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NEW DATA ON MORPHOMETRICS, DISTRIBUTION AND ECOLOGY OF *MIOSCIRTUS WAGNERI* (KITTARY, 1859) (ORTHOPTERA, ACRIDIDAE) IN SPAIN: IS *MAGHREBI* A WELL DEFINED SUBSPECIES?

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ABSTRACT

We studied different populations of *Mioscirtus wagneri* (Kittary, 1859) in Spain assigned to subspecies *maghrebi* by Fernandes (1968) and obtained some new records for the species. To see if *maghrebi* is a consistent taxon for the Iberian populations, we performed a morphometric analysis involving 53 individuals from different origins considering body size (front of the head to tip of the abdomen); the shape of pronotum and presence of a second anterior notch or sulcus; length of the antennae and epiphallum, according to the characters used to define subspecies *maghrebi*. If *maghrebi* is consistent, we would expect intermediate sizes between *wagneri* and *rogenhoferi*, the other two well separated subspecies considered for *M.w.* However, in our measurements we obtained that body size is not intermediate between *M. w. wagneri* and *M. w. rogenhoferi* contrary to expectations if assuming the existence of *maghrebi*. Body size is similar to *wagneri* and further, we recorded some of the smallest individuals described so far. Also, the pronotum varied widely across and within populations showing different phenotypes that formerly were used to separate *maghrebi* and *wagneri*. Taking into account body size, pronotum, length of antenna and epiphallum, we think that differences between the studied Spanish populations and *wagneri* form are not enough to assign the studied populations to *maghrebi*. In the studied area, *M.w.* shows a narrow ecological niche inhabiting shores or proximities of hipersaline lagoons wherever *Suaeda vera* (Forsskål 1791, *Chenopodiacea*) is present, *M.w.* uses this plant as refuge and food. The species also inhabits bare saline low grounds with scattered *S vera*. It presents a markedly discontinuous and patchy distribution in Spain, showing up punctually, where the microhabitat is appropriate. We obtained a morphometric variability with a significant association between body size and locality, and between body size and the colour of posterior wings in males. Because of its wide range disjunction, its discontinuous regional distribution and morphological variability, we believe that *M.w.* is an interesting species to investigate possible substructuring of populations in which we probably may recognize ecological forms or varieties that deserve deeper and further study.

Key words: Orthoptera, Acrididae, subspecies, *maghrebi*, ecological variation, Iberian Peninsula, hipersaline lagoons.

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RESUMEN

Nuevos datos sobre morfología, distribución y ecología de *Mioscirtus wagneri* (Kittary, 1859) (Orthoptera, Acrididae) en España: ¿es *maghrebi* una subespecie bien definida?

Estudiamos distintas poblaciones de *Mioscirtus wagneri* (Kittary, 1859), considerado como *M. w. maghrebi* por Fernandes (1968) en España, con algunas nuevas citas para la especie. Para dilucidar si el taxón *maghrebi* es consistente en nuestras poblaciones, realizamos un análisis morfométrico de 53 ejemplares considerando los mismos caracteres utilizados para establecer dicha subespecie, a citar: tamaño del cuerpo, relieve y forma del pronoto, longitud de la antena y forma del epifalo. El tamaño de los individuos de nuestras poblaciones no es intermedio entre las formas conocidas de *M. w. wagneri* y *M. w. rogenhoferi* Saussuare, 1888, como cabría esperar asumiendo la existencia de *maghrebi*. Nuestras poblaciones no se apartan del tamaño de *wagneri* e incluso encontramos las menores tallas descritas para este taxón. El relieve del pronoto, y en particular la presencia de un segundo surco, el anterior, es muy variable abarcando en una misma población fenotipos dispares utilizados anteriormente para separar las formas *maghrebi* y *wagneri*. Las diferencias entre el tamaño del cuerpo, el pronoto, la longitud de la antena y la forma del epifalo no nos parecen suficientes para asignar como *maghrebi* al conjunto de las poblaciones estudiadas y separarlas de la subespecie nominada *wagneri*. *M.w.* es una especie de requerimientos ecológicos muy restringidos. La hemos encontrado a orillas de lagunas hipersalinas y siempre dependiendo de *Suaeda vera* (Forsskål, 1791) Chenopodiacea que utiliza como refugio y alimento, en particular en suelos desnudos y salitrosos donde predominan manchas de esa planta. Su distribución regional es marcadamente discontinua y muy puntual, presentándose allí donde el hábitat le es propicio. Aunque el análisis es preliminar, encontramos una variabilidad morfométrica y una asociación del tamaño corporal con la localidad, y del tamaño corporal con la coloración de las alas posteriores en los machos. Debido a su distribución geográfica disjunta, localmente discontinua, y a la variabilidad morfométrica encontrada en sus poblaciones, creemos que *M. w.* es una especie interesante para investigar la posible subestructuración de sus poblaciones en las cuales es posible se reconozcan diversas formas o variedades ecológicas lo que merece mayor investigación.

