincent 2008). *Taeniopoda eques* (Burmeister) and *Romalea microptera* (Palisot de Beauvois) produce a defensive secretion which contains, in part, components derived from their diet; they consume poisonous plants and sequester plant toxins that are used as a defensive mechanism (Whitman & Orsak 1985; Whitman & Vincent 2008). Moreover, according to Rowell (1983), *Tropidacris cristata* (Linne) and several other Romaleini seem to prefer plants with secondary chemicals that many herbivores avoid consuming. The lack of information about the biology and ecology of *Diponthus* species prevents any inference about the factors that might be causing color polymorphism in the species.

Given that factors determining variation in body coloration in *Diponthus* species are unknown we used coordinates to examine geographic patterns of body coloration in *D. argentinus*. No character correlation resulted with latitude or longitude, and only the first and second principal components for females and the first principal component for males showed weak but significant correlation with latitude. Also, the proportions of the different color morphs of *D. argentinus* did not differ significantly over the biogeographic regions and displayed high levels of overlap across the distribution range, as well as intra-population variation. The maintenance of color polymorphism in natural populations of grasshoppers has also been explained through frequency-dependent selection or a combination of gene flow and spatially variable selection (Dearn 1990; Forsman & Appelqvist, 1999; Hochkirch et al. 2008).

In conclusion, we consider that in *D. argentinus* body coloration varies considerably over the geographic distribution range but without any noticeable color gradient correlated with latitude or longitude. Future studies, including understanding environmental factors that could determine variation in body coloration and analyzing the correlation between morphological variation and molecular data, could eventually reveal the nature of polymorphism of the grasshoppers studied.

Systematics

Synonymy

Diponthus argentinus Pictet & Saussure 1887

Diponthus argentinus Pictet & Saussure 1887: 372 (Holotype, female, Buenos Aires, Argentina, Muséum d'Histoire naturelle, Geneva (MHNG); Kirby 1910: 382; Rehn 1913: 336; Liebermann 1948: 84; Mesa 1956: 35; Barrera & Paganini 1975: 121; Otte 1976: 205; Otte & Joern 1977; Orians & Solbrig 1977: 265; Sanchez & de Wysiecki 1983: 246, 1993: 29; Orrego Aravena 1985: 10; Lange & de Wysiecki 1996: 24; de Wysiecki et al. 2000: 217; Cigliano et al. 2000: 85; Lange 2003: 311; Lange & Cigliano 2005: 68; Lange 2005: 140; Carbonell et al. 2006; 1713; Capinera 2008; Lange et al. 2008: 154; Listre 2009: 26; Lange 2010: 1051; Hollier 2011: 348; Mariottini et al. 2011: 739; Bardi et al. 2012: 506; Capello et al. 2013: 61; Mariottini et al. 2013: 116.

Diponthus permistus (Serville 1838) ***Nomen oblitum***
Acridium permistum Serville 1838[1839]: 669 (Holotype female lost, Argentina, Buenos Aires, Muséum National d'Histoire Naturelle, France, Paris, (MNHN).
Calacris permista: Walker 1870: 639.
Diponthus permistus: Pictet & Saussure 1887: 372; Kirby 1910: 382; Liebermann 1939: 187; Carbonell et al. 2006.

Diponthus communis Bruner 1900 **n. syn.**
Diponthus communis Bruner 1900: 80 (Hololectotype, male, so labeled by Carlos S. Carbonell, and here formally designated; Carcarañá, Argentina, University of Nebraska State Museum (UNSM). The original labels of the syntypes of *D. communis* read *Diponthus conspersus* Bruner, but according to Carbonell (pers. com.), who examined, measured and took images of Bruner's syntypes at UNSM, this is an original error by L. Bruner); Kirby W.F. 1910: 382; Liebermann 1948: 84; Liebermann 1966[1967]: 98; Carbonell et al. 2006.

Diponthus schulzi Bruner 1900 **n. syn.**
Diponthus schulzi Bruner 1900: 63 (Syntype, male, Córdoba, Argentina, Academy of Natural Sciences, Philadelphia (ANSP); Kirby 1910: 382; Carbonell et al. 2006.

Diponthus pictus (Bolivar 1884) **n. syn.**
Zoniopoda picta Bolivar 1884: 37 (Holotype, female, "Americal Meridional", Museo Nacional de Ciencias Naturales, Madrid (MNMS); Kirby 1910: 376; Liebermann 1939: 181; Otte 1995: 61.
Diponthus pictus: Pictet & Saussure 1887: 357; Otte 1995: 44; Otte 1997: 208; Carbonell et al. 2006.

Comments

Since the name *Diponthus permistus* (Serville) has only been cited five times in catalogs and/or regional checklists, and the new junior synonym *Diponthus argentinus* Pictet & Saussure has been used in at least 25 studies (see citations above and in Eades et al. 2013) in the past 50 years, according to article 23.9.2 of the International Code of Zoological Nomenclature, we declare *Diponthus permistus* (Serville) a *nomen oblitum* and *Diponthus argentinus* Pictet & Saussure a *nomen protectum*.

It was not possible to find any material belonging to the type series of *Acridium permistum*, except for two female specimens labeled as *Diponthus permistus* in the collection in Paris that did not match the original description and measurements (confirmed by Carbonell, pers. commun.; MMC and Simon Poulain, pers.commun.). So we considered the types are lost.

Diponthus puelchus **Pictet & Saussure 1887, n. st.** (LSID: Orthoptera.speciesfile.org: TaxonName: 45104)
Diponthus puelchus Pictet & Saussure 1887: 375 (Hololectotype male, so labeled by Carlos S. Carbonell and here formally designated; Argentina, MHNG). The original label of the type of *D. puelchus* reads *Prionacris pulchrus* [< sic] Pict. et Sauss.); Hollier 2011: 386.

The case of *Diponthus puelchus* also merits some comments. Bruner (1900) mentions that the species *Diponthus puelchus* Pictet & Saussure "seems to be the same as that described by Ignacio Bolivar (1884) as *Zoniopoda picta*. Should this prove true Bolivar's name would have priority". Later, Kirby (1910) in his catalogue of Orthoptera listed *Diponthus puelchus* as a synonym of the *Zoniopoda picta* and Otte (1997) transferred it to the genus *Diponthus*. However, after examination of the type specimens of *Diponthus puelchus* Pictet & Saussure and *Diponthus pictus* (Bolivar) and based on the original descriptions, as well as the examination of specimens collected in the distribution area of the species, we consider that *Diponthus puelchus* is a valid species. It can easily be identified by the black pattern with creamy spots; bright orange head, posterior border of pronotum and knees; three creamy longitudinal bands on the pronotum; and tegmina with white large spots on lateral field. The species occurs in the provinces of Córdoba, San Luis, Salta, Tucumán and Catamarca. (See images of male habitus in the species page of *D. puelchus* in OSF (LSID: Orthoptera.speciesfile.org: TaxonName: 45104).

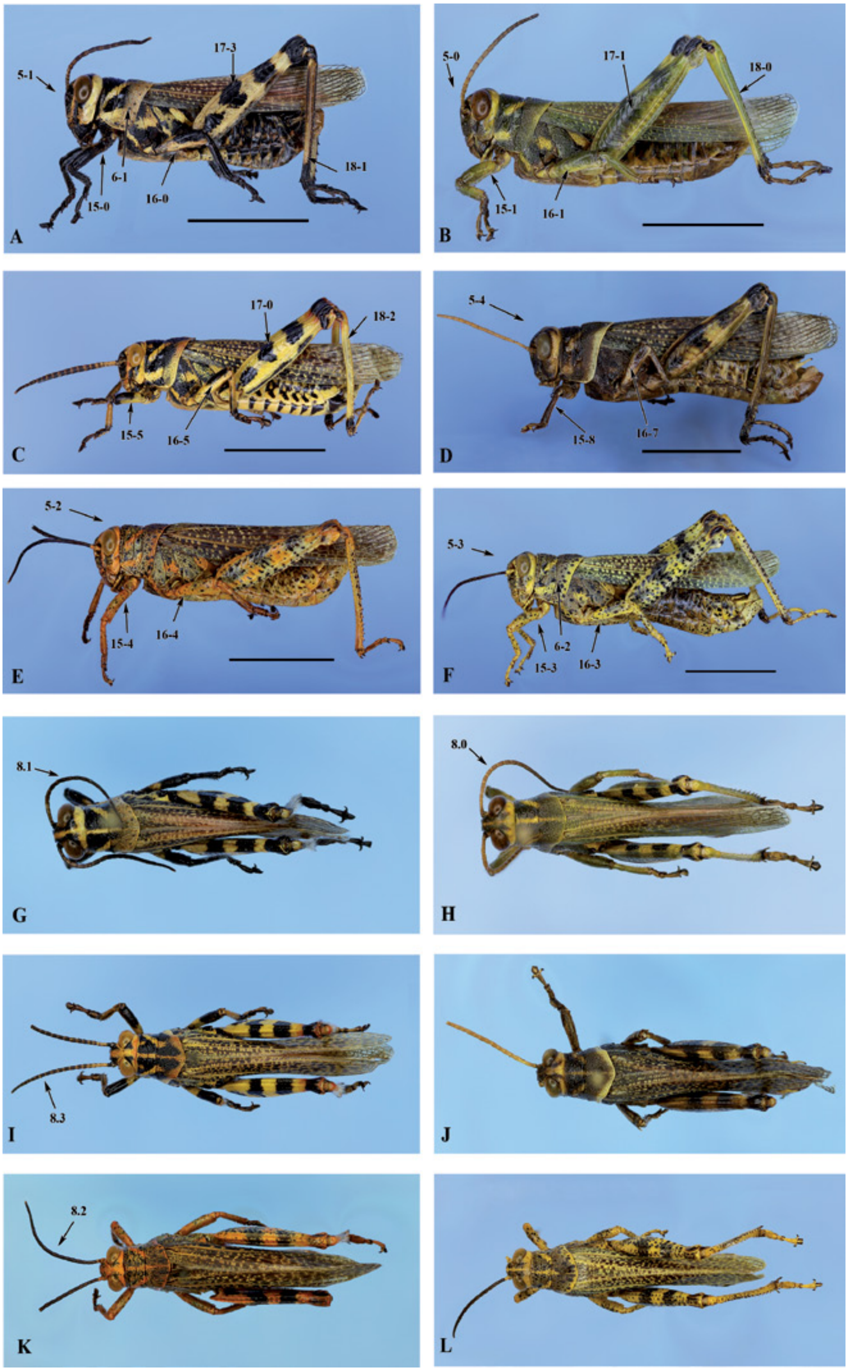

Fig. 6. Morphological characters and states used in CA and PCA analyses. *Diponthus* males. Habitus, lateral (A-F) and dorsal views (G-L). A,G: *D. argentinus*; B, H: *D. permistus*; C,I: *D. schulzi*; D,J: undescribed greenish-brown color morph; E,F,K,L: *D. pycnostictus*. Scale bar = 1 cm. This figure is published in colour in the online version of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/1876312x.

Diponthus argentinus **Pictet & Saussure, 1887** (LSID: Orthoptera.speciesfile.org: TaxonName: 45132)
Figs. 6A–D, G–J; 7A–D, G–J; 8A–D,G–J; 9A,C,E,G; 10A, C, E; 11

Diagnosis

Pronotal disk with light longitudinal median band and two oblique bands that converge towards the principal sulcus; lateral lobes with light-colored horizontal band near the lower margin. Tegmina with white spots on proximal lateral field, transversal veins weakly and irregularly marked (Fig. 10E). Prosternal tubercle straight, with rounded apex. Male epiproct with rounded borders, pointed tip, and with tubercles on distal margin (Fig. 10C); furculae prominent and with subacute tips. Male cerci slender and tapering towards the apex, distal third slightly down-curved, slightly surpassing the tip of epiproct (Fig. 10A). Dorsal valves of aedeagus with distal third down-curved and apex weakly sclerotized (Fig. 9A,G). Valves of cingulum narrow at the base, anterior margin straight, distal portion subcircular (Fig. 9A,G). Cingulum W-shaped; zygoma with anterior margin concave, V-shaped (Fig. 9C). Lophi of epiphallus placed perpendicular to bridge (Fig. 9E); subtriangular in frontal view.

Redescription

Male: head relatively small, fastigium excavated with the apex usually straight in dorsal view (Fig. 7A–D). Interocular distance about equal to width of fastigium apex (Fig. 7A–D). Eyes prominent and oval, reaching the level of vertex in lateral view (Fig. 7G–J). Median dorsal carina of pronotum slightly marked on metazona, obsolete on prozona, cut by two transverse sulci (Fig. 8A–D); principal sulcus deep (Fig. 8A–D). Metazona equal in length or slightly longer than prozona (Fig. 8A–D). Anterior pronotal margin straight or with a slight notch in the middle; posterior margin of disk angulated (Fig. 8A–D). Integument of prozona dorsally slightly foveolate (Fig. 8A–D), laterally smooth (Fig. 8G–J). Integument of metazona impresso-punctuate dorsally (Fig. 8A–D) and laterally (Fig. 8G–J). Prosternal tubercle straight with rounded apex. Tegmina surpassing the tip of the abdomen, with rounded apex (Fig. 6A–D). Cerci slender, surpassing tip of epiproct, tapering towards the apex, apical third slightly down-curved, with pointed tip (Fig. 10A). Epiproct with rounded borders, tubercles on posterior margin, furculae prominent, with subacute tips (Fig. 10C). Phallic complex: dorsal valves of aedeagus with distal third down-curved, apex weakly sclerotized (Fig. 9A,G). Valves of cingulum with distal third directed upwards and parallel to dorsal valves, narrow at the base, anterior margin straight, distally expanded and subcircular (Fig. 9A,G). Cingulum W-shaped; zygoma with anterior margin concave, V-shaped (Fig. 9C). Lophi of epiphallus placed perpendicular to bridge in dorsal view (Fig. 9E); subtriangular in frontal view.

Chromatic characters

Body coloration and color pattern is highly variable in this species. Results have shown that different specific names (*Diponthus permistus*, *D. communis*, *D. schulzi*, *D. pictus*)

Fig. 7. Morphological characters and states used in CA and PCA analyses. *Diponthus* males. Head, dorsal (A-F) and lateral views (G-L). A,G: *D. argentinus*; B, H: *D. permistus*; C,I: *D. schulzi*; D,J: color morph greenish-brown; E,F,K,L: *D. pycnostictus*. This figure is published in colour in the online version of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/1876312x.