Palabras clave: Orthoptera, Acrididae, subespecie, *maghrebi*, variación ecológica, península ibérica, lagunas hipersalinas.

Introduction

Mioscirtus wagneri (Kittary, 1849) (*M.w.* from now on) is an *Oedipodinae* of disjunct distribution with patches of presence in the extremes of the Paleartic Region, Asia Minor and Near East. It occurs in North Africa and the Iberian Peninsula. To the East we do not find it until southern Ukraine (shores of Black Sea and Azov), shores of the Volga, Kazakhstan deserts, and Central Asia to the limit with China at its easternmost extreme of distribution. It also occurs in most countries of the Middle East and Cyprus (Bei-Bienko & Mishchenko, 1951; Harz, 1975; Fauna European Web Service, 2004). One of its principal taxonomic characteristics is the presence of a well defined but not very high medium keel in the pronotum. The pronotum is sharply interrupted by a median sulcus, sometimes with a second knob before the keel (Bei-Bienko & Mishchenko, 1951). As a consequence of its disjunct distribution, up to three subspecies have been considered: *M. w. wagneri*, of smaller size, with tegmen not surpassing half of hind tibiae. This form is known from East Europe, Kazakhstan and up to China. The form *M. w. rogenhoferi* (Saussuare, 1888) is larger in size and with the tegmen relatively longer and surpassing half of the hind tibiae. Remaining morphological characters, coloration included, are rather similar to *wagneri*. The *rogenhoferi* form occurs in Central Asia, East of Transcaucasia, North of Afghanistan and other countries of the Middle East from Iran to Palestine (Bei-Bienko & Mishchenko, 1951; Harz 1975). Also, a third subspecies *M. w. maghrebi* has been described by Fernandes (1968) from the Iberian Peninsula and North of Africa and this is the form that we will study here.

In the Iberian Peninsula, *M. w.* was recorded for the first time from two distant localities of Portugal: Castro Marim, Algarve and Setubal, Lagoa de Albufeira) (Fernandes, 1968). This author analyzed several individuals, without mentioning sex or number, and created the new taxon *M. w. maghrebi* because of the apparent similarities between the Portuguese sample and individuals from Algeria with respect to the forms *wagneri* and *rogenhoferi* defined by Bei-Bienko & Mishchenko (1951). The morphological characters used by Fernandes to define *maghrebi* are taken from a previous description of individuals from Algeria (Finot, 1895) that matched his sample from Portugal, and in his study he included several individuals from Turkey, Kazakhstan and Algeria (Natural History Museum), and finally a male conserved in the Instituto Español de Entomología (now Museo Nacional de Ciencias Naturales), also from Algeria. The characters he used to define *maghrebi* included body size, which is intermediate between *wagneri* and *rogenhoferi*. Secondly, he used the presence of a second and anterior interruption of the median carina of the pronotum by another sulcus or depression before the typical and sharp interruption of the posterior sulcus. A third character used by Fernandes was the length of the antenna, longer than the head and pronotum together in *maghrebi* (also Finot, 1895, 448-449). Furthermore, he refers that the epiphallum is slightly different in *maghrebi* with respect to *wagneri* without any further description than several similar figures.

Up to now, *M. w. maghrebi* has been recorded in a few localities of Spain, different authors often coinciding in nearby localities from previous records. The first records published comes from collections of the Institut voor Taxonomische Zoölogie of Amsterdam (Presa, 1979) having Aranjuez (Madrid) and the Laguna de la Playa, Mequinenza (Zaragoza) as localities of origin. He mentions in this work that individuals were collected in saline land among halophilous vegetation (Presa, 1979). The species was not included in the Spanish Orthopteran Catalogue published by Herrera (1982). The second record of the species for the same locality comes from Zaragoza and is supplied by Pardo *et al.* (1990) who found it in the salicornal of La Laguna de la Playa (UTM= 30TYL3489). *M.w.* of the subspecies *maghrebi,* has also been recorded from Granada, Huesca and Lérida provinces. The records are as follows: Barranco del Espartal (Baza, Granada, UTM: 30SWG2754) and the Saladar de El Margen (Cúllar-Baza, Granada, UTM: 30SWG3766), inhabiting arid terrain with salty grounds and several halophilous vegetation communities (Badih *et. al.*, 1993). Apart the population core of Mequinenza (Zaragoza) there are several more recent records in Huesca, Zaragoza and Lérida provinces with localities like Villanueva de Sígena (Huesca), Torres del