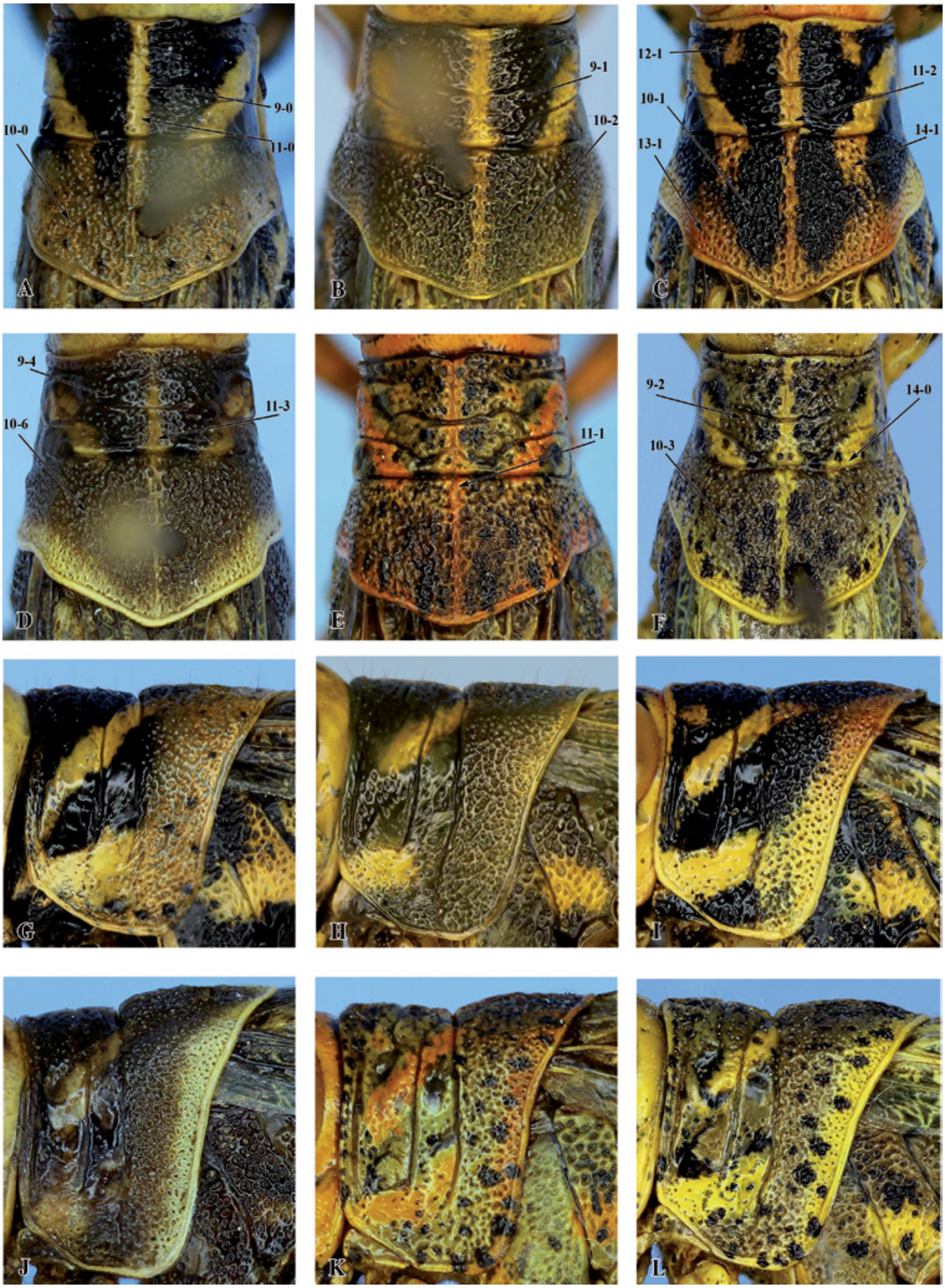

Fig. 8. Morphological characters and states used in CA and PCA analyses. *Diponthus* males. Pronotum, dorsal (A-F) and lateral views (G-L). A,G: *D. argentinus*; B, H: *D. permistus*; C,I: D. *schulzi*; D,J: color morph greenish-brown; E,F,K,L: *D. pycnostictus*. This figure is published in colour in the online version of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/1876312x.

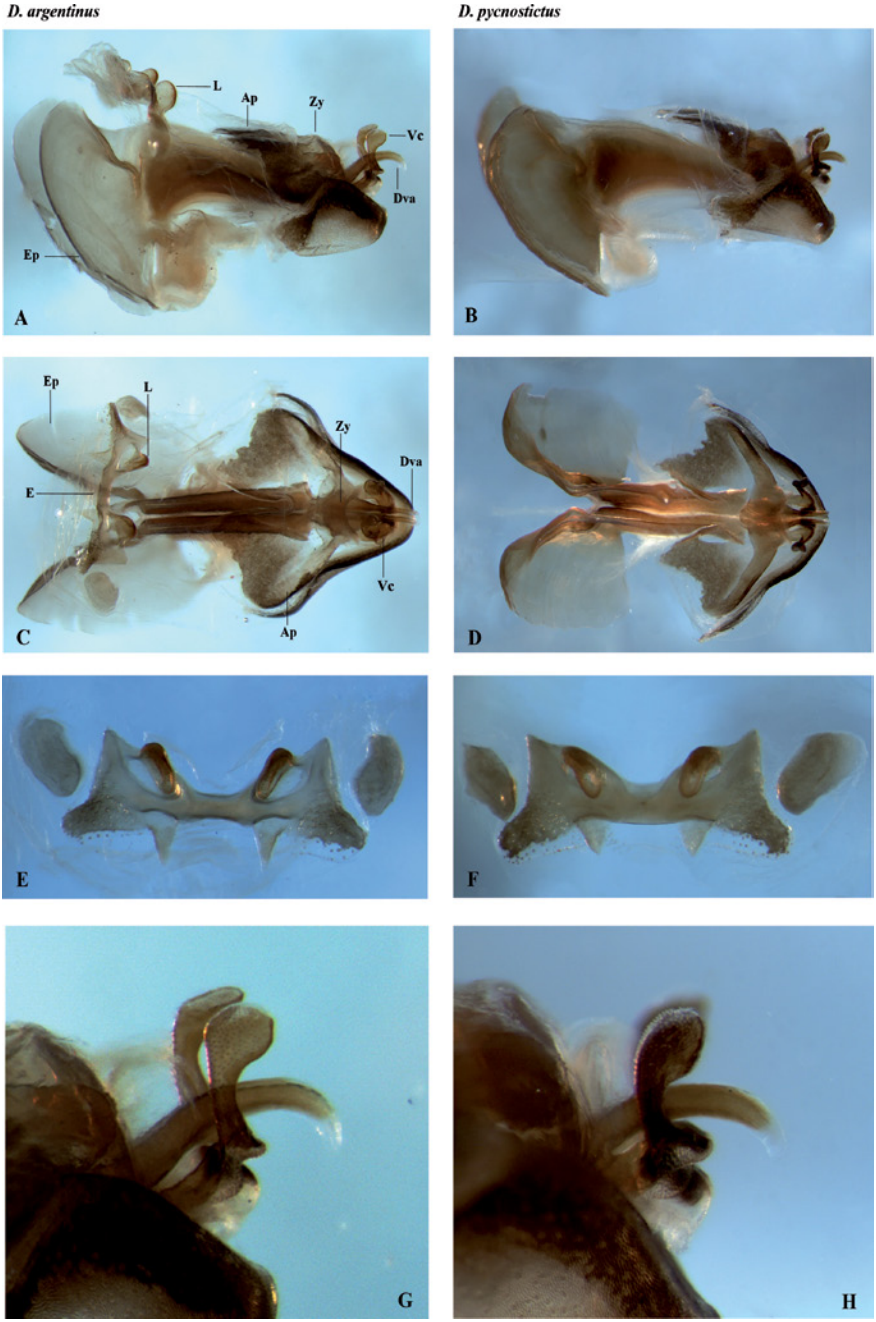

Fig. 9. *Diponthus* males. Phallic complex, species as indicated. (A, C) phallic complex, lateral (A) and dorsal (C) views; (B, D) endophallic plates (basal and apical valves of aedeagus) and cingulum, lateral (B) and dorsal (D) views; (E, F) epiphallus, dorsal view; (G, H) distal portion of aedeagal valves, lateral view. Abbreviations: Ap, apodemes of cingulum; Dav, dorsal valves of aedeagus; E, epiphallus; Ep, endophallic plates; L, lophi of epiphallus; Vc, valves of cingulum; Zy, zygoma. This figure is published in colour in the online version of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/1876312x.

have been given to forms that actually represent individual or geographic variation. Such variation can be described as different color morphs. However, a high degree of variability within each color morph is also found.

Color morph "green with yellow" (Figs. 6B,H, 7B,H, 8B,H). General body color green and yellow (Fig. 6B,H). Head: green with the posterior edge of vertex, a median dorsal line on fastigium and vertex, occiput, postgenae and areas of the mouthparts yellow (Fig. 7B,H). Antennae yellow or light brown to dark brown; in some specimens with the basal half of each segment yellow and the distal half black (Fig. 6H). Pronotum green, with yellow median longitudinal band, two oblique yellow bands converging towards principal sulcus and a yellow band near the lower margin of lateral lobes; meso and metapleurae with a yellow spot (Fig. 8B,H). Anterior and middle legs green with ventral side yellow; tarsi brown or black (Fig. 6B,H). Hind femur light green to yellow, with a dark green or blackish longitudinal band on the external face (Fig. 6B); three black spots on internal face; upper lobe of knee black; some specimens exhibit a basal spot and incomplete rings instead of a longitudinal band on the external face. Hind tibiae green, ventrally yellow, and with a transverse black band on distal tip (Fig. 6B). Tegmina with yellow or creamy veins on green background; yellow spots on cross veins (Fig. 6B,H). Hind wings orange to reddish. Male epiproct yellow with tubercles and furculae black; male cerci yellow with black tip.

Color morph "black and yellow" (Fig. 6A,G, 7A,G, 8A,G): general body color black with yellow areas (Fig. 6A,G). Metazona yellow to creamy or mostly black (Fig. 8A). Anterior and middle legs yellow with black areas, or mostly black with yellow areas (Fig. 6A,G). Hind femur yellow with one basal spot on outer and inner faces, and two wide transverse black bands, and apex black (Fig. 6A). Tegmina with yellow veins and spots on dark background (Fig. 6A).

Color morph "black and yellow, with red markings" (Figs. 6C,I; 7C,I; 8C,I): general body color black and yellow (Figs. 6C, I). The same pattern as described above, but with dorsal area of head (Fig. 7C), posterior edge of pronotum (Fig. 8C) and proximal tip of hind tibiae red (Fig. 6C). Some specimens are dark greenish and yellow, instead of black and yellow. Antennae usually with the basal half of each segment yellow and the distal half black (Fig. 6I).

Color morph "greenish brown" (Figs. 6D,J, 7D,J, 8D,J): general body color greenish brown and yellow (Fig. 6D,J). The same pattern described for color morph green and yellow, but the green areas are brownish in this color morph. Posterior border of pronotum conspicuously yellow (Fig. 8D).

Variations in color and color patterns within color morphs: Oblique bands of pronotum may end at the principal transverse sulcus (Fig. 8B) or surpass it, reaching the metazona (Fig. 8C). Prozona with two yellow spots, one at each side of the median longitudinal band (Fig. 8C), or without them (Fig. 8B). Some specimens exhibit black mottles on pronotum and abdomen and sometimes also on legs (Fig. 6A,G).

Females: similar to males, but larger and more robust. Ovipositor valves short and robust.

Measurements (in mm)

Body length: males: 24.6 (19–32); females: 33.8 (25–41); femur III length: males: 13.3 (10–16); females: 18.4 (16–24); tegmen length: males: 21.6 (17–26); females: 28.5 (25–35).

Material examined

ARGENTINA, 2 ♂, Salta, 5 km E Lumbrera, RN 34, 25°12'02.1"S, 64°54'02.4"W, 715 m, 16/02/2011, Cigliano & Lange, MLP; 8 ♂, 1 ♀, Salta, 27 Km N Trancas, 26°04'07.5"S, 65°08'37.3"W, 919, 17/11/2011, Cigliano & Lange, MLP; 5 ♀, Salta, 25 km S General Güemes, 40 km detour Lumbrera RN 34, 24°55'33.1"S, 64°59'13.0"W, 934 m, 16/02/2011, Cigliano & Lange, MLP; 4 ♂ , 2 ♀, Salta, 8 km S from Lumbrera, RN 34, 25°16'40.6"S, 64°55'27.4"W, 146 m, 16/02/2011, Cigliano & Lange, MLP; 5 ♂ , 2 ♀, Salta, Campo Quijano, 25°04'26.0"S, 65°29'49.7"W, 1170 m, 14/02/2011, Cigliano & Lange, MLP; 1 ♂, Salta, Pocitos, 24°20'45.65"S 67° 0'16.82"W, 01/01/1964, A.Martinez, MACN; 1♂, Salta, Ruiz de los Llanos, 02/1947, R.Colbach, IFML; 14 ♂, 11 ♀, Tucumán, El Simbolar, Ruta 311 to San Pedro de Colalao, 26°15'37.8"S, 65°18'36.1"W, 17/02/2011, Cigliano & Lange, MLP; 1 ♂, Salta, Lesser, 25/01/2010, E. Castillo & Castillo, IBS; 9 ♂, Tucumán, from Tapia to Raco, 26°36'29.7"S, 65°19'18.2"W , 779 m, 17/11/2011, Cigliano & Lange, MLP; 1 ♂, Tucumán, Benjamin Paz, 26°22'10.72"S, 65°17'59.05"W, 27/04/1976, IFML; 1 ♀, Tucumán, Benjamin Paz, 26°22'10.72"S, 65°17'59.05"W, 30/01/1968, M. Barrera & I. Paganini, IFML; 1 ♂, Tucumán, Benjamin Paz, 26°22'10.72"S, 65°17'59.05"W, 16/02/1984, Barrera & Turk, IFML; 2 ♂, 1 ♀, Tucumán, Dpto. Leales, Agua Azul, 10/04/1975, Barrera & Turk, IFML; 1 ♂, Tucumán, Graneros, 27°38'56.63"S, 65°27'5.54"W, 05/03/1971, A.Martinez, IFML; 1 ♂, 1 ♀, Tucumán, India Muerta, 26°34'2.95"S, 65°15'6.88"W, 14/02/1973, M.Barrera, IFML; 2 ♂, 2 ♀, Tucumán, Tapia, 26°36'16.93"S, 65°15'43.55"W, 21/04/1975, Barrera & Turk, IFML; 3 ♂, 2 ♀, Tucumán, Vipos, 26°29'6.85"S, 65°22'1.22"W, 02/03/1968, M.Barrera & I. Paganini, IFML; 1 ♂ , Tucumán, Lolita Cruz Alta, 02/1971, M.Barrera & V.Mistreta, IFML; 3 ♀, Buenos Aires, J.Boso, MLP; 1 ♀, Buenos Aires, Flores, 34°39'48.91"S, 58°27'24.24"W, 16/02/1914, MLP; 1 ♀, Buenos Aires, K.Wolffhiigel, MLP; 1 ♂, Buenos Aires, Flores, 34°39'48.91"S, 58°27'24.24"W, 27/02/1915, MLP; 1 ♂, ♀, Buenos Aires, Coronel Suarez, 37°43'58.15"S, 61°43'18.87"W, 02/2007, Lange & de Wysiecki, MLP; 1 ♂, 1 ♀, Buenos Aires, 1900, J.Kunckel, FCMU; 1 ♀, Buenos Aires, Moreno, 34°37'43.37"S, 58°49'21.55"W, 03/1936, J.B.Daguerre, MACN; 1 ♂, Buenos Aires, Jose.C.Paz, 34°32'7.97"S, 58°45'58.13"W, 1940, J.A.R.Costa, MLP; 2 ♂, Buenos Aires, Saladillo, 35°39'32.68"S, 59°48'2.87"W, 15/01/1969, A.Filpo, MLP; 1 ♂, Buenos Aires, Abra de la Ventana, 38° 4'0.16"S, 61°59'3.73"W, Ronderos, MLP; 1 ♂, Buenos Aires, Chacabuco, 34°37'44.88"S 60°29'45.87"W, F.Lynch, MLP; 1 ♂, Buenos Aires, 1900, J.Kunckel, MLP; 2 ♂, Buenos Aires, Gunther, MLP; 1 ♂, Buenos Aires, Pirovano, MLP; 1 ♂, Buenos Aires, Tornquist, 38° 6'13.24"S, 62°14'27.10"W, 26/01/2010, MLP; 1 ♂, Buenos Aires, Villarino, 38°49'20.48"S, 62°42'38.86"W, 27/01/2010, MLP; 1 ♂, Buenos Aires, Tres Lomas, 36°28'20.70"S 62°52'21.69"W, 14/02/2006, MLP; 1 ♂, Olavarría, Buenos Aires, 24/01/1961, A.Mesa & M.A.Monne, MZSP; 2 ♂, Chaco, Resistencia, 27°29'15.03"S, 59° 1'54.51"W, 10-12/1935, J.B.Daguerre, MACN; 2 ♂ , Chaco,Tres Estacas, 26°55'15.76"S, 61°37'30.38"W, 27/02/2009, MLP; 1 ♂, Picada Guaycuru, 29° 5'38.53"S 60°12'46.70"W, 18/11/1941, M.Biraben, MLP; 1 ♂, 1 ♀, Chaco, Isla Cerrito, 13/12/2007, Baldo, Castillo, Martí, IBS; 1 ♂, 1 ♀, Córdoba, Estancia El Chingolo, 29/12/2011, Martí, IBS; 1 ♂, 2 ♀, Córdoba, Cerro La Banderita, 24/03/2012, Ferro, Boeris, Taffarel, Martí, IBS; 1 ♂, Córdoba, El Carrizal, 30°43'08.7"S, 64°36'12.7"W, 644m, Pocco & Plischuk, 17/03/2012, MLP; 1 ♂, Córdoba, Tabaquillo, 12 km from Cruz del Eje, 31°44'47.9"S, 65°09'37.6"W, 16/03/2012, Pocco & Plischuk, MLP; 2 ♂, 3 ♀ Córdoba, La Cumbre, 30°59'58.84"S, 64°26'33.20"W, 11/02/2013, Cigliano & Lange, MLP; 1 ♂, Córdoba, Yacanto, 32°1'14.43"S, 64°42'36.12"W, 12/02/2013, Cigliano & Lange, MLP; 3 ♂, Córdoba, La Cumbre 2 km detour Covadonga, 30°58'39.13"S, 64°28'28.24"W 03/03/2013, Cigliano & Lange, MLP; 1 ♀, Córdoba, Cabana, 31°13'3.82"S, 64°21'12.30"W, 02/1937, M.Biraben, MLP; 1 ♀, Cordoba, D. Punilla-Tanti 31°19'49.60"S, 64°36'3.64"W, 09/1950, J.M.Viana, MACN; 16 ♂, 5 ♀, Córdoba, Dpto. de Calamuchita-"El Sauce", 32° 2'52.23"S, 64°34'25.91"W, 12/1938, M.J.Viana, MACN; 1 ♀, Córdoba, Tulumba, 30°24'27.79"S, 64° 7'43.33"W, MLP; 1 ♂, Córdoba, Embalse Rio III, 32°12'9.06"S, 64°23'30.25"W, 18/12/1967, R.A.Ronderos-M.A.Monne, MLP; 1♀, Córdoba, La Cumbre, 30°59'39.68"S, 64°30'35.01"W, 11/1942, J.A.Rosas Costa, MLP; 1 ♂, Córdoba, V.Carlos Paz, 31°24'17.26"S, 64°31'11.49"W, 17/04/1940, A.A.Piran, MACN; 1 ♂, Entre Ríos, Pronunciamiento, 32°21'5.03"S, 58°26'33.97"W, 12/1970, Ronderos, MLP; 1 ♂, Entre Ríos, Paraná, 31°43'1.08"S, 60°27'8.68"W, 1931, J.A.R.Costa, MLP; 1 ♂, 2 ♀, Entre Ríos, Arroyo Los Chañares,19/02/1965,C.S.Carbonell, A.Mesa & M.A.Monne, FCMU; 3 ♂, Entre Ríos, Arroyo Los Chañares, 19/02/1965, C.S.Carbonell, A.Mesa & M.A. Monne, MZSP; 1 ♂, Formosa, 10 km W Las Lomitas, 24°40'55.28"S, 60°41'56.13"W, 13/04/1999, Cigliano & Lange, MLP; 2 ♂, Formosa, RN 81, km 1448, between Ibarreta and Las Lomitas, 24°50'57.58"S 60°23'6.55"W, 24/02/2012, Pocco, Pelizza, Bardi & Plischuk, MLP; 2 ♂, Formosa, Ibarreta, 25°11'49"S; 59°51'41"W, 24/02/2012, Pocco, Pelizza, Bardi & Plischuk, MLP; 1 ♂, Formosa, RN 81 junction RN 11 to Clorinda, 13/12/2007, Baldo, Castillo & Martí, IBS; 1 ♀, La Pampa, Col.Penal, 28/01/1957,Torres-Ronderos, MLP; 2 ♂, 2 ♀, La Pampa, General Pico, 35°37'53.73"S, 63°44'58.70"W, 01/03/1943, Williamson & J.A.Rosas Costa, MLP; 1 ♂, La Pampa, 10 km W Rancul, 01/03/1973, A.Mesa & E. Corbella, MZSP; 1 ♀, La Pampa a 5 km Macachín, MLP; 1 ♀, Mendoza, Las Chacritas,12/04/1937, P. Denier, MLP; 2 ♂, Mendoza, MACN; 1 ♂ , 1 ♀, Mendoza, Cacheuta, 33° 2'23.14"S, 69° 6'9.10"W, MACN; 1 ♂, Mendoza, Arroyo Carrizal, 33°19'57.02"S 68°45'6.35"W,10/01/1980, A.Willink & otros, IFML; 1 ♀, Mendoza, Tunuyan, los arboles-bodega Sanentein, 33°34'10.42"S, 69° 2'50.57"W, 30/03/2005, C.Ganci, IADIZA; 1 ♂, Mendoza, Malargue-20Km Bardas Blancas, 35°36'27.29"S, 69°36'45.49"W, IADIZA; 1 ♂, 1 ♀, Mendoza, 1977, IADIZA; 1 ♂, Mendoza,