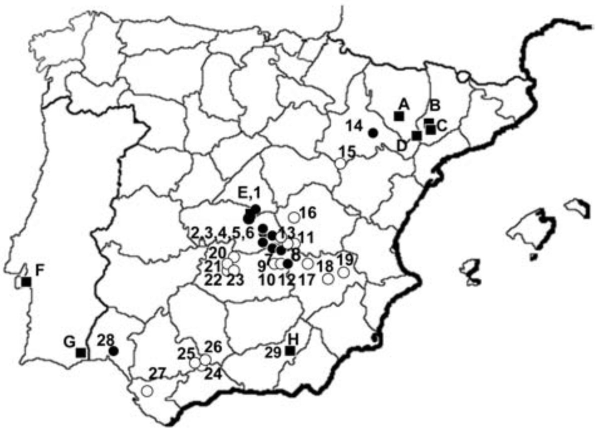

Fig. 1.— Distribution of *M. w.*. Full squares, bibliographic data: A= Villanueva de Sigena. B= Alcarrás and Menàrgens. C= Utxesa artificial lake. D= La Playa, Mequinenza. E= Aranjuez. F= Setúbal. G= Castro Marim. H= El Márgen & El Barranco del Espartal. Circles and numbers, localities and lagoons prospected in this study. Full circles, localities with one or more lagoons with presence of *M.w.* Open circles, localities where *M.w.* was not found. Numbers as in table 1.

Fig. 1.— Distribución de *M.w.*. Cuadrados negros, datos bibliográficos: A= Villanueva de Sigena. B= Alcarrás y Menàrgens. C= Pantano de Utxesa. D= La Playa, Mequinenza. E= Aranjuez. F= Setúbal. G= Castro Marim. H= El Margen y El Barranco del Espartal. Círculos y números, localidades y lagunas prospectadas en este estudio. Círculos negros, localidades con una o más lagunas con presencia de *M.w.* Círculos vacíos, localidades donde *M.w.* no fue encontrado. Números como en la tabla 1.

Segre in the artificial lake of Utxesa (Segriá, Lérida) linked to halophilous communities of *Suaedion brevifoliae* (Llucià-Pomares, 2002). Also, in Alcarràs (Segrià, Lérida), (UTM: 31TBG90) and in the near locality of Menàrgens, Noguera, Lérida) UTM: 31TCG12), cited in herbaceous salicornal (Olmo-Vidal, 2002) (Fig. 1). All references of individuals sampled in Spain except those of Pardo *et al.* (1990) and Olmo-Vidal (2002) are considered as *maghrebi*. The area covered by the denomination *maghrebi* includes the provinces of Granada, Madrid, Zaragoza, Huesca and Lleida. Thus, this distributional picture suggests a consensus for assigning *maghrebi* to the Spanish and Portuguese populations.

In spite of the apparent abundance of records in Spanish territory, we know very little of the real distribution and biology of this species. *M.w.* is one of the few Iberian Orthopteran species with global

Table 1.— Lagoons studied with localities, province, Lat-Long position and Ha. The number of each lagoon is also referred on the map of Figure 1. *M. w.*, presence of *Mioscirtus wagneri*: NN= Nymphs; AA= Adults. NN>>A= Mostly nymphs, a few or single adult detected. NN>A= Nymphs more frequent than adults, over 25% or higher). AA>N= Adults more frequent than nymphs, over 25% or higher). The sex and number of captures for present morphometric analyses are in brackets in the column of studied dates (m= males; f= females). Type of lagoon refers to levels of salinity, hydric regime and degradation (inspired in Cirujano-Bracamonte & Medina-Domingo 2002). 1, hipersaline, stationary; 2, permanent with variable salinity (sometimes artificially permanent); 3 medium salinity, stationary; 4, low salinity and stationary; 5, variable salinity but not hipersaline, large extension with areas of permanent water; 6 saline, stationary; 7 Degraded: ploughed, drained or replenished with rubbish for most of its extension, but not hipersaline. In the column *M.w.*, the asterisk refers to the presence of the species only in small swollen and salty grounds very close to the main lagoon.

Tabla 1.— Lagunas estudiadas con localidad, provincia, latitud-longitud y superficie en Ha. El número de cada laguna es referido también en el mapa de la Figura 1. *M.w.*, presencia de *Mioscirtus wagneri*: NN= Ninfas; AA= adultos; NN>>A= La mayoría ninfas, unos pocos o un sólo adulto registrado. NN>A= Ninfas más frecuentes que adultos, por encima de un 25% ó superior. AA>N= Adultos más frecuentes que ninfas, por encima de un 25% ó superior. El sexo y número de capturas para el presente estudio morfométrico se presenta entre paréntesis en la columna de fechas de estudio (m= machos; f= hembras). Tipo de laguna se refiere a niveles de salinidad, régimen hídrico y estado de conservación (inspirado en Cirujano-Bracamonte y Medina-Domingo 2002). 1, hipersalina y estacional; 2, permanente con salinidad variable (a veces artificialmente permanente); 3, salinidad media y régimen estacional; 4, baja salinidad y estacional; 5, salinidad variable pero no hipersalina, gran extensión con zonas de aguas permanentes; 6, salina y estacional; 7, degradada: arada, drenada o convertida en vertedero en buena parte de su extensión, pero no hipersalina. En la columna *M.w.,* el asterisco se refiere a la presencia de la especie solo en los alrededores de la laguna principal, en zonas bajas y saladas inundadas estacionalmente.

NUMBER FOR MAP OF FIG. 1	LAGOON	LOCALITY	N-W	HA	*M.w.*	LAGOON TYPE	STUDY DATES (captures)
1	El Corralejo	Aranjuez, Madrid	39º59´-3º37´	19	AA 0 NN>>A	1	21-09-05 (5m, 2f) 06-05-06 17-06-06
2	Grande (or del Longar)	Lillo, Toledo	39º42´-3º19´	108	AA NN>>A	1	21-07-05 (4m, 5f) 20-06-06
2	El Altillo	Lillo, Toledo	39º41´-3º18´	24	AA NN>>A	1	21-07-05 20-06-06
2	El Cerrillo (or Altillo Chica)	Lillo, Toledo	39º42´-3º18´	16	AA NN	1	21-07-05 20-06-06
3	Tirez	Villacañas, Toledo	39º32´-3º21´	95	AA NN	1	21-07-05 (3m, 2f) 16-06-06
3	La Larga	Villacañas,Toledo	39º36´-3º19´	114	AA	2*	21-07-05
3	Peña Hueca	Villacañas, Toledo	39º31´-3º20´	135	AA>N AA 0 NN NN NN NN>A NN>A	1	7-07-05 (1m) 21-09-05 (8m, 8f) 24-10-05 17-05-06 29-05-06 07-06-06 23-06-06 26-06-06
4	Las Yeguas	Alcazar San Juan, Ciudad Real	39º25´-3º17´	69	AA>N 0 0 NN>>A	1	30-06-05 (1m, 4f) 24-03-06 03-04-06 12-06-06
5	Lagunas Grande & Chica de Villafranca	Villafranca de los Caballeros, Toledo	39º28´-3º19´	185	AA NN	2*	21-07-05 12-06-06
5	Laguna de la Sal	Villafranca de los Caballeros, Toledo	39º26´-3º20´	22	AA>N	1	14-07-06
6	Grande de Quero	Quero, Toledo	39º30´-3º15´	98	AA NN	1	21-09-05 (5m, 3f) 22-05-06
7	El Salicor	Campo de Criptana, Ciudad Real	39º28´-3º10´	64	NN NN>>A NN>A	1	29-05-06 06-06-06 20-06-06

Table 1.— (Cont.).

NUMBER FOR MAP OF FIG. 1	LAGOON	LOCALITY	N-W	HA	*M.w.*	LAGOON TYPE	STUDY DATES (captures)
8	La Nava	El Toboso, Toledo	39º29´-2º59´	48	0	4	22-05-06
9	Pedro Muñoz	Pedro Muñoz, Ciudad Real	39º24´-2º56´	36	0	2	22-05-06
10	Navalafuente	Pedro Muñoz, Ciudad Real	39º25´-2º55´	35	0	7	22-05-06
11	Manjavacas	Mota del Cuervo, Cuenca	39º25´-2º52´	231	0	2	22-05-06
12	Alcahozo	Mota del Cuervo, Cuenca	39º23´-2º52´	70	NN	1	22-05-06
13	Charcones Miguel Esteban	Miguel Esteban, Toledo	39º31´-3º03´	45	0		22-05-06
14	La Salada	Mediana de Aragón Zaragoza	41º30´-0º44´	12	AA	1	03-08-05 (2m)
15	Gallocanta	Gallocanta, Zaragoza	40º58´-1º30´	1440	0	5	28-07-05
16	Hito	Hito, Cuenca	39º52´-2º41´	320	0	6	13-09-05
17	Navalcudia	Bonillo, Albacete	38º56´-2º29´	11	0	7	28-09-05
18	Pétrola	Pétrola, Albacete	38º50´-1º34´	170	0	6	28-09-05
19	Salobrejo	El Salobrejo, Albacete	38º54´-1º28´	33	0	3	28-09-05
20	Nava Grande	Malagon, Ciudad Real	39º08´-3º57´	105	0	3	01-09-05
21	Fuentillejos	Valverde, Ciudad Real	38º56´-4º03´	10	0	7	01-09-05
22	Caracuel	Caracuel, Ciudad Real	38º49´-4º04´	56	0	3	01-09-05
23	Argamasilla	Pozuelo de Calatrava, Ciudad Real	38º53´-3º51´	12	0	7	25-05-06
24	Fuente de Piedra	Fuente de Piedra, Málaga	37º07´-4º45´	1364	0	5	11-08-05
25	Gosque	Sierra de Yeguas, Málaga	37º07´-4º57´	28	0	4	11-08-05
26	Ratosa	Los Perez, Málaga	37º12´-4º42´	23	0	4	11-08-05
27	Medina	Prov Cádiz	36º37´-6º03´	97	0	5	23-07-06
28	Desemb Río Tinto	Palos de la Frontera, Huelva	37º13´-6º45´	15	AA	6	23-07-06
29	Saladar de El Margen	Cúllar, Granada	37º31´-2º14´	1	AA	1	25-07-06

disjunct distribution not included as such in other biogeographic studies of Arthropoda fauna (i.e. Ribera & Blasco-Zumeta, 1998; Martín-Piera & Sanmartín, 1999; Sanmartín, 2003).