Mendoza, 32°51'41.30"S, 68°43'56.96"W, 23/03/1963, A.Mesa, MZSP; 1 ♂, Río Negro, 5 km W Choele Choel, 29/01/1973, A.Mesa & E. Corbella, MZSP; 1 ♂, Río Negro, 70 km E Choele Choel, 28/01/1973, A.Mesa & E. Corbella, MZSP; 2 ♂, 2 ♀, SanLuis,Praga,32°32'9.48"S65°38'51.35"W,17/12/1967,R.A.Ronderos-M.A.Monne, MLP; 1 ♂, San Luis, Verban, MACN; 1 ♂, San Luis, 74 km N Villa Mercedes-road from Dolores, 33° 4'28.76"S 65°21'16.39"W, 16/01/2008, MLP; 1 ♂, San Luis, MACN; 1 ♀, San Luis, Pancauta, 10/01/1976, A.Ruig, IADIZA; 1 ♀, Santa Fe, 20 km from Ciudad, 31°38'53.72"S, 60°56'8.32"W, 10/02/2009, MLP; 1 ♀, Santa Fe, Arocena, 32°50'38.31"S, 61° 8'59.66"W, 23/02/1965, C.S.Carbonell, A.Mesa & M.A.Monne, FCMU; 19 ♂, 4 ♀, Santa Fe, Carcaraña, 32°50'38.31"S, 61° 8'59.66"W, 21/02/1965, C.S.Carbonell, A.Mesa & M.A.Monne, FCMU; 2 ♂, Santa Fe, Carcaraña, 32°52'48.92"S 61° 7'44.30"W, 21/02/1965, C.S.Carbonell, A.Mesa & M.A.Monne, MZSP; 1 ♂, 1 ♀, Santa Fe, Ceres, 29°52'8.22"S, 61°57'51.60"W, 12/01/1939, C.J.Drake, FCMU; 1 ♂, Santa Fe, Santa Emilia, 33°49'59.08"S 61°29'10.38"W, 20/12/1967,R.A.Ronderos-M.A.Monne, MLP; 2 ♂, 1 ♀, Santa Fe, Rafaela, 31°16'34.55"S 61°29'14.39"W, 08/02/2009, Bardi, MLP; 1 ♂, 1 ♀, Santa Fe, Santa Rosa, 31°25'0.22"S 60°19'59.98"W, 23/02/1965, C.S.Carbonell,A.Mesa & M.A.Monne, FCMU; 1 ♂, Santa Fe, Rosario, 32°57'23.17"S, 60°45'31.66"W, MACN; 1 ♂, 2 ♀, Santa Fe,Villa Ana, 28°28'51.38"S 59°37'2.75"W, 16/02/1946, Haywara & Willmk, IFML; 1 ♀, Santiago del Estero, Dto.Robles, 27°54'12.92"S, 63°53'45.31"W, 18/09/1969, Maldonado, MLP; 1 ♀, Santiago del Estero, Turena 27°59'5.47"S 64° 0'4.46"W, 22/10/1934,Maldonado, MLP; 1 ♀, Santiago del Estero, Rio Salado, 31/01/1970, MLP; 1 ♀, Santiago del Estero,01/1947, Boteanc, IFML; 1 ♀, MLP; 1 ♀, "Ppa Ctl", MACN; URUGUAY: Banda Oriental, 1 ♂, MLP. BOLIVIA: 1 ♀, Tarija, Tarija Caisa, 21°31'45.15"S 64°44'59.98"W, 02/02/1965, A.Mesa & R.Sandulski, FCMU.

Distribution

This species is found in southern South America (mostly Argentina; with only one record from Bolivia and one from Uruguay, lacking the locality information), between 21° and 39° S, and 69° and 55° W, being widely distributed in central and northern Argentina (Buenos Aires, Santa Fe, Entre Ríos, La Pampa, San Luis, Córdoba, Tucumán, Salta, Jujuy, Santiago del Estero, Formosa, Chaco, Río Negro, Mendoza, La Rioja) (Fig. 11).

Habitat

In grassland areas with forbs, and shrubs; and in edges of low forests.

Diponthus pycnostictus **Pictet & Saussure, 1887** (LSID: Orthoptera.speciesfile.org: TaxonName: 45099)

Figs. 6E,F,K,L; 7E,F,K,L; 8E,F,K,L; 9B,D,F,H; 10B,D,F; 12)

Diponthus pycnostictus Pictet & Saussure 1887: 367 (Hololectotype female, so labeled by Carlos S. Carbonell, and here formally designated; Bahia Blanca, Argentina, MHNG); Kirby 1910: 382; Liebermann 1939: 187; Liebermann 1948: 84; Carbonell et al. 2006; Hollier 2011: 387.

Type specimen

Two female type specimens are in the collection in Geneva (MHNG) however none of them is from Entre Ríos, Argentina as mentioned in the original description. One specimen is from "Bahia Blanca, envoi G. Claraz", the other specimen "Buen Air, La Plata 609-33 Mr. H. de Sauss." Both specimens have the label "*Prionacris picnostictus* Pict. et Sauss." Besides, the specimen from Bahia Blanca has another label "*Diponthus pycnostictus* P. et S.", this female was selected as the hololectotype by Carlos S. Carbonell, and it is here designated as such. Hollier (2011) indicates that besides the materials mentioned before, there is also a male with labels: "Buenos Ayres, Février 1868"; "Prionacris pycnostichus Pict. et Sss.", that might also be a syntype.

Diagnosis

This species is distinguished from *D. argentinus* by the following characters: whole body mottled black, ground body color reddish orange (Fig. 6E,K) or yellow (Fig. 6F,L) and dark grey; phallic complex: valves of cingulum with anterior margin curved and distal portion oblong (Fig. 9B,H).

Chromatic characters

Within this species at least two color morphs can be found: Color morph "reddish orange and dark grey": general body color reddish orange and dark grey, whole body mottled black (Fig. 6E,K). Head: reddish orange with posterior edge of vertex, a median dorsal line on fastigium and vertex, occiput, postgenae and areas of the mouthparts dark grey (Fig. 7E,K). Antennae usually black, in some specimens with the basal half of each segment yellow and the distal half black (Fig. 6K). Pronotum dark grey, with median longitudinal band reddish orange, two oblique reddish orange bands converging towards the principal sulcus; posterior margin of pronotum reddish orange, and a reddish orange band near lower margin of lateral lobes (Fig. 8E,K); meso-and metapleurae with a reddish orange spot. Anterior and middle legs reddish orange; tarsi red (Fig. 6E,K). Hind femur reddish orange, with a basal spot on external and internal faces and two wide dark grey transverse bands; upper lobe of knee black (Fig. 6E). Hind tibiae red with distal tip black (Fig. 6E). Tegmina with dark background and creamy veins; creamy spots on cross veins (Figs. 6E, K; 10F). Hind wings orange to reddish. Male epiproct pale red with tubercles and furculae black (Fig. 10D); male cerci pale red with black tips (Fig. 10B).

Color morph "yellow and dark grey": body color yellow and dark grey, entirely mottled black (Fig. 6F,L). The same color pattern as described above but the reddish orange areas are yellow in this color morph.

Fig. 10. *Diponthus* males. Species as indicated. (A, B) male distal abdominal segment, lateral view; (C, D) male distal abdominal segment, dorsal view; (E, F) detail of tegmina veins. Abbreviations: C, cerci; E, epiproct; F, furculae. This figure is published in colour in the online version of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/1876312x.

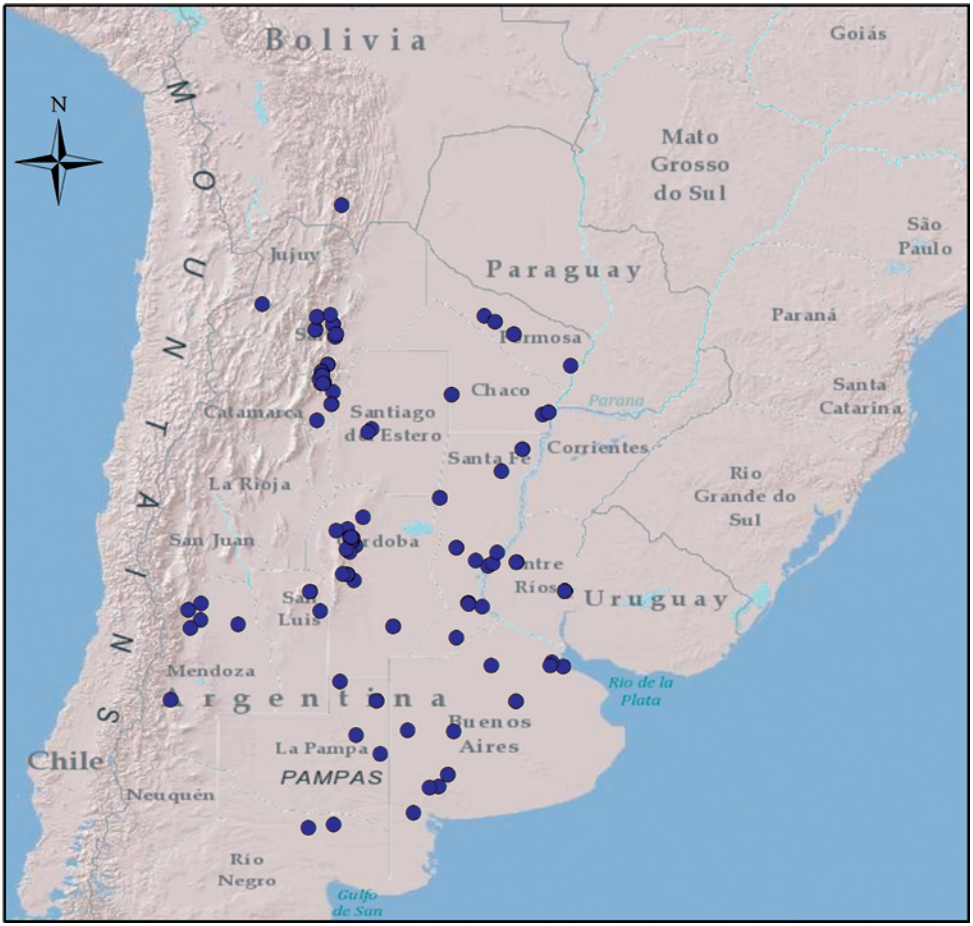

Fig. 11. Geographic distribution of *Diponthus argentinus* based on specimens with recorded sampling localities only. This figure is published in colour in the online version of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/1876312x.

Females: similar to males, but more robust and larger. Ovipositor valves robust and short, with black tips.

Measurements (in mm)

Body length: males: 25.5 (21–33); females: 35.2 (30–40); femur III length: males: 13.8 (12–17); females: 18.3 (15–21); tegmen length: males: 22.1 (19–28); females: 29.2 (26–32).