In this study we provide new data on *M. w.* in Spain, with new records in localities so far undetected, by exploring potentially appropriate habitats for the species such as the shores of salty marshes, particularly in bare ground where there are soft and swollen softwarts (Bei-Bienko & Mishchenko, 1951). We also revise the criteria used to define the subspecies *maghrebi* by means of a preliminary morphometric study of 53 individuals collected from different sampling localities in central Spain including areas where *maghrebi* has been cited and adding new information about its geographical variation.

Material and methods

We sampled the shores of a total of 34 lagoons, most of them saline or hipersaline between May and October 2005, and between March and mid July 2006, in order to ascertain the phenology and new localities of distribution of *M. wagneri*, particularly in Castilla-La Mancha, although other areas were not disregarded. The prospected area included lagoons from the river mouth of the Tinto river (Huelva) up to the salty Laguna Salada in

Zaragoza. Information of dates and localities is summarized in Table 1. In most of the lagoons we made a complete transect around paying attention to different vegetation communities bordering them. Alternatively we prospected only part of those lagoons when they were too large for a complete inspection in a single day (Fuente de Piedra, Gallocanta). We also carried out systematic and repetitive transects to analyse the Orthopteran community and to obtain details of the microhabitat of the species particularly in Toledo province in the Villacañas Lagoon complex, and to a lesser extent in those of Ciudad Real (Alcázar de San Juan). These will be published elsewhere. However, all field prospections have been useful here to accumulate data on the biology and phenology of the species. The specimens were captured by hand, sweep netted or visually detected, but always captured when the diagnosis could be confusing, particularly referred to nymphs. We used sweep netting in those cases and whenever other species were abundant and there was no apparent sign of the presence of this species. In 2005, we inspected in hand up to a total of 228 adult individuals of which 175 were released *in situ* after determining their sex, colouration and spot design of posterior wing. Records from 2006 included presence-absence information by visual contact or hand inspection of an undetermined number of nymphs and a total of 55 adult individuals.

Nymph identification from the middle stages of development is easy. We identified the earliest nymph stages, by making a photographic nymph collection of potentially similar species and keeping them in the laboratory until they developed into the adult stage for species inhabiting the same microhabitats or their surroundings: e.g. *Aiolopus strepens* (Latreille, 1804), *Oedipoda charpentieri* Fieber, 1853 and several species of the genus *Sphingonotus* Fieber, 1852. An analysis of morphological differences of nymphal stages of these species is beyond the scope of this study (data P.J.Cordero *et al. unpublished*) and was used only to stablish a criterium for identification of *M.w*.

A total of up to 228 adults were collected in 2005 and 55 in 2006. However, for present morphometric analyses we used only 53 individuals and the remaining individuals of 2005 were released *in situ* after inspection of sex and wing colouration. According to the apparent presence of *maghrebi* throughout Spain (see references above), we performed a morphometric analysis using this preliminary sample of 53 individuals selected at random (24 females and 29 males) from different localities and from all captures of 2005, mostly in central Spain (see "study date captures" column in Table 1 for details) to test for differences among populations. This is not a large sample size, and the conclusions derived from the comparison obtained among localities should be taken with some caution. We are conscious that sample extraction from localised and small populations of *M.w.* may endanger or affect the dynamics of these small populations. However, we believe that this sample size may be enough for a preliminary analysis of populations and particularly to disentangle the *wagneri-maghrebi* question at least in some populations of Spain and provide initial insight for future work to carry out on this species. We used morphometric variables that Fernandes (1968) took into account in his comparative study. We agree that these variables are not always the most adequate to use, however, our purpose was to compare Fernandes' results with our data. Measures are taken in mm to the left appendix when available, using callipers and from fresh individuals except those related to museum specimens. Whenever possible, we measured the Antenna, from base to its apical extreme (A). In order to stablish a simple numerical comparative ratio of A with the length of head-pronotum, and following Fernandes (1968), we took the Head-Pronotum lenght, measured from frontal extreme of the head to the posterior tip of the median carina (HP). We also measured Body size: from frontal extreme of head to the tip of the abdomen (BS). This measurement may vary in females depending on gestation state, however it is one of the measures used to establish subspecific criteria (Bei-Bienko & Mishchenko, 1951; Fernandes, 1968). For this reason, we also use the hind femur (F), as a more constant variable than BS, considered as the distance between its most proximal edge to the tip of the knee. F was used as a surrogate of BS because of the high correlation between both variables and as a test for variation of size between localities. However, analyses performed with F yielded the same results as with BS and thus were omitted in the result section. Tegmen was measured from its most anterior insertion to the body (costal) at the base and lateral side of pronotum to its distal tip (T). This measure did match that of the extended tegmen.