Material examined

ARGENTINA: 1 ♂, Tucumán, El Simbolar, Ruta 311 to San Pedro de Colalao, 26°15'37.8"S, 65°18'36.1"W, 17/02/2011, Cigliano & Lange, MLP; 1 ♂, Salta,

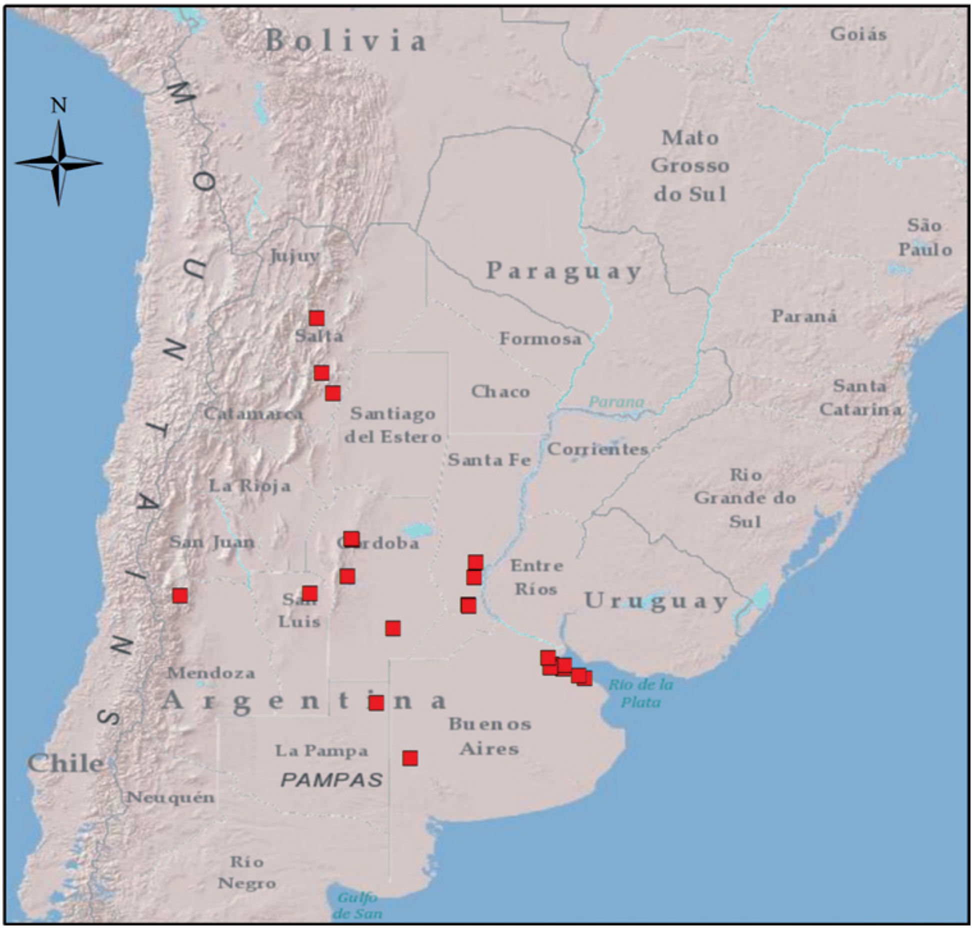

Fig. 12. Geographic distribution of *Diponthus pycnostictus* based on specimens with recorded sampling localities only. This figure is published in colour in the online version of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/1876312x.

Lesser, 25/01/2010, Castillo & Castillo, IBS; 1 ♂, Tucumán, Lolita Cruz Alta, 02/1971, M.Barrera & V.Mistreta, IFML; 1 ♀, Buenos Aires, Flores, 34°39'48.91"S, 58°27'24.24"W, 05/02/1959, MLP; 1 ♂, 1 ♀, Buenos Aires, Flores, 34°39'48.91"S, 58°27'24.24"W, 27/02/1915, MLP; 1 ♀, Buenos Aires, MACN; 1 ♂, Buenos Aires, Jose C.Paz, 34°32'7.97"S, 58°45'58.13"W, 1940, J.A.R.Costa, MLP; 1 ♀, Buenos Aires, La Plata, 34°56'35.27"S, 57°51'3.34"W, 02/01/1962, J.Moli, MLP; 1 ♂, Buenos Aires, La Plata, 34°56'35.27"S, 57°51'3.34"W, MLP; 1 ♂, Buenos Aires, Carhue, Lago Epecuen, 37°12'9.65"S, 62°47'36.25"W, 15/01/1963, H.E.Trotta, MLP; 1 ♀, Buenos Aires, M.B. Gonnet, 34°51'28.63"S, 58° 0'28.40"W, 06/02/1958, H.Trotta, MLP; 2 ♂, 1 ♀, Buenos Aires, Moreno, 34°37'43.37"S, 58°49'21.55"W, MACN; 1 ♂, Buenos Aires, Palermo, 34°34'21.40"S, 58°24'54.83"W, “Antigua”, MACN; 1 ♂, Buenos Aires, Zalaya, 34°21'42.56"S, 58°52'37.18"W, J.H.Pereyra,

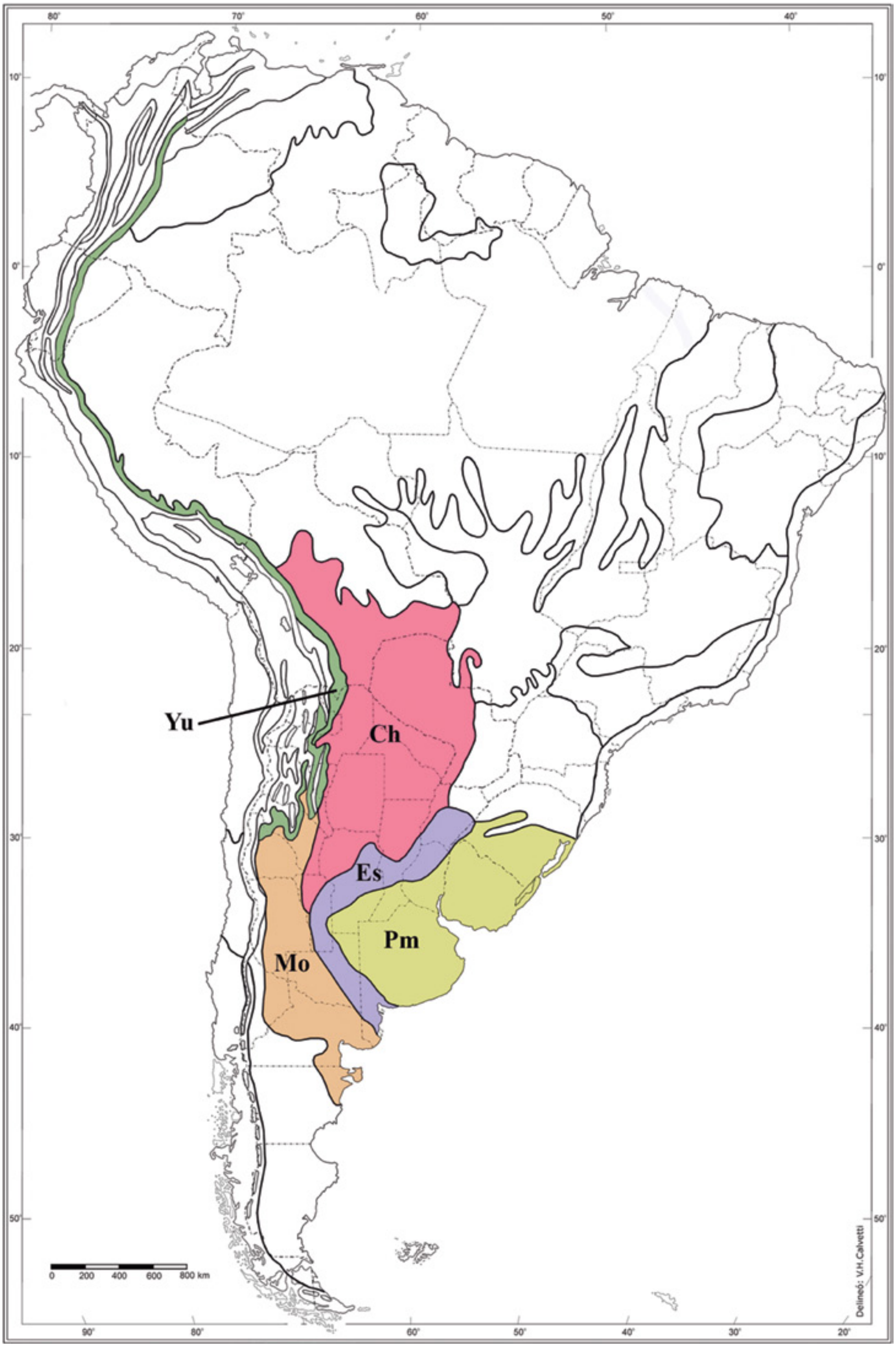

Fig. 13. Biogeographic scheme modified from Cabrera & Willink (1973) indicating the biogeographic provinces considered in this study. Yu, Yungas province; Ch, Chaqueña province; Es, Espinal province; Pm, Pampeana province; Mo, Monte province. This figure is published in colour in the online version of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/1876312x.

MACN; 1 ♀, Buenos Aires, Zalaya, 34°21'42.56"S, 58°52'37.18"W, MACN; 1 ♀, Buenos Aires, Zalaya, 34°21'42.56"S, 58°52'37.18"W, 00/04/1938, J.B.Daguerre, MACN; 5 ♂, 4 ♀, Córdoba, Dpto. Calamuchita-"El Sauce", 32°2'52.23"S, 64°34'25.91"W, 00/12/1938, M.J.Viana, MACN; 1 ♂, Córdoba; 1 ♂, Córdoba, El Chingolo, 11/01/2006, D. Marti, IBS ; 1 ♂, Córdoba, La Cumbre, 30°59'58.84"S, 64°26'33.20"W, 11/02/2013, Cigliano & Lange, MLP; 1 ♂, 1 ♀ Córdoba, La Cumbre 2 km detour Covadonga, 30°58'39.13"S, 64°28'28.24"W, 03/03/2013, Cigliano & Lange, MLP; 1 ♂, La Pampa, General Pico, 35°37'53.73"S, 63°44'58.70"W, 01/03/1943, Williamson & J.A.Rosas Costa, MLP; 1 ♂, La Rioja, MACN; 1 ♂, Mendoza, Uspallata, 32°35'12.36"S, 69°19'48.79"W, IFML; 1 ♂, San Luis, Praga, 32°32'9.48"S, 65°38'51.35"W,17/12/1967, R.A.Ronderos-M.A.Monne, MLP; 1 ♂, 1 ♀, Santa Fe, Carcaraña, 32°50'38.31"S, 61° 8'59.66"W, 21/02/1965, C.S.Carbonell, A.Mesa & M.A.Monne, FCMU; 1 ♂, Santa Fe, Carcaraña, 32°52'48.92"S 61° 7'44.30"W, 21/02/1965, C.S.Carbonell, A.Mesa & M.A.Monne, MZSP; 2 ♂, Santa Fe, 20 Km from city, 31°38'53.72"S, 60°56'8.32"W, 10/02/2009, MLP; 1 ♂, Santa Fe, Arocena, 32°50'38.31"S, 61° 8'59.66"W, 23/02/1965, C.S.Carbonell, A. Mesa & M.A.Monne, MZSP; 1 ♂, MACN.

Distribution

This species is found in southern South America, being widely distributed in central and northern Argentina (Buenos Aires, La Pampa, Santa Fe, Córdoba, San Luis, La Rioja, Mendoza, Tucumán, Salta) (Fig. 12).

Habitat

In grassland areas with forbs, and shrubs; and in edges of low forests.

Acknowledgements

Very special thanks to Prof. Carlos S. Carbonell who greatly contributed to this study with photographs, drawings, and notes on the type specimens and comments on the manuscript, as well as with the loan materials. We also want to express our gratitude to Julián Lange, Nélida Caligaris and Hernán Pereira for their invaluable technical assistance, to Holger Braun for the revision of this manuscript and to Diego Salariato for his comments about some statistical methods implemented here. Financial support was provided by the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), and a research grant from The Orthopterists' Society provided funding to Martina E. Pocco. We thank Simon Poulain (MNHN), Eliana Marques Cancello (MZSP), Dardo Martí (IBS), M.V. Colomo de Correa (IFML), Diego Carpintero (MACN) and Federico Ocampo (IADIZA) for the loan of specimens.

References

Alström, P., Rasmussen, P.C., Olsson, U. & Sundberg, P. (2008) Species delimitation based on multiple criteria: the Spotted Bush Warbler *Bradypterus thoracicus* complex (Aves: Megaluridae). *Zoological Journal of the Linnean Society* **154**: 291–307.

Bardi, C., Mariottini, Y., Plischuk, S. & Lange, C.E. (2012) Status of the alien pathogen Paranosema locustae (Microsporidia) in grasshoppers (Orthoptera: Acridoidea) of the Argentine Pampas. *Biocontrol Science and Technology* **22**: 497–512.

Barrera, M. & Paganini, H.I. (1975) Acridios de Tucumán: notas bioecológicas. *Acta Zoológica Lilloana* **31**: 107–123.

Bergmann, C. (1847) Über die Verhältnisse der Wärmekönomie der Thiere zu ihrer Grösse. *Göttinger Studien* **3**: 595–708.

Berner, D. & Blanckenhorn, W.U. (2006) Grasshopper ontogeny in relation to time constraints: adaptive divergence and stasis. *Journal of Animal Ecology* **75**: 130–139.

Bidau, C.J. & Martí, D.A. (2007a). Clinal variation of body size in *Dichroplus pratensis* (Orthoptera: Acrididae): Inversion of Bergmann's and Rensch's Rules. *Annals of the Entomological Society of America* **100**: 850–860.

Bidau, C.J. & Martí, D.A. (2007b). *Dichroplus vittatus* Bruner 1900 (Acrididae, Melanoplinae) follows the converse to Bergmann's rule although male morphological variability increases with latitude. *Bulletin of Entomological Research* **97**: 69–79.

Blanckenhorn, W.U. & Demont, M. (2004) Bergmann and converse Bergmann latitudinal clines in arthropods: Two ends of a continuum? *Integrative and Comparative Biology* **44**: 413–424.

Bolívar, I. (1884) *Insectos Neurópteros y Ortópteros. Artrópodos del viaje al Pacífico verificado de 1862 a 1865 por una comisión de naturalistas enviada por el gobierno español.* Imprenta de Miguel Ginesta, Madrid, 120 pp.

Bruner, L. (1900) *Second Report of the Merchants' Locust Investigation Commission of Buenos Aires*. Lincoln, NE, 80 pp.

Cabrera, Á.L. & Willink, A. (1973) *Biogeografía de América Latina. Monografía 13. Serie de Biología*. Secretaría General de la Organización de los Estados Americanos, Washington, DC, EEUU, 120 pp.

Capello, S., Marchese, M. & De Wysiecki, M.L. (2013) Orthoptera assemblages associated with macrophytes of floodplain lakes of the Paraná River. *Revista Brasileira de Entomologia* **7**: 59–66.

Capinera, J.L. (2008) Grasshoppers, katydids and crickets (Orthoptera). *Encyclopedia of Entomology*: pp. 1695–1714.

Carbonell, C.S. (1984) Nomenclature and systematics of *Tropidacris* and *Eutropidacris* (Orthoptera: Acridoidea, Romaleidae). *Notulae Naturae* **461**: 1–11.

Carbonell, C.S. (1986) Revision of the neotropical genus *Tropidacris* (Orthoptera Acridoidea, Romaleidae, Romaleinae). *Proceedings of the Academy of Natural Sciences of Philadelphia* **138**: 366–402.

Carbonell, C.S. (1996) New species of the genus *Radacridium* Carbonell 1984 (Acridoidea: Romaleidae: Romaleinae) from the Brazilian northeast. *Journal of Orthoptera Research* **5**: 37–41.

Carbonell, C.S. (2004) The genus *Xyleus* Gistel 1848 (Acridoidea, Romaleidae, Romaleinae). *Journal of Orthoptera Research* **13**: 63–133.

Carbonell, C.S. (2007) The genus *Zoniopoda* Stål 1873 (Acridoidea, Romaleidae, Romaleinae). *Journal of Orthoptera Research* **16**: 1–33.

Carbonell, C.S., Cigliano, M.M. & Lange, C.E. (2006) *Especies de acridomorfos (Orthoptera) de Argentina y Uruguay/Acridomorph (Orthoptera) species of Argentina and Uruguay*. Publications on Orthopteran Diversity, The Orthopterists' Society, La Plata, 300 pp.

Cigliano, M.M. & Eades, D. (2010) New technologies challenge the future of Taxonomy in Orthoptera. *Journal of Orthoptera Research* **19**: 15–18.

Cigliano, M.M., de Wysiecki, M.L. & Lange, C.E. (2000) Grasshopper (Orthoptera: Acridoidea) species diversity in the Pampas, Argentina. *Diversity and Distributions* **6**: 81–91.

Ciplak, B., Sirin, D., Taylan, M.S. & Kaya, S. (2008) Altitudinal size clines, species richness and population density: case studies in Orthoptera. *Journal of Orthoptera Research* **17**: 157–163.