The 53 individuals used for morphometric analysis were also photographed with a digital camera Nikon D70 with a macro Sigma and an annular flash incorporated to obtain details of the shape of pronotum and sulcus variation. We established patterns of the shape of pronotum and of median carina, characters used by Fernandes (1968) to define *maghrebi*. Male genitalia were soaked in KOH at 10% dilution

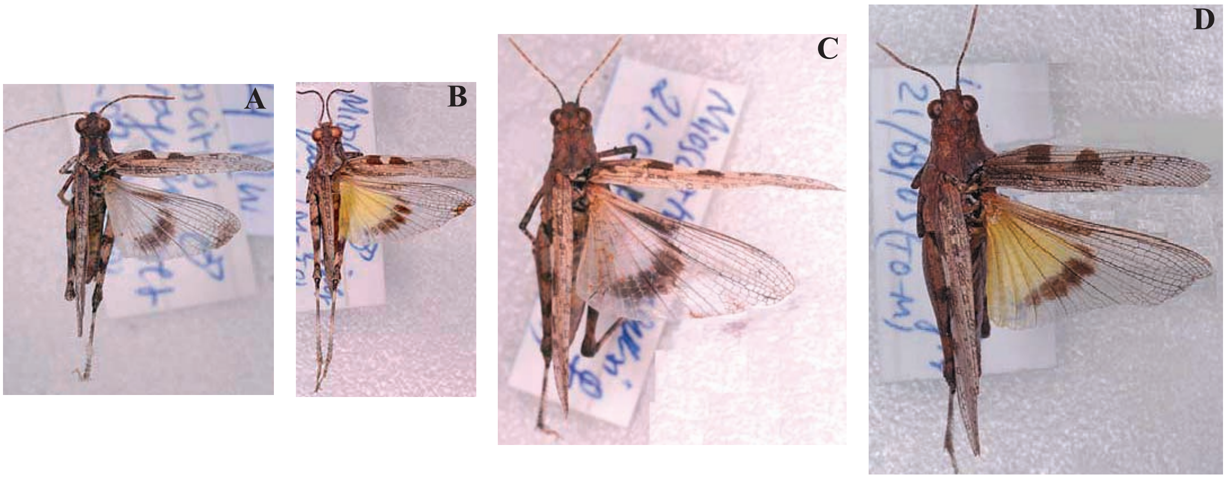

Fig. 2.— Males (A, B) and females (C, D) of hyaline and yellow wing phenotypes.

Fig. 2.— Machos (A, B) y hembras (C, D) de los fenotipos alares hialino y amarillo.

for less than five minutes, an optimal time to clean the epiphallum from debris and prevent the dilution of the tissue, and then photographed inmediately and stored in absolute ethanol.

To have a preliminary picture of size and colouration variability in different Spanish populations of *M.w.*, we used General Lineal Models implemented in SPSS v. 7.5 package to analyse body size and Tegmen variation in relation to locality and sex, and body size again in relation to sex and colour of the posterior wing as factors.

Results

M. w. was identified in 15 of 34 sites. All lagoons with presence of the species are markedly hipersaline and stationary (Table 1) with most records occurring in Toledo and Ciudad Real provinces. These are all new for the literature. We confirm its presence in Madrid, in several separate areas of Aranjuez and in the Saladar de El Margen (Granada). We also report a new locality near Zaragoza and in the mouth of the Tinto River in Palos de la Frontera (Huelva) (Fig. 1).

Colouration of the posterior wing

The design of colouration of individuals studied is variable, particularly the posterior wing. The triangle delimited by the insertion angle of the wing and its blackish strip is yellow or hyaline with variations in intensity of colouration. It may also be whitish or, rarely hyaline-white with a slight wine-red tinge (Fig. 2A, C). According to Llucià-Pomares (2002), some populations from Lleida may have bluish wings, suggesting the high variation of this character. The colour of the wing has a local component of variation: Out of 228 independent records collected in 2005, all individuals (22) from our Aranjuez sample (El Corralejo, Madrid) had intense yellow wings. The same occurred also in all individuals collected in 2006 from Rio Tinto (20 males and 9 females) and El Saladar de El Margen (13 males and 13 females). On the contrary, all 15 individuals seen or captured in Laguna Salada from Zaragoza and all 31 from Tirez (Toledo) had hialine wings, sometimes with slight whitish or even a slight wine-red tinge. In other lagoons the percentage of yellow wings varied.

We also show the presence of a sexual dichromatism trait, a diffuse smoked blackish spot comprising the apical end of the wing lobes already mentioned by Finot (1895) and present in males but not in females of our populations. However neither Chopard (1943) nor Bei-Bienko & Mishchenko (1951) and Harz (1975) mentioned it or depicted it in their respective descriptions or figures (see for example Fig. 1798, pag. 507, in Harz, 1975). Harz showed a wing assigned to a male that is virtually identical in pattern and shape to the female wing drawn by Bei-Bienko

Table 2.— Range of variation of Body Size (BS) and Tegmen (T) in mm for the different forms of *M. w.* described according to: 1, Bei-Bienko & Mishchenko (1951); 2, Fernandes (1968) and 3, this study (Males= 29, Females= 24).

Tabla 2.— Rango de variación del Tamaño del cuerpo (BS) y la Tegmina (T) en mm para las diferentes formas de *M. w.* descritas según: 1, Bei-Bienko & Mishchenko (1951); 2, Fernandes (1968) y 3, este estudio (Machos= 29, Hembras= 24).

Variable		***M w wagneri*[1]**	***M w maghrebi*[2]**	***M w rogenhoferi*[1]**	***M wagneri spp*[3]**
Body Size	Females	21 – 22	19 – 24	23 – 27	16.7 - 20.4
	Males	13 – 15	14 – 16	16 – 17	11.2 - 15.0
Tegmen	Females	17 – 23	20 – 23	21 – 28	16.30 - 19.7
	Males	10 – 14	10 – 16	13 – 17	11.90 - 13.9

& Mishchenko (Fig. 1273, pag. 232, 1951) who only showed the figure of a female. We are not sure if the apparent similarity between male and female wing pattern, according to both authors, is a mistake or a lack of information of previous authors on this respect, or if the apparent similarity of sexes in those descriptions with respect to our differences is due to particular features of our western populations. However, we suspect that it may be the first possibility, since the shape of the posterior wing of the male also ends more sharply and is more acute than in the female as shown in Fig. 2.

Body measurements

Body size, (BS) was 18.34 ± 0.19 (x ± SE; N= 24) for females and 12.81 ± 0.18 mm (x ± SE; N= 29) for males. Tegmen (T) was 17.89 ± 0.16, (x ± SE; N= 22) for females and 12.86 ± 0.09 mm (N= 28) for males. Table 2 shows how these values do not surpass the range given by Bei-Bienko & Mishchenko (1951) for subspecies *wagneri* and are smaller than those obtained for *maghrebi* by Fernandes (1968) who considered this form larger than *wagneri*. Although neither Bei-Bienko &

Table 3.— General Linear Models for Body Size (BS) (a) and for Tegmen (T) (b) as dependent variables in relation to sex and locality.

Table 3.— Modelos lineales Generales para el Tamaño del cuerpo (BS) (a) y para la Tegmina (T) (b) como variables dependientes en relación al sexo y la localidad.

General Lineal Model (a) Dependent variable: Body Size		F	df	p	power
	Corrected model	67.8	12	0.000	1.00
	Intercept	16809.8	1	0.000	1.00
	Sex	569.45	1	0.000	1.00
	Lagoon	4.17	6	0.002	0.95
	Interaction Sex x Lagoon	1.47	5	0.22	0.46
General Lineal Model (b) Dependent Variable: Tegmen					
	Corrected model	77.76	12	0.000	1.00
	Intercept	24101.9	1	0.000	1.00
	Sex	667.01	1	0.000	1.00
	Lagoon	1.83	6	0.119	0.61
	Interaction Sex x Lagoon	0.64	5	0.669	0.208

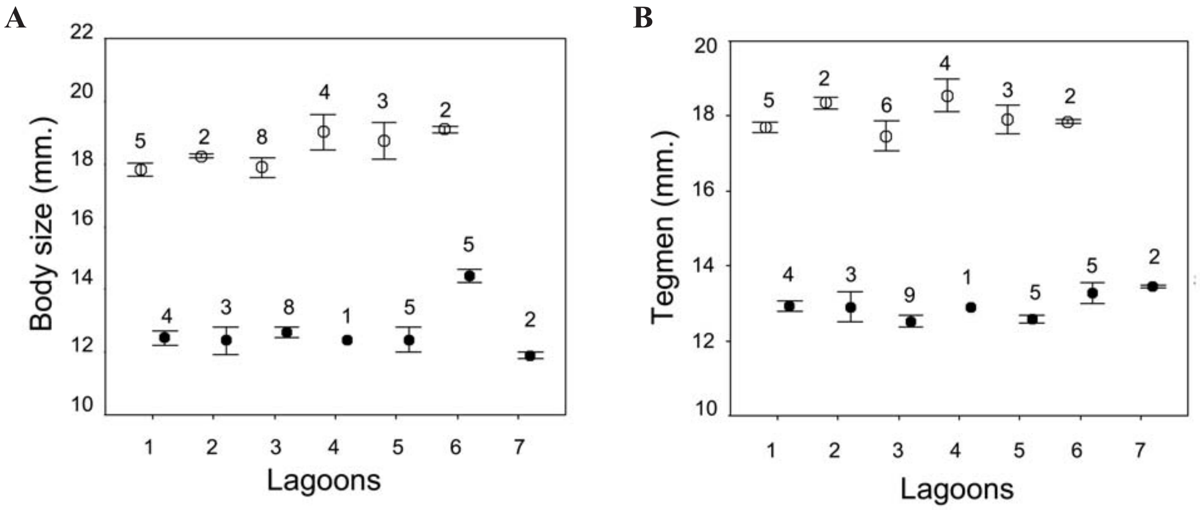

Fig. 3.— Relationship between; (A) Body size according to sex and lagoon; (B) Length of Tegmen according to sex and lagoon. Measurements in milimeters (Mean ± 1SE): 1= El Longar or Grande de Lillo. 2= Tirez. 3= Peña Hueca. 4= Yeguas. 5= Quero. 6= El Corralejo. 7= Salada de Zaragoza. Number of individuals over the error bars. Full circles, males; open circles, females.