Colvin, J. & Cooter, R.J. (1995) Diapause induction and coloration in the Senegalese grasshopper, *Oedaleus senegalensis*. *Physiological Entomology* **20**: 13–17.

Davis, J.I. & Nixon, K.C. (1992) Populations, Genetic Variation, and the Delimitation of Phylogenetic Species. *Systematic Biology* **41**: 421–435.

de Queiroz, K. (1998) The general lineage concept of species, species criteria, and the process of speciation: a conceptual unification and terminological recommendations. In: Howard, D.J. & Berlocher, S.H. (Eds.) *Endless forms: species and speciation*. Oxford University Press, New York, NY, pp. 57–75.

de Queiroz, K. (2005) A unified concept of species and its consequences for the future of taxonomy. *Proceedings of the California Academy of Sciences* **56**: 196–215.

de Queiroz, K. (2007) Species concepts and species delimitation. *Systematic Biology* **56**: 879–886.

de Wysiecki, M.L., Sánchez, N.E. & Ricci, S. (2000) Grassland and shrubland grasshopper community composition in northern La Pampa province, Argentina. *Journal of Orthoptera Research* **9**: 213–217.

Dearn, J.M. (1990) Color pattern polymorphism. In: Chapman, R.F. & Joern, A. (Eds.) *Biology of Grasshoppers*. John Wiley and Sons, New York, NY, pp. 517–549.

Descamps, M. & Carbonell, C.S. (1985) Revision of the Neotropical arboreal genus *Titanacris* (Orthoptera, Acridoidea, Romaleidae). *Annales de la Société Entomologique de France* **21**: 259–285.

Eades, D.C., Otte, D., Cigliano, M.M. & Braun, H. (2013) *Orthoptera Species File Online. Version 2.0/4.0*, available online at http://Orthoptera.SpeciesFile.org.

Forsman, A. & Appelqvist, S. (1999) Experimental manipulation reveals differential effects of colour pattern on survival in male and female pygmy grasshoppers. *Journal of Evolutionary Biology* **12**: 391–401.

Forsman, A., Karlsson, M., Wennersten, L., Johansson, J. & Karpestam, E. (2011) Rapid evolution of fire melanism in replicated populations of pygmy grasshoppers. *Evolution* **65**: 2530–2540.

Hadley, A. (2006) *CombineZ5*. Published by the author, available online at http://www.hadleyweb.pwp.blueyonder.co.uk (accessed 10 April 2010).

Hammer, Ø, Harper, D.A.T. & Ryan, P.D (2001) PAST: paleontological statistics software package for education and data analysis. *Palaeontología Electrónica* **4**: 1–9.

Henderson, A.J. (2004) A multivariate analysis of Hyospathe (Palmae). *American Journal of Botany* **91**: 953–965.

Henderson, A.J. (2005) A multivariate study of Calyptrogyne (Palmae). *Systematic Botany* **30**: 60–83.

Hochkirch, A., Deppermann, J. & Gröning, J. (2008) A phenotypic plasticity in insects: the effects of substrate color on the coloration of two ground-hopper species. *Evolution & Development* **10**: 350–359.

Hollier, J. (2011). An annotated list of the Orthoptera (Insecta) species described by Alphonse Pictet (alone, and with Henri de Saussure) with an account of the primary type material present in the Muséum d'histoire naturelle in Geneva. *Revue Suisse de Zoologie* **118**: 345–400.

Karlsson, M., Caesar, S., Ahnesjo, J. & Forsman, A. (2008) Dynamics of colour polymorphism in a changing environment: fire melanism and then what? *Oecologia* **154**: 715–724.

Key, K.H.L. (1954) *The taxonomy, phases and distribution of the genera Chortoicetes Brunn and Austroicetes Uv. (Orthoptera: Acrididae)*. Division of Entomology, CSIRO, Canberra, ACT, 237 pp.

Key, K.H.L. & Day, M.F. (1954) A temperature controlled physiological colour-response in the grasshopper *Kosciuscola tristis* Sjost. (Orthoptera: Acrididae). *Australian Journal of Zoology* **2**: 309–339.

Kirby, W.F. (1910) *A Synonymic Catalogue of Orthoptera (Orthoptera Saltatoria, Locustidae vel Acridiidae)*. British Museum (Natural History), London **3**: 674 pp.

Knowles, L.L. & Carstens, B.C. (2007) Delimiting species without monophyletic gene trees. *Systematic Biology* **56**: 887–895.

Lange, C.E. (2003) Long-term patterns of occurrence of *Nosema locustae* Canning and *Perezia dichroplusae* Lange (Microsporidia) in grasshoppers (Orthoptera: Acrididae) of the Pampas, Argentina. *Acta Protozoologica* **42**: 309–315.

Lange, C.E. (2005). The host and geographical range of *Paranosema (Nosema)* locustae revisited. *Journal of Orthoptera Research* **14**: 137–141.

Lange, C.E. (2010) *Paranosema locustae* (Microsporidia) in grasshoppers (Orthoptera: Acridoidea) of Argentina: field host range expanded. *Biocontrol Science and Technology* **20**: 1047–1054.

Lange, C.E. & de Wysiecki, M.L. (1996) The fate of *Nosema locustae* (Microsporida: Nosematidae) in argentine grasshoppers (Orthoptera: Acrididae). *Biological Control* **7**: 24–29.

Lange, C.E. & Cigliano, M.M. (2005) Overview and perspectives on the introduction and establishment of the grasshopper biocontrol agent *Paranosema locustae* (Microsporidia) in the western Pampas of Argentina. Vedalia *International Journal of Biological Control* **12**: 61–84.

Lange, C.E., Bardi, C. & Plischuk, S. (2008) Infectividad de *Paranosema locustae* (Microsporidia) en la "tucura quebrachera" *Tropidacris collaris* (Orthoptera: Romaleidae) en laboratorio. *Revista de la Sociedad Entomológica Argentina* **67**: 151–155.

Lecoq, M. & Pierozzi, I. (1996) Chromatic polymorphism and geophagy: two outstanding characteristics of *Rhammatocerus schistocercoides* (Rehn, 1906) grasshoppers in Brazil (O: A: Gomphocerinae). *Journal of Orthoptera Research* **5**: 13–17.

Lehmann, G.U.C. & Lehmann, A.W. (2008) Variation in body size among populations of the bushcricket *Poecilimon thessalicus* (Orthoptera: Phaneropteridae): an ecological adaptation. *Journal of Orthoptera Research* **17**: 165–169.

Liebermann, J. (1939) Catálogo sistemático y biogeográfico de acridoideos argentinos. *Revista de la Sociedad Entomológica Argentina* **10**: 125–230.

Liebermann, J. (1948) Los Acridios de Santa Fe. *Revista de la Sociedad Entomológica Argentina* **14**: 55–114.

Liebermann, J. 1966[1967] Revisión de algunos materiales típicos de tucuras argentinas publicadas por Lawrence Bruner en su trabajo de 1900 (Orth. Acrididae). *Revista de la Sociedad Entomológica Argentina* **29**: 96–100.

Listre, A. (2009) *Distribución geográfica de las familias Romaleidae y Ommexechidae (Orthoptera: Acridoidea) en el Uruguay*. Tesina, Facultad de Ciencias, Universidad de la República, Montevideo, 61 pp.

Mallet, J. (2008) Hybridization, ecological races and the nature of species: empirical evidence for the ease of speciation. *Proceedings of the Royal Society of London B* **363**: 2971–2986.

Mariottini, Y., de Wysiecki, M.L. & Lange, C.E. (2011) Seasonal occurrence of life stages of grasshoppers (Orthoptera: Acridoidea) in the southern Pampas, Argentina. *Zoological Studies* **50**: 737–744.

Mariottini, Y., de Wysiecki, M.L. & Lange, C.E. (2013) Diversidad y distribución de acridios (Orthoptera: Acridoidea) en pastizales del sur de la región pampeana, Argentina. *Revista de Biología Tropical* **61**: 111–124.

Marshall, J.C. & Sites Jr., J.W. (2003) A summary of some contemporary methods used to delimit species boundaries. *Boletin de la Sociedad Herpetologica Mexicana* **11**: 1–8.

Mayden, R.L. (1997) A hierarchy of species concepts: the denouement in the saga of the species problem. In: Claridge, M.F., Dawah, H.A. & Wilson, M.R. (Eds.) *Species: the units of biodiversity*. Chapman & Hall, London: pp. 381–424.

Mayr, E. (1942). *Systematics and the origin of species*. Columbia University Press, New York, NY, 334 pp.

McGowen, M.H.,Wiltshire, R.J.E., Potts, B.M. & Vaillancourt, R.E. (2001) The origin of *Eucalyptus vernicosa*, a unique shrub eucalyptus. *Biological Journal of the Linnean Society* **74**: 397–405.

Mesa, A. (1956) Los cromosomas de algunos acridoideos uruguayos (Orthoptera, Caelifera, Acridoidea). *Agros, Revista de la Asociacion de Estudiantes de Agronomia, Montevideo* **141**: 32–45.

Mousseau, T.A. (1997) Ectotherms follow the converse to Bergmann's rule. *Evolution* **51**: 630–632.

Nixon, K.C. & Wheeler, Q.D. (1990) An amplification of the phylogenetic species concept. *Cladistics* **6**: 211–223.

Nosil, P. (2007) Divergent host plant adaptation and reproductive isolation between ecotypes of *Timema cristinae* walking sticks. *American Naturalist* **169**: 151–162.

Nosil, P. & Crespi, B.J. (2004) Does gene flow constrain trait divergence or vice-versa? A test using ecomorphology and sexual isolation in *Timema cristinae* walking-sticks. *Evolution* **58**: 101–112.

Nosil, P. & Crespi, B.J. (2006) Experimental evidence that predation promotes divergence in adaptive radiation. *Proceedings of the National Academy of Sciences of the United States of America* **103**: 9090–9095.

Nosil, P., Crespi, B.J. & Sandoval, C.P. (2002) Host-plant adaptation drives the parallel evolution of reproductive isolation. *Nature* **417**: 440–443.

Okay, S. (1956) The effect of temperature and humidity on the formation of green pigment in Acrida bicolor (Thunb.). *Archives Internationales de Physiologie et de Biochimie* **64**: 80–91.

Olson, L.E., Goodman, S.M. & Yoder, A.D. (2004) Illumination of cryptic species boundaries in long-tailed shrew tenrecs (Mammalia: Tenrecidae; Microgale), with new insights into geographic variation and distributional constraints. *Biological Journal of the Linnean Society* **83**: 1–22.

Orians, G.H. & Solbrig, O.T. (1977) Convergent evolution in warm deserts: an examination of strategies and patterns in deserts of Argentina and the United States. Dowden, Hutchinson & Ross (eds) Stroudsburg, New York, NY, 333 pp.

Orrego Aravena, R. (1985) Trabajos de Acridiologías realizados en el Museo Provincial-La Pampa Argentina. *Metaleptea* **7**: 9–10.

Otte, D. (1976) Species richness patterns of New World desert grasshoppers in relation to plant diversity. *Journal of Biogeography* **3**: 197–209.

Otte, D. (1995) Grasshoppers [Acridomorpha] C. Orthoptera Species File, *The Orthopterists' Society and The Academy of Natural Sciences of Philadelphia, Philadelphia* **4**: 518 pp.

Otte, D. (1997) Tetrigoidea and Tridactyloidea (Orthoptera: Caelifera) and Addenda to OSF Vols. 1–5. Orthoptera Species File. *The Orthopterists' Society and The Academy of Natural Sciences of Philadelphia* **6**: 1–261.

Otte, D. & Williams, K. (1972) Environmentally induced color dimorphisms in grasshoppers. *Syrbula admirabilis*, *Dichromorpha viridis*, and *Chortophaga viridifasciata*. *Annals of the Entomological Society of America* **65**: 1154–1161.

Otte, D. &. Joern, J.A. (1977) On feeding patterns in desert grasshoppers and the evolution of specialized diets. *Proceedings of the Academy of Natural Sciences, Philadelphia* **128**: 89–126.

Pener, M.P. (1991) Locust phase polymorphism and its endocrine relations *Advances in Insect Physiology* **23**: 1–79.

Pener, M.P. & Yerushalmi, Y. (1998) The physiology of locust phase polymorphism: an update. *Journal of Insect Physiology* **44**: 365–377.

Pictet, A. & Saussure, H. (1887) Catalogue d'Acridiens. Mitteilungen der Schweizerischen Entomologischen Gesellschaft (Mitt. Schweiz. Ent. Gesellsch.) **7**: 331–376.

Rehn, J.A.G. (1913) A contribution to the knowledge of the Orthoptera of Argentina. *Proceedings of the Academy of Natural Sciences, Philadelphia* **65**: 273–379.

Remis, M.I. (2008) Population differentiation in the grasshopper *Sinipta dalmani*: body size varies in relation to karyotype and climatic conditions. *Journal of Orthoptera Research* **17**: 213–218.

Roberts, H.R. & Carbonell, C.S. (1982) A revision of the grasshopper genera *Chromacris* and *Xestotrachelus* (Orthoptera, Romaleidae, Romaleinae). *Proceedings of the California Academy of Sciences* **43**: 43–58.

Roberts, H.R. & Carbonell, C.S. (1992) Revision of the genera *Agriacris* Walker 1870 and *Staleochlora* nov. (Orthoptera, Romaleidae). *Journal of Orthoptera Research* **1**: 75–106.

Rowell, C.H.F. (1970) Environmental control of coloration in an acridid, *Gastrimargus africanus* (Saussure). *Anti-Locust Bulletin* **47**: 1–48.

Rowell, C.H.F. (1971) The variable coloration of the acridoid grasshoppers. *Advances in Insect Physiology* **8**: 145–198.

Rowell, C.H.F. (1983) *Tropidacris cristata* (saltamonte o chapulín gigante, giant red-winged grasshopper). In: Janzen, D.H. (ed.) Costa Rican natural history. University of Chicago Press, Chicago, IL, pp. 772–773.

Rowell, C.H.F. & Cannis, T.I. (1972) Environmental factors affecting the green/brown polymorphism in the Cyrtacanthacridinae grasshopper *Schistocerca vaga* (Scudder). *Acrida* **1**: 69–77.

Salariato, D.L. Zuloaga, F.O. & Al-Shehbaz, I.A. (2012) Morphometric studies and taxonomic delimitation in *Menonvillea scapigera* and related species (Cremolobeae: Brassicaceae). *Plant Systematics and Evolution* **298**: 1961–1976.

Sánchez, N.E. & de Wysiecki, M.L. (1983) Estimación del daño causado por acridios en pasturas naturales. I. Reducción de forraje debida a *Dichroplus pratensis* Bruner. *Revista de la Sociedad Entomológica Argentina* **42**: 243–250.

Sánchez, N.E. & de Wysiecki, M.L. (1993) Abundancia y diversidad de acridios en pasturas de la Provincia de La Pampa, Argentina. *Revista de Investigaciones Agropecuarias* **24**: 29–39.

Sandoval, C.P. (1994a) Differential visual predation on morphs of *Timema cristinae* (Phasmatodea: Timemidae) and its consequences for host range. *Biological Journal of the Linnean Society* **52**: 341–356.

Sandoval, C.P. (1994b) The effects of relative geographic scales of gene flow and selection on morph frequencies in the walking stick *Timema cristinae*. *Evolution* **48**: 1866–1879.

Sandoval, C.P. & Crespi, B.J. (2008) Adaptive evolution of cryptic coloration: the shape of host plants and dorsal stripes in *Timema* walking-sticks. *Biological Journal of the Linnean Society* **94**: 1–5.

Serville, J.G. (1838[1839]) *Histoire naturelle des insectes Orthoptères*. Collection des suites a Buffon, Paris **17**, 776 pp.

Simpson, S.J. & Sword, G.A. (2008) Locusts. *Current Biology* **18**: R364–366.

Simpson, S.J., McCaffery, A.R. & Hagele, B.F. (1999) A behavioural analysis of phase change in the desert locust. *Biological Reviews* **74**: 461–480.

Simpson, S.J., Raubenheimer, D. Behmer, S.T., Whitworth, A. & Wright, G.A. (2002) A comparison of nutritional regulation in solitarious-and gregarious-phase nymphs of the desert locust, *Schislocerca gregaria*. *Journal of Experimental Biology* **205**: 121–129.

Simpson, S.J., Sword, G.A. & De Loof, A. (2005) Advances, controversies and consensus in locust phase polymorphism research. *Journal of Orthoptera Research* **14**: 213–222.

Sites Jr., J.W. & Marshall, J.C. (2003) Delimiting species: A renaissance issue in systematic biology. *Trends in Ecology and Evolution* **18**: 462–470

Sites Jr., J.W. & Marshall, J.C. (2004) Operational criteria for delimiting species. *Annual Review of Ecology, Evolution, and Systematics* **35**: 199–227

Sword, G.A. (1999) Density-dependent warning coloration. *Nature* **397**: 217.

Sword, G.A. (2001) Tasty on the outside, but toxic in the middle: Grasshopper regurgitation and host plant-mediated toxicity to a vertebrate predator. *Oecologia* **120**: 416–421.

Sword, G.A. & Dopman, E.B. (1999) Developmental specialization and geographic structure of host plant use in a polyphagous grasshopper, *Schistocerca emarginata* (= *lineata*) (Orthoptera: Acrididae). *Oecologia* **120**: 437–445.

Sword, G.A., Joern, A. & Senior, L.B. (2005) Host plant-associated genetic differentiation in the snakeweed grasshopper, *Hesperotettix viridis* (Orthoptera: Acrididae). *Molecular Ecology* **14**: 2197–2205.

Sword, G.A., Simpson, S.J., El Hadi, O.T.M. & Wilps, H. (2000) Density-dependent aposematism in the desert locust. *Proceedings of the Royal Society of London Series B: Biological Sciences* **267**: 63–68.

Tanaka, Y. (2008) Effects of temperature on body color change in the grasshopper *Atractomorpha lata* (Orthoptera: Pyrgomorphidae) with reference to sex differences in color morph frequencies. *Entomological Science* **11**: 49–54.

Uvarov, B. (1966) *Grasshoppers and Locusts. Vol. I.* Cambridge University Press, Cambridge.

Walker, F. (1870). *Catalogue of the Specimens of Dermaptera Saltatoria in the Collection of the British Museum*, *London* **4**: 605–809.

Whitman, D.W. (2008) The significance of body size in the Orthoptera: a review. *Journal of Orthoptera Research* **17**: 117–134.

Whitman, D.W. & Orsak, L.J. (1985) Biology of *Taeniopoda eques* (Orthoptera: Acrididae) in southeastern Arizona. *Annals of the Entomological Society of America* **78**: 811–825.

Whitman, D.W. & Vincent, S. (2008) Large size as an anti-predator defense in a grasshopper. *Journal of Orthoptera Research* **17**: 253–371.

Wiens, J.J. (2007) Species delimitation: new approaches for discovering diversity. *Systematic Biology* **56**: 875–878.

Wiens, J.J. & Penkrot, T.A. (2002) Delimiting species using DNA and morphological variation and discordant species limits in spiny lizards (*Sceloporus*). *Systematic Biology* **51**: 69–91.

Wiens, J.J. & Servedio, M.R. (2000) Species delimitation in systematics: inferring diagnostic differences between species. *Proceedings of the Royal Society of London Series B: Biological Sciences* **267**: 631–636.

Zapata, F. & Jiménez, I. (2012) Species delimitation: Inferring gaps in morphology across geography. *Systematic Biology* **61**: 179–194.

Appendix A

List of characters (with acronyms) used in CA and PCA analyses

0. Body length (BL), from the fastigium verticis to the end of abdomen.
1. Pronotum length (PL), along the midline from the front to hind margin.
2. Tegmina length (TL), along the midline from the front to hind margin.
3. Femur III length (FL), from the dorso-proximal lobe to the distal extremity
4. Metazona width (MW), maximum width of disk of pronotum.
5. General body color (BC): green and yellow (0) (Fig. 6B); black and yellow (1) (Fig. 6A); reddish orange and dark grey (2) (Fig. 6E); yellow and dark grey (3) (Fig. 6F); greenish-brown (4) (Fig. 6D).
6. Body color pattern (BCP): without black mottles (0) (Fig. 6B; with black mottles in metazona and abdomen (1) (Fig. 6A); wholly black mottled (2) (Fig. 6F).
7. Head color (HC): yellow with green bands/stripes (0) (Fig. 7B); yellow with black stripes (1) (Fig. 7A); reddish orange with grey stripes (2) (Fig. 7E); yellow with grey stripes (3) (Fig. 7F); red dorsally, yellow laterally and with dark stripes (4) (Fig. 7C); yellow with green stripes and in fastigium black bands (5); yellow with brown bands (6) (Fig. 7D); yellow with black stripes in fastigium (7).
8. Antennae color (AC): light brown to dark brown (0) (Fig. 6H); basal half dark brown and distal half black (1) (Fig. 6G); black (2) (Fig. 6K); each segment yellow and black (3) (Fig. 6I); green (4).
9. Prozona color (PC): black (0) (Fig. 8A); green (1) (Fig. 8B); dark grey (2) (Fig. 8F); greenish-brown (3); brown (4) (Fig. 8D).
10. Metazona color (MC): yellow or cream (0) (Fig. 8A); black (1) (Fig. 8C); green (2) (Fig. 8B); dark grey (3) (Fig. 8F); greenish-brown (4); black and cream (5); brown (6) (Fig. 8D).
11. Median and oblique bands (BPC): yellow (0) (Fig. 8A); reddish orange (1) (Fig. 8E); median red and oblique yellow (2) (Fig. 8C); brown (3) (Fig. 8D).
12. Spot at each side of median band of pronotum (SP): absent (0); present (1) (Fig. 8C).
13. Posterior edge of disk of pronotum with tinges/markings of red (RMP): absent (0); present (1) (Fig. 8C).
14. Oblique bands of pronotum (OBP): not surpassing the principal transverse sulcus (0) (Fig. 8F); surpassing the principal transverse sulcus (1) (Fig. 8C).
15. Anterior leg color (ALC): black with basal spot yellow in femur (0) (Fig. 6A);

green with basal spot yellow in femur, tarsi brown (1) (Fig. 6B); green with basal spot yellow in femur, tarsi black (2); yellow with grey small spot dorsally (3) (Fig. 6F); reddish orange with grey small spot dorsally (4) (Fig. 6E); yellow with black spots (5) (Fig. 6C); black with red basal spots (6); black (7), brown (8) (Fig. 6D).

16. Middle leg color (MLC): black with basal spot yellow in femur (0) (Fig. 6A); green with basal spot yellow in femur, tarsi brown (1) (Fig. 6B); green with basal spot yellow in femur, tarsi black (2); yellow with grey small spot dorsally (3) (Fig. 6F); reddish orange with grey small spot dorsally (4) (Fig. 6E); yellow with black spots (5) (Fig. 6C); black with red basal spots (6); brown (7) (Fig. 6D).
17. Femur III color pattern (HFC): with spot and transverse bands or incomplete rings on outer face, upper lobe of knee black (0) (Fig. 6C); with a continuous longitudinal band on outer face, upper lobe of knee black (1) (Fig. 6B); with spots and incomplete rings slightly marked on outer face, upper lobe of knee black (2); with spot and transverse bands or incomplete rings on outer face, knee entirely black (3) (Fig. 6A).
18. Tibia III color pattern (HTC): uniform color, with black ring in distal tip (0) (Fig. 6B); black and yellow, with black ring in distal tip (1) (Fig. 6A); uniform color, with black ring in distal tip and red ring in proximal tip (2) (Fig. 6C); black and yellow, with black ring in distal tip and red ring in proximal tip (3).

Appendix B

Table B1. Data matrix A (male specimens) used in the multivariate and statistical analyses.

Sp. No.	Sp-Dist	BL	PL	TL	FL	MW	BC	BCP	HC	AC	PC	MC	BPC	SP	RMP	OBP	ALC	MLC	HFC	HTC
1	G-Yu	2.4	0.4	2.2	1.3	0.4	1	1	1	1	0	0	0	0	0	1	0	0	3	0
2	A-Yu	2.5	0.4	2.1	1.3	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
3	A-Yu	2.2	0.4	2.1	1.3	0.4	0	0	5	0	1	2	0	0	0	0	1	1	2	0
4	A-Yu	2.3	0.5	2.2	1.3	0.4	0	0	5	0	1	2	0	0	0	0	1	1	1	0
5	A-Yu	2.1	0.4	2.1	1.2	0.3	0	0	5	0	1	2	0	0	0	0	1	1	1	0
6	A-Yu	2.2	0.5	1.8	1.1	0.3	0	0	0	0	1	2	0	0	0	0	1	1	1	0
7	A-Yu	2.3	0.4	2	1.1	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
8	A-Yu	2.4	0.4	2.1	1.4	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
9	A-Yu	2.5	0.5	2.2	1.4	0.4	0	0	5	0	1	2	0	0	0	0	1	1	1	0
11	A-Yu	2.5	0.5	2.2	1.2	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
13	A-Yu	2.3	0.5	2	1.2	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
14	A-Yu	2.2	0.4	2.1	1.3	0.4	0	0	0	3	1	2	0	0	0	0	1	1	2	0
17	A-Yu	2.4	0.4	2.3	1.3	0.4	0	0	5	0	1	2	0	0	0	0	1	1	1	0
18	A-Yu	2.5	0.5	2	1.4	0.4	0	0	0	0	1	2	0	0	0	0	1	1	2	0
19	A-Yu	2.4	0.5	2.2	1.3	0.3	0	0	5	0	1	2	0	0	0	0	1	1	1	0
20	A-Yu	2.6	0.4	2.3	1.4	0.3	0	0	0	0	1	2	0	0	0	0	1	1	1	0
21	A-Yu	2.3	0.4	2.2	1.4	0.4	0	0	0	0	1	2	0	0	0	0	1	1	2	0
22	A-Yu	2.4	0.4	2.2	1.3	0.4	0	0	0	0	1	2	0	0	0	0	1	1	2	0
26	A-Yu	1.9	0.4	1.9	1.1	0.3	0	0	5	0	0	2	0	0	0	0	1	1	0	0
28	A-Yu	2.5	0.5	2.1	1.4	0.4	0	0	0	0	1	2	0	0	0	0	1	1	2	0
29	A-Yu	2.3	0.4	2.2	1.2	0.4	0	0	0	3	1	2	0	0	0	0	1	1	1	0
30	A-Yu	2.4	0.4	2.3	1.4	0.4	0	0	5	3	1	2	0	0	0	0	1	1	1	0
31	A-Yu	2.2	0.4	2	1.3	0.4	0	0	5	0	1	2	0	0	0	0	1	1	1	0
32	A-Yu	2.4	0.5	2.3	1.4	0.4	0	0	5	0	1	2	0	0	0	0	1	1	2	0
33	A-Yu	2.5	0.5	2.2	1.4	0.4	0	0	5	3	1	2	0	0	0	0	1	1	2	0
41	A-Yu	2.1	0.5	2	1.2	0.3	0	0	5	0	1	2	0	0	0	0	2	2	1	0
42	A-Yu	2.3	0.5	2.2	1.4	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
43	A-Yu	2.4	0.5	2.2	1.4	0.4	0	0	5	0	1	2	0	0	0	0	1	1	2	0
44	A-Yu	2.2	0.4	2.1	1.4	0.4	0	0	5	0	1	2	0	0	0	0	1	1	2	0
45	A-Yu	2.2	0.5	2.1	1.4	0.4	0	0	5	0	1	2	0	0	0	0	1	1	2	0

48	A-Yu	2.4	0.4	2.2	1.5	0.4	0	0	5	1	3	4	0	0	0	0	1	1	0	0
49	A-Yu	2.4	0.4	2.1	1.4	0.4	0	0	5	0	1	2	0	0	0	0	1	1	0	0
50	A-Yu	2.4	0.4	2.2	1.4	0.4	0	0	5	1	3	4	0	0	0	0	2	2	3	0
51	A-Yu	2.2	0.4	2	1.3	0.4	0	0	0	3	1	2	0	0	0	0	1	1	2	0
52	A-Ch	2.5	0.4	2	1.4	0.4	0	0	5	0	1	1	0	0	0	0	1	1	0	0
53	A-Yu	2.4	0.4	2.2	1.4	0.4	0	0	5	0	1	2	0	0	0	0	1	1	2	0
56	G-Yu	2.2	0.4	2.2	1.2	0.4	1	0	1	1	0	0	3	0	0	0	0	0	3	0
57	G-Yu	2.5	0.5	2.2	1.4	0.4	1	0	1	0	0	0	0	0	0	1	0	0	3	0
58	G-Yu	2.2	0.4	2.3	1.3	0.4	1	0	1	0	0	0	0	0	0	0	0	0	0	0
59	B-Yu	2.3	0.4	2.1	1.3	0.4	1	0	1	1	0	1	0	0	0	0	0	0	3	1
61	G-Yu	2.2	0.4	2	1.2	0.4	1	1	1	1	0	0	0	0	0	1	0	0	3	0
62	A-Yu	2.4	0.4	2.2	1.4	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
63	C-Yu	2.4	0.4	2.3	1.4	0.4	2	2	2	2	2	3	1	0	0	0	4	4	0	0
66	A-Es	2.6	0.5	2.3	1.5	0.4	0	0	5		0	2	0	0	0	1	1	1	0	0
70	C-Es	2.7	0.6	2.3	1.4	0.5	3	2	3	2	2	3	0	0	0	0	3	3	0	0
72	C-Pm	2.5	0.5	2	1.5	0.4	3	2	1	3	2	3	0	0	0	0	5	4	3	0
73	A-Ch	2.8	0.5	2.1	1.4	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
74	C-Pm	2.6	0.5	2.2	1.4	0.4	2	2	2		2	3	1	0	0	0	4	4	0	0
75	C-Pm	2.5	0.5	2.3	1.4	0.4	2	2	2		2	3	1	0	0	0	4	4	0	0
76	A-Es	2.4	0.4	2	1.2	0.4	0	0	5	0	3	2	0	0	0	0	1	1	2	0
78	G-Pm	2.5	0.5	2.2	1.4	0.4	1	0	1	3	0	0	0	0	0	0	5	5	3	0
79	A-Es	2.4	0.4	2.3	1.3	0.4	0	0	1	3	0	2	0	0	0	1	2	2	0	0
80	A-Es	2.4	0.5	2.2	1.2	0.4	0	0	5		3	4	0	0	0	1	2	2	0	0
81	B-Pm	2.6	0.5	2.5	1.4	0.5	1	0	1	3	0	2	0	0	0	1	5	5	0	0
82	A-Es	2.6	0.5	2.4	1.4	0.5	0	0	0	0	1	2	0	0	0	0	1	1	0	0
83	G-Es	2.6	0.5	2.5	1.5	0.5	1	0	0	0	0	0	0	0	0	1	5	5	0	0
90	G-Pm	3.2	0.6	2.6	1.6	0.5	1	1	1	3	0	0	0	0	0	1	5	5	0	0
91	G-Pm	2.5	0.5	2.1	1.5	0.5	1	0	1		0	0	0	0	0	0	5	5	0	0
93	G-Pm	2.8	0.5	2.2	1.5	0.5	1	0	1	1	0	0	0	0	0	0	5	5	0	0
94	G-Pm	2.5	0.5	2.2	1.5	0.5	1	0	1		0	0	0	0	0	0	0	0	0	0
95	G-Pm	2.2	0.4	1.9	1.3	0.4	1	0	1		0	0	0	0	0	0	5	5	0	0

(*Continued*)

Table B1. (*Cont.*)

Sp. No.	Sp-Dist	BL	PL	TL	FL	MW	BC	BCP	HC	AC	PC	MC	BPC	SP	RMP	OBP	ALC	MLC	HFC	HTC
96	G-Pm	2.7	0.5	2.2	1.4	0.5	1	0	1		0	0	0	0	0	0	0	0	3	0
97	G-Pm	3.1	0.6	2.6	1.6	0.5	1	0	1		0	0	0	1	0	0	5	5	0	0
98	B-Pm	2.5	0.5	2.1	1.4	0.5	1	0	1		0	1	0	0	0	0	5	5	0	0
103	G-Pm	2.9	0.5	2.5	1.5	0.5	1	0	1	0	0	0	0	0	0	1	5	5	0	0
105	B-Pm	2.8	0.5	2.6	1.5	0.5	1	0	1	3	0	4	0	0	0	1	5	5	0	0
108	C-Pm	3.3	0.6	2.8	1.6	0.6	2	2	2		2	3	1	0	0	0	4	4	0	0
109	C-Pm	2.4	0.4	2.2	1.7	0.5	2	2	2	2	2	3	1	0	0	0	4	4	0	0
111	E-Es	2.5	0.5	2.1	1.3	0.5	1	0	4	3	0	4	0	1	1	1	2	2	0	2
112	E-Es	2.4	0.5	2.1	1.1	0.5	1	0	4	3	0	1	0	1	1	1	5	5	0	2
113	E-Es	2.2	0.4	1.9	1.2	0.4	1	0	4	3	0	4	0	1	1	1	2	2	0	2
114	E-Es	2.4	0.4	2.1	1.4	0.4	1	0	4	3	0	4	2	1	1	1	2	2	0	2
115	B-Es	2.4	0.4	2	1.4	0.4	1	0	1	3	0	5	0	1	0	1	5	5	0	0
116	B-Es	2.8	0.5	2.2	1.5	0.5	1	0	1	3	0	1	0	1	0	1	5	5	0	0
117	E-Es	2.4	0.5	2	1.3	0.5	1	0	4	3	0	5	0	1	1	1	5	5	0	2
118	C-Es	2.7	0.5	2.3	1.5	0.5	3	2	1	2	2	3	0	0	0	1	5	5	0	0
119	C-Es	2.5	0.5	2	1.3	0.5	3	2	4	2	2	3	2	1	0	0	5	5	0	2
120	C-Es	2.5	0.4	2.2	1.3	0.4	3	2	3	2	2	3	0	0	0	0	3	3	0	0
121	D-Ch	2.8	0.4	2.1	1.2	0.5	0	1	5	1	1	2	0	0	0	0	2	2	2	0
122	C-Es	2.8	0.6	2.3	1.4	0.5	3	2	3	2	2	3	0	0	0	0	3	3	0	0
131	E-Es	2.5	0.4	2.2	1.2	0.4	1	0	4	3	0	1	0	1	1	1	0	0	0	2
132	B-Es	2.4	0.4	2.1	1.4	0.4	1	0	1	3	0	5	0	1	0	1	2	2	0	0
133	G-Es	2.6	0.5	2.1	1.3	0.4	1	1	1	1	0	0	0	0	0	0	1	1	0	0
134	B-Es	2.6	0.5	2.1	1.1	0.5	1	0	1	3	0	5	0	1	0	1	5	5	0	0
135	E-Es	2.5	0.5	2.4	1.3	0.5	1	0	4	3	0	1	0	0	0	1	5	5	0	0
136	E-Es	2.4	0.5	2	1.2	0.5	1	0	4	3	0	4	2	0	1	0	5	5	0	2
137	C-Mo	3	0.5	2.6	1.5	0.5	3	2	1		2	3	0	0	0	1	3	3	0	0
138	E-Es	2.4	0.4	2	1.3	0.5	0	0	4	3	3	4	0	0	1	1	1	1	2	2
139	B-Es	2.5	0.5	2.2	1.4	0.5	1	0	1	3	0	1	0	0	0	1	0	0	0	0
140	E-Es	2.3	0.5	2.1	1.4	0.5	1	0	4	3	0	5	0	0	0	1	5	5	0	2

141	C-Es	2.1	0.4	2	1.2	0.4	3	1	3	2	2	3	0	0	0	1	3	3	0	0
142	E-Es	2.4	0.5	2.2	1.3	0.4	1	0	4	3	0	1	2	1	1	1	5	5	0	2
143	A-Mo	2.7	0.5	2.2	1.4	0.5	0	0	0	0	1	2	0	0	0	0	1	1	0	0
144	A-Es	2.3	0.5	2.3	1.3	0.5	0	0	0	3	3	4	0	1	0	1	2	2	0	0
145	A-Mo	2.8	0.6	2.5	1.5	0.5	0	0	0	0	1	2	0	0	0	0	1	1	0	0
147	C-Pm	2.4	0.5	2	1.4	0.5	2	2	2	3	2	3	1	0	0	0	4	4	0	0
148	C	2.6	0.4	2.1	1.2	0.4	2	2	2		2	3	1	0	0	0	4	4	0	0
149	C-Pm	2.5	0.4	2.2	1.3	0.4	2	2	2	2	2	3	1	0	0	0	4	4	0	0
150	C-Pm	2.5	0.4	2.3	1.4	0.4	2	2	2	2	2	3	1	0	0	0	4	4	0	0
153	C-Pm	2.4	0.6	2.4	1.4	0.5	2	2	2	2	2	3	1	0	0	0	4	4	0	0
157	B-Pm	3	0.6	2.4	1.5	0.6	1	0	1	0	0	4	0	0	0	1	5	5	0	0
158	F-Pm	2.3	0.5	2.2	1.4	0.5	4	0	1	0	4	4	0	0	0	1	1	1	0	0
159	A-Ch	2.4	0.4	1.9	1.1	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
160	A-Es	2.4	0.4	2.1	1.2	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
161	A-Pm	2.6	0.5	2.1		0.5	0	0	0	0	1	2	0	0	0	0	1	1		0
162	A-Es	2.6	0.5	2	1.2	0.5	0	0	0	3	1	2	0	0	0	0	1	1	1	0
163	A-Es	2.8	0.5	2.2	1.3	0.5	0	0	5	0	3	4	0	0	0	0	1	1	0	0
164	A-Ch	2.2	0.4	1.7		0.4	0	0	0		1	2	0	0	0	0	1	1		0
165	C-Es	2.3	0.4	1.9	1.2	0.5	2	2	2	2	2	3	1	0	0	0	4	4	0	0
166	C-Es	2.4	0.5	2.1	1.3	0.5	2	2	2	2	2	3	1	0	0	0	4	4	0	0
167	A-Pm	2.8	0.6	2.3	1.4	0.6	0	0	1	3	0	4	0	0	0	0	1	1	0	1
168	A-Es	2.6	0.5	2.1	1.2	0.4	0	0	0	3	1	2	0	0	0	0	1	1	1	0
170	A-Es	2.5	0.5	2.1	1.4	0.5	0	0	0	3	1	2	0	0	0	0	1	1	2	0
171	A-Es	2.3	0.5	2	1.2	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
172	B-Es	2.4	0.5	2.1	1.3	0.4	1	0	7	3	0	2	0	0	0	1	5	5	0	0
176	G-Pm	2.3	0.5	2.2	1.2	0.5	1	0	7	3	0	0	0	1	0	1	0	5	3	0
181	A-Es	2.5	0.5	2.1	1.1	0.5	0	0	0	3	1	2	0	0	0	0	1	1	0	0
182	A-Es	2.3	0.5	2.1	1.2	0.5	0	0	0	3	1	2	0	0	0	0	1	1	0	0
183	A-Es	2.4	0.5	2.3	1.2	0.5	0	0	0	3	1	2	0	0	0	0	1	1	2	0
184	C-Es	2.6	0.5	2.2	1.3	0.5	3	2	3	2	2	3	0	0	0	0	3	3	2	0
185	A-Es	2.5	0.5	1.9	1.1	0.5	0	0	0	3	1	2	0	0	0	0	1	1	2	0
191	A-Es	2.5	0.5	2.3	1.2	0.5	0	0	0	3	1	2	0	0	0	0	1	1	0	0

(*Continued*)

Table B1. (*Cont.*)

Sp. No.	Sp-Dist	BL	PL	TL	FL	MW	BC	BCP	HC	AC	PC	MC	BPC	SP	RMP	OBP	ALC	MLC	HFC	HTC
192	A-Es	2.2	0.5	2.1	1.2	0.5	0	0	0	3	1	2	0	0	0	0	1	1	1	0
193	A-Es	2.4	0.5	2.1	1.4	0.5	0	0	0	3	1	2	0	0	0	0	1	1	0	0
194	A-Es	2.5	0.5	2.1	1.4	0.5	0	0	0	3	1	2	0	0	0	0	1	1	2	0
195	A-Es	2.5	0.5	2.3	1.4	0.5	0	0	0	3	1	2	0	0	0	0	1	1	1	0
196	A-Es	2.5	0.5	2.2	1.3	0.5	0	0	0	3	1	2	0	0	0	0	1	1	1	0
197	D-Es	2.5	0.5	2.1	1.3	0.5	0	1	0	3	1	2	0	0	0	0	1	1	0	0
198	A-Es	2.5	0.5	2.1	1.3	0.5	0	0	0		1	2	0	0	0	0	1	1	2	0
199	D-Es	2.5	0.5	2.2	1.4	0.5	0	1	0	3	1	2	0	0	0	0	1	1	2	0
200	A-Es	2.4	0.4	2.2	1.3	0.5	0	0	0	3	1	2	0	0	0	0	1	1	0	0
201	G-Es	2.3	0.5	1.9	1.2	0.5	1	0	1		4	0	0	0	0	0	5	5	0	0
203	A-Ch	2.4	0.5	2	1.3	0.5	0	0	0	0	1	2	0	0	0	0	1	1	1	0
204	A-Es	2.5	0.5	2.1	1.4	0.5	0	0	0		1	2	0	0	0	0	1	1	1	0
205	G-Es	2.2	0.5	2	1.2	0.4	1	0	1	0	0	0	0	0	0	0	5	5	0	0
206	B-Ch	2.6	0.5	2	1.3	0.4	1	1	1	0	3	4	0	0	0	0	5	5	0	0
207	A-Ch	2.2	0.4	1.8	1.3	0.5	0	0	5	1	3	4	0	0	0	0	1	1	0	0
208	A-Ch	2.3	0.4	2	1.2	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
209	A-Ch	2.1	0.4	2.1	1.3	0.5	0	0	0	0	1	2	0	0	0	0	1	1	1	0
210	C-Es	2.6	0.5	2.1	1.4	0.5	3	2	3	2	2	3	0	0	0	1	3	3	0	0
212	A-Pm	2.5	0.5	2.4	1.3	0.5	0	0	1	3	0	2	0	0	0	1	2	2	3	0
213	A-Es	2.6	0.6	2.1	1.4	0.5	0	0	5	0	3	4	0	0	0	0	1	1	0	1
214	A-Es	2.4	0.4	2.1	1.2	0.5	0	0	5	0	3	4	0	0	0	0	1	1	0	0
215	A-Ch	2.2	0.4	1.9	1.2	0.5	0	0	0	0	1	2	0	0	0	0	1	1	1	0
216	G-Es	2.5	0.5	2.4	1.5	0.5	1	1	1		0	0	0	0	0	0	5	5	0	0
219	A-Yu	2.3	0.4	2	1.2	0.4	0	0	0	0	1	2	0	0	0	0	1	1	1	0
220	B-Pm	2.1	0.4	1.9	1.2	0.4	1	0	1		0	4	0	0	0	1	5	5	0	0
222	F-Mo	2.7	0.6	2.4	1.5	0.7	4	0	7	0	4	6	0	0	0	0	8	7	0	0
225	G-Es	2.6	0.5	2.3	1.3	0.5	1	0	1	3	4	0	0	0	0	0	5	5	0	0
226	A-Ch	2.6	0.5	2.2	1.4	0.5	0	0	5		3	4	0	0	0	0	1	1	0	0
227	A-Yu	2.6	0.5	2.1	1.4	0.5	0	0	0		1	2	0	0	0	0	1	1	1	0
228	C-Mo	2.6	0.5	2.3	1.4	0.5	3	2	3		2	3	0	0	0	0	3	3	0	

229	A-Ch	2.3	0.4	2.2	1.3	0.4	0	0	0		1	2	0	0	0	0	1	1	1	0
232	A-Yu	2.2	0.5	2	1.2	0.4	0	0	5	0	3	4	0	0	0	0	1	1	1	0
235	C-Yu	2.7	0.5	2.2	1.4	0.5	2	2	2	2	2	3	1	0	0	0	4	4	0	0
236	G-Yu	2.9	0.5	2.2	1.5	0.5	1	0	1	1	0	0	0	0	0	0	5	5	3	0
237	F-Yu	2.6	0.6	2.4	1.5	0.5	4	0	5	0	3	4	0	0	0	0	1	1	3	0
240	A-Yu	2.4	0.5	2.1		0.5	0	0	0		1	2	0	0	0	0	1	1	2	0
248	A-Yu	2.7	0.5	1.9	1.4	0.5	0	0	5		3	4	0	0	0	0	1	1	0	0
249	A-Yu	2.7	0.5	2.1	1.3	0.5	0	0	5	0	1	2	0	0	0	0	1	1	1	0
250	A-Mo	2.8	0.5	2.5	1.5	0.5	0	0	5	0	3	4	0	0	0	0	2	2	0	0
251	A-Yu	2.7	0.5	2.4	1.5	0.5	0	0	5		3	4	0	0	0	0	2	2	0	0
252	G-Yu	2.6	0.5	2.4	1.4	0.5	1	0	1		0	0	0	0	0	0	5	5	3	0
253	G-Yu	2.3	0.5	2	1.3	0.4	1	0	1		0	0	0	0	0	1	5	5	0	0
254	A-Yu	2.2	0.5	1.9	1.2	0.4	0	0	5		1	2	0	0	0	0	1	1	1	0
259	C-Es	2.7	0.5	2.3	1.4	0.5	2	2	2	2	2	3	1	0	0	1	4	4	0	0
260	B-Es	2.8	0.5	2	1.4	0.5	1	1	1	2	0	1	0	1	0	1	0	0	3	1
263	A-Es	2.4	0.5	2.1	1.2	0.5	0	0	5	3	1	2	0	0	0	0	1	1	0	0
266	B-Yu	2.3	0.5	2.1	1.3	0.5	1	0	1	1	0	1	0	0	0	0	0	0	3	0
267	A-Ch	2.7	0.5	2.4		0.5	0	0	0	0	1	2	0	0	0	0	1	1		
268	A-Ch	2.5	0.5	2.1		0.5	0	0	0	0	1	2	0	0	0	0	1	1		
275	G-Mo	2.9	0.6	2.5	1.5	0.5	1	0	7	0	4	0	0	0	0	0	5	5	3	0
277	G-Mo	2.9	0.6	2.6	1.5	0.6	1	0	1	0	0	0	0	0	0	0	1	1	0	0
285	A-Yu	2.6	0.5	2.3	1.3	0.5	0	0	5	3	1	2	0	0	0	0	2	2	0	0
286	C-Yu	2.4	0.5	2.1	1.4	0.5	3	2	3	2	2	3	0	0	0	0	3	3	0	0
287	A-Es	2.5	0.5	2.2	1.4	0.5	0	0	5	3	1	2	0	0	0	1	1	1	0	0
288	C-Es	2.4	0.5	2.1	1.3	0.5	2	2	2	0	2	3	1	0	0	0	4	4	0	0
289	G-Es	2.3	0.5	2.3	1.4	0.5	1	1	1	0	4	0	0	0	0	0	5	5	0	0
290	A-Es	2.5	0.5	2.2	1.4	0.5	0	0	5	3	1	2	0	0	0	0	1	1	2	0
291	C-Es	2.5	0.5	2.2	1.5	0.5	2	2	2	2	2	3	1	0	0	0	4	4	0	0
292	G-Es	2.6	0.5	2.1	1.3	0.5	1	0	7	3	4	0	0	1	0	1	8	7	2	0
293	A-Mo	2.4	0.5	2.2	1.4	0.5	0	0	5	0	3	4	0	0	0	0	1	1	0	0

(*Continued*)

Table B1. (*Cont.*)

Sp. No.	Sp-Dist	BL	PL	TL	FL	MW	BC	BCP	HC	AC	PC	MC	BPC	SP	RMP	OBP	ALC	MLC	HFC	HTC
294	G-Mo	2.5	0.6	2.5	1.5	0.6	1	0	1	1	0	0	0	0	0	1	8	7	3	0
295	F-Mo	2.7	0.6	2.4	1.5	0.6	4	0	1	0	4	6	0	0	0	0	8	7	3	0
296	F-Pm	1.9	0.4	1.9	1	0.4	4	0	1	3	4	6	0	0	0	1	8	7	0	0
298	B-Pm	2.9	0.6	2.4	1.5	0.5	1	0	1	3	0	5	0	0	0	1	0	5	3	0
300	E-Es	2.8	0.42	2.2	1.2	0.37	1	0	4	3	0	1	0	1	1	1	5	0	3	0
302	D-Es	2.8	0.5	2.2	1.2	0.43	0	1	0	3	1	2	0	0	0	0	1	1	0	0
305	A-Pm						0	0	0	4	1	2	0	0	0		1	1	0	0
308	C-Es	3	0.5	2.1	1.3	0.4	2	2	2	2	2	3	1	0	0	0	4	4	0	0
309	G-Es	2.9	0.5	2.1	1.3	0.4	1	1	1	0	0	0	0	0	0	0	5	5	0	0
310	B-Es	3.2	0.5	2.2	1.4	0.5	1	0	1	0	0	5	0	0	0	0	5	5	3	0
311	E-Es	3	0.45	2.1	1.2	0.4	1	0	4	3	0	2	2	0	1	0	5	5	3	3
315	B-Es	2.9	0.55	2.3	1.4	0.45	1	1	1	3	0	5	0	0	0	0	0	0	3	0
316	C-Es	2.8	4.5	2.2	1.4	0.4	2	2	2	2	2	3	1	0	0	0	4	4	0	0
317	B-Es	2.9	0.5	2.2	1.3	0.4	1	0	1	0	0	5	0	1	0	1	5	5	0	1
318	B-Es	2.9	0.55	2.2	1.4	0.45	1	0	1	3	0	4	0	0	0	0	5	5	3	1

Table B2. Data matrix B (female specimens) used in the multivariate and statistical analyses.

Sp. No.	Sp-Dist	BL	PL	TL	FL	MW	BC	BCP	HC	AC	PC	MC	BPC	SP	RMP	OBP	ALC	MLC	HFC	HTC
10	A-Yu	2.6	0.7	2.5		0.6	0	0	5	0	1	2	0	0	0	0	1	1	1	
12	A-Yu	3.1	0.7	2.6	1.8	0.6	0	0	5	0	1	2	0	0	0	0	1	1	2	0
15	A-Yu	3	0.7	2.7	1.6	0.6	0	0	5	0	1	2	0	0	0	0	1	1	2	0
16	A-Yu	3.1	0.7	2.9	1.8	0.6	0	0	0	0	1	2	0	0	0	0	1	1	1	0
23	A-Yu	2.7	0.6	2.6	1.6	0.5	0	0	5	0	1	2	0	0	0	0	1	1	2	0
24	A-Yu	3.1	0.7	2.7	1.8	0.6	0	0	0	0	1	2	0	0	0	0	1	1	1	0
25	A-Yu	3.1	0.7	2.9	1.8	0.6	0	0	0	0	1	2	0	0	0	0	1	1	1	0
27	A-Yu	3.3	0.8	3	2	0.6	0	0	5	0	1	2	0	0	0	0	1	1	2	0
34	A-Yu	3.1	0.6	2.8	1.8	0.6	0	0	0	0	1	2	0	0	0	0	1	1	1	0
35	A-Yu	3.2	0.7	3	2	0.7	0	0	0	0	1	2	0	0	0	0	1	1	1	0
36	A-Yu	3.5	0.7	3	2	0.6	0	0	0	0	1	2	0	0	0	0	1	1	1	0
37	A-Yu	2.8	0.6	2.9	1.9	0.6	0	0	0	0	1	2	0	0	0	0	1	1	1	0
38	A-Yu	2.5	0.5	2.7	1.7	0.5	0	0	5	0	1	2	0	0	0	0	1	1	2	0
39	A-Yu	2.8	0.6	2.5	1.6	0.5	0	0	5	0	1	2	0	0	0	0	1	1	1	0
40	A-Yu	2.9	0.6	2.6	1.6	0.6	0	0	5	0	1	2	0	0	0	0	1	1	1	0
46	A-Yu	2.9	0.6	2.9	1.8	0.5	0	0	0	1	1	2	0	0	0	0	1	1	2	0
47	A-Yu	3.4	0.7	3	1.8	0.7	0	0	5	1	1	2	0	0	0	1	2	2	2	0
54	G-Yu	3.2	0.7	2.9	1.9	0.6	1	1	1	1	0	0	0	0	0	0	0	0	3	0
55	G-Yu	3.1	0.6	2.7	1.8	0.6	1	0	1	0	0	0	0	0	0	1	8	7	0	0
60	B-Yu	2.8	0.6	2.6	1.6	0.6	1	0	1	1	0	1	0	0	0	1	7	0	3	1
60’	B-Yu	3	0.6	2.5	1.6	0.5	1	0	1	1	0	1	0	0	0	1	7	0	3	1
64	A-Es	3.8	0.6	3.1	2.1	0.6	0	0	0	0	1	2	0	0	0	1	1	1	0	0
65	A-Es	3.9	0.7	3.1	2.1	0.7	0	0	0	0	1	2	0	0	0	0	1	1	0	0
67	A-Pm	3.9	0.8	3	2	0.7	0	0	0	0	1	2	0	0	0	0	1	1	2	0
68	A-Es	3	0.6	2.6	1.8	0.7	0	0	1	3	0	2	1	0	0	1	2	2	0	0
69	A-Ch	3.2	0.7	2.7	1.7	0.7	0	0	0		1	2	0	0	0	0	1	1	1	0
71	C-Pm	3.6	0.7	3.1	2	0.7	3	2	3	2	2	3	0	0	0	1	3	3	0	0
77	B-Pm	3.6	0.7	3.1	1.9	0.6	1	0	1	3	0	2	0	0	0	1	5	5	0	0
84	G-Ch	3.6	0.7	2.8	1.8	0.6	1	0	1		0	0	0	0	0	0	0	5	0	0
85	G-Pm	3.5	0.7	2.8	1.8	0.7	1	0	1	2	0	0	0	1	0	0	0	5	0	0

(*Continued*)

Table B2. (*Cont.*)

Sp. No.	Sp-Dist	BL	PL	TL	FL	MW	BC	BCP	HC	AC	PC	MC	BPC	SP	RMP	OBP	ALC	MLC	HFC	HTC
86	G-Pm	3.4	0.7	3	1.9	0.6	1	0	1		0	0	0	0	0	1	0	5	0	0
87	G-Pm	3.9	0.8	2.9	1.9	0.6	1	0	1		0	0	0	0	0	0	0	0	3	0
88	G-Pm	3.6	0.7	3	2	0.7	1	0	1	2	0	0	0	0	0	1	0	0	3	0
89	G-Ch	3.5	0.7	2.7	1.9	0.7	1	1	1	3	0	0	0	0	0	0	5	5	0	0
92	G-Pm	3.4	0.7	2.9	1.8	0.7	1	1	1		0	0	0	0	0	1	0	0	0	0
99	G-Es	3.2	0.7	2.8	1.8	0.7	1	0	1	3	0	0	0	0	0	0	5	5	0	0
100	F-Mo	3.9	0.7	2.9	2.1	0.7	4	0	6	0	4	4	0	0	0	1	8	7	0	0
102	G	3.8	0.7	2.8	1.9	0.7	1	0	1		0	0	0	0	0	1	7		3	1
104	G-Pm	3.2	0.7	2.8	1.6	0.6	1	0	1	0	0	0	0	0	0	0	0	0	3	0
106	C-Pm	3.8	0.7	3.2	2.1	0.7	2	2	2	2	2	3	1	0	0	0	4	4	0	0
107	C-Pm	3.6	0.7	3.1		0.7	2	2	2		2	3	1	0	0	0	4	4		
110	C-Pm	4	0.8	3.1	2	0.8	2	2	2	2	2	3	1	0	0	0	4	4	2	0
123	E-Es	3.1	0.6	2.7	1.7	0.7	0	0	4	3	0	4	2	0	0	0	2	2	0	2
124	C-Es	3	0.7	2.6	1.6	0.7	3	2	3	2	2	3	0	1	0	0	3	3	0	0
125	B-Es	3.2	0.7	2.6	1.6	0.7	1	1	1	2	0	1	0	1	0	1	0	0	0	0
126	C-Es	3.2	0.7	2.7	1.5	0.7	3	2	4	2	2	3	2	0	0	0	3	3	0	2
127	C-Es	3.6	0.7	2.8	1.8	0.7	3	2	4	2	2	3	2	0	0	1	3	3	0	2
128	C-Es	3.5	0.7	2.9	1.7	0.7	3	2	4	2	2	3	2	0	0	1	3	3	0	2
129	E-Es	3.8	0.7	3.1	2	0.7	1	0	4	3	0	5	0	1	0	1	5	5	0	2
130	E-Es	3.4	0.7	2.9	1.9	0.7	1	0	4	3	0	5	0	1	0	1	5	5	0	2
146	C-Pm	3.3	0.7	2.8	1.8	0.7	2	2	2	2	2	3	1	0	0	0	4	4	0	0
151	C-Pm	3.6	0.8	3	1.9	0.8	2	2	2	2	2	3	1	0	0	1	4	4	0	0
152	C-Pm	3.2	0.7	2.8	2	0.8	2	2	2	2	2	3	1	0	0	0	6	6	3	0
154	B-Pm	3.7	0.8	3.3	2.2	0.7	1	0	1	2	0	5	0	0	0	1	0	0	3	0
155	G-Es	2.9	0.6	2.6	1.8	0.6	1	0	1	3	0	0	0	1	0	1	0	0	3	0
156	G-Es	3.4	0.7	3	1.8	0.7	1	0	1	0	0	0	0	1	0	1	5	5	0	0
169	A-Ch	3.3	0.7	2.7	1.7	0.7	0	0	0	3	1	2	0	0	0	0	1	1	2	0
173	D-Es	3.5	0.7	2.9	1.7	0.7	0	1	0	0	1	2	0	0	0	1	1	1	0	0
174	C-Es	3.8	0.7	2.8	1.8	0.7	3	2	3	2	2	2	0	0	1		3	3	0	0
175	G-Es	3.8	0.8	3	2	0.7	1	0	7	3	0	0	0	0	0	0	0	5	0	0

178	B-Pm	3.2	0.8	3	1.9	0.8	1	0	1		0	5	0	1	0	1	0	0	3	1
179	G-Es	3.9	0.8	3.1	2	0.8	1	0	1	3	0	0	0	1	0	1	5	5	0	0
186	G-Es	3.3	0.7	2.9	1.6	0.6	1	1	1	3	0	0	0	0	0	0	5	5	0	0
187	A-Es	3.2	0.7	2.6	1.6	0.6	0	0	0	3	1	2	0	0	0	0	1	1	2	0
188	D-Es	3.5	0.7	2.8	1.6	0.7	0	1	0	3	1	2	0	0	0	0	1	1	2	0
189	A-Es	3.5	0.7	3	1.8	0.7	0	0	0		1	2	0	0	0	0	1	1	2	0
190	A-Es	3.2	0.7	2.8	1.8	0.7	0	0	0	3	1	2	0	0	0	0	1	1	2	0
202	A-Ch	3.5	0.7	2.8	1.9	0.7	0	0	0	0	1	2	0	0	0	0	1	1	1	0
211	A-Pm	3.4	0.7	3	1.7	0.7	0	0	5	0	1	2	0	0	0	0	2	2	0	0
217	B-Es	3	0.6	2.6	1.6	0.6	1	0	1	3	0	1	0	1	0	1	0	0	3	0
218	G-Pm	3.1	0.8	3	1.8	0.8	1	0	1	2	0	0	0	1	0	1	7	0	3	1
221	G-Es	3.2	0.7	2.8	1.7	0.7	1	0	1	0	0	0	0	0	0	0	8	7	0	0
223	F-Mo	3.7	0.8	2.9	2	0.8	4	0	6	1	4	4	0	0	0	0	0	0	3	1
224	C-Pm	3.6	0.8	3.1		0.7	2	2	2	2	2	3	1	0	0	1	4	4		
230	A-Yu	3.5	0.7	3	2	0.7	0	0	0	0	1	2	0	0	0	0	1	1	1	0
231	B-Ch	3.6	0.7	3	1.9	0.8	1	0	1		0	5	0	0	0	1	0	5	3	0
233	A-Yu	3.6	0.7	2.8	1.8	0.7	0	0	0		1	2	0	0	0	0	1	1	1	0
234	A-Yu	3.6	0.7	2.9	1.7	0.8	0	0	0		3	4	0	0	0	0	1	1	1	0
238	A-Yu	3.3	0.6	2.7	1.9	0.7	0	0	0		1	2	0	0	0	0	1	1	1	0
239	A-Yu	3.2	0.7	2.8	2	0.8	0	0	0	0	1	2	0	0	0	0	1	1	2	0
241	A-Ch	3.4	0.7	2.6	1.8	0.7	0	0	0		1	2	0	0	0	0	1	1	1	0
242	A-Ch	3.2	0.7	2.5	1.6	0.7	0	0	0	0	1	2	0	0	0	0	1	1	1	0
243	A-Yu	3.4	0.7	2.9	1.9	0.7	0	0	0	0	1	2	0	0	0	0	1	1	2	0
246	A-Yu	3.5	0.7	2.5	1.8	0.7	0	0	5	0	3	4	0	0	0	1	1	1	0	0
247	F-Yu	3.4	0.7	2.6	2	0.7	4	2	6		4	4	3	0	0	1	8	7	0	0
255	F-Ch	3.8	0.7	2.9	1.9	0.7	4	2	6		4	6	3	0	0	1	8		0	0
258	F-Ch	3.3	0.7	3	2	0.7	4	1	7	0	4	4	0	0	0	0	8	7	0	0
261	B-Es	3.5	0.8	3	2	0.8	1	0	1	3	0	1	0	0	0	1	0	0	3	1
264	G-Es	3.7	0.8	3.1	2	0.8	1	0	1	2	0	0	0	1	0	1	0	0	3	1
265	B-Es	4.1	0.8	3	2.1	0.9	1	1	1		0	1	0	0	0	0	5	5	3	0
270	G-Es	3.7	0.7	3.1	2.1	0.8	1	0	7	0	0	0	0	1	0	1	5	5	0	0
272	F-Mo	3.5	0.7	2.8	2	0.7	4	0	1		3	4	0	0	0	0	2	2	0	0

(*Continued*)

Table B2. (*Cont.*)

Sp. No.	Sp-Dist	BL	PL	TL	FL	MW	BC	BCP	HC	AC	PC	MC	BPC	SP	RMP	OBP	ALC	MLC	HFC	HTC
276	G-Mo	3.9	0.9	3.3	2.3	0.9	1	0	1	0	0	0	0	0	0	1	0	0	3	0
282	F	4	0.8	3.5	2.4	0.8	4	0	6	1	4	4	0	0	0	0	0	0	3	1
284	A-Yu	3.5	0.7	3	1.9	0.7	0	0	5	3	1	2	0	0	0	0	2	2	0	0
297	E-Es	3.4	0.6	2.6	1.6	0.6	1	0	4	3	0	1	0	1	0	1	7	0	3	3
299	E-Es	4	0.7	3	1.8	0.7	1	0	4	3	0	1	0	1	1	1	0	0	0	2
301	E-Es	3.2	0.6	2.8	1.6	0.55	1	0	4	3	0	1	0	0	1	1	5	0	3	2
303	D-Es	3.6	0.75	3	1.7	0.63	0	1	0	0	1	2	0	0	0	0	1	1	0	0
304	B-Pm	3.5	0.7	2.9	1.7	0.65	1	0	1	3	0	5	0	1	0	1	0	0	3	1
306	A-Pm						0	0	0	4	1	2	0	0	0		1	1	0	0
307	G-Es	3.4	0.65	2.9	1.7	0.55	1	0	1		0	0	0	1	0	1	0	5	0	0
312	G-Es	4	0.8	3	1.9	0.65	1	0	1	0	0	0	0	0	0	0	5	5	0	0
313	G-Es	3.9	0.7	3	1.9	0.6	1	0	1	3	0	0	0	0	0	0	5	5	0	0
314	G-Es	3.8	0.7	2.7		0.6	1	1	1	0	0	0	0	1	0	1	5	5		
319	C-Es	4	0.8	3		0.6	2	2	2	2	2	3	1	1	0	1	4	4		