Fig. 3.— Relación entre (A) el tamaño del cuerpo (BS) y (B) la longitud de la Tegmina (T) en milímetros (Media ± 1SE) según sexo y lagunas prospectadas: 1= El Longar o Grande de Lillo. 2= Tirez. 3= Peña Hueca. 4= Yeguas. 5= Quero. 6= El Corralero. 7= Salada de Zaragoza. Número de individuos sobre los barras de error. Círculos negros, machos; círculos blancos, hembras.

Mishchenko (1951) nor Fernandes (1968) described the variable "length of the body" we assume that in both cases it is the same and equivalent to our BS (see methods). Anyway, comparison of T in our sample is similar to the results obtained with respect to BS: the values are within the interval of *wagneri*, even with the smallest sizes of the range described for the species (Table 2).

BS also varies among localities but not T (Table 3, Fig. 3A and B). Because of the proximity of the lagoons in the Villacañas (Tirez and Peñahueca)-Lillo (Grande de Lillo)-Quero-Alcázar de San Juan (Yeguas) area (V-L-Q-A), and as there were no significant morphometric differences between them, we pooled data from V-L-Q-A and formed three groups: V-L-Q-A lagoons, El Corralejo of Aranjuez and the Laguna Salada from Zaragoza. Although we only had two males from the latter lagoon, F values for lagoon in relation to BS were still higher ($F_{2, 51}$= 11.96, p < 0.0001). In turn, values of F for the model implying T instead of BS were still the same and showed that T was not related to locality ($F_{2,51}$= 1.16, p = 0.323). Because of the small size of some of the subpopulations we could not perform *post hoc* tests. Instead, we performed simple ANOVAs relating BS for each sex separately and in relation to locality. For males and considering all localities: $F_{6,46}$= 8.18, p < 0.0001. Grouping in three as before: $F_{2,51}$= 27.54, p< 0.0001. On the contrary, the same analyses applied to females were not significant (For all localities: $F_{6, 51}$= 1,845, p = 0,155. Grouping as before: $F_{1,49}$= 1.74, p = 0.2). These results suggest that size in males is more variable with locality than in females. Males from El Corralejo (Aranjuez) have larger BS than males of the rest of localities studied (Fig. 3). However, the small sample sizes prevented us from making a wider generalisation. Before looking at the possibility that female BS changed according to gestation state and thus we were seeing introduced noise masking true local female differences, we used the femur (F) as a surrogate measure of body size, considering the high correlation between F and BS (Pearson Correlation, for females: r = 0.61, p = 0.002; N = 24. For males: r = 0.68, p < 0.001; N= 27). The analyses performed using F instead of BS provided identical differences for males in relation to locality whereas females showed similar F between localities as before (results not shown).

Table 4.— General Linear Model for Body Size in relation to sex and colour of posterior wing.

Table 4.— Modelos lineales Generales para el Tamaño del cuerpo en relación al sexo y el color del ala posterior.

General Lineal Model Dependent variable: Body Size		F	df	P	Power
	Corrected model	246.35	3	0.000	1.00
	Intercept	15769.2	1	0.000	1.00
	Sex	415.68	1	0.000	1.00
	Colour of wing	22. 642	1	0.000	0.99
	Interaction Sex x Colour	5.59	1	0.02	0.64

An intriguing aspect to analyse in different populations is the colour of the posterior wing and its relationship with BS. BS was associated with wing colour: individuals with a yellow patch in the wing also showed larger BS this relationship being more apparent in males than in females (Table 4; Fig. 4). To control for locality in this relationship, we performed a new analysis obtaining positive results between BS and wing colouration ($F_{1, 49}$= 12.75; p = 0.001) with a positive interaction of sex with colouration, ($F_{1, 49}$= 5. 27, p = 0.026): males with yellow wings presented larger body sizes than hyaline winged males whereas this difference was not present between hyaline and yellow winged females (Fig. 4).

Pronotum and sulcus of the median carina.

Another character used by Fernandes to define *M.w. maghrebi* was the presence of a second and more proximal sulcus in the median carina of the pronotum. We summarize the variability of pronota and the presence of the anterior sulcus in Fig. 5. The presence of anterior sulcus varies among individuals. Pronota ranged from plain and straight to those with saddle shape, found particularly in the Laguna Salada of Zaragoza (Fig 5, G e I). The distribution of different pronota studied in relation to sex and locality is depicted in Fig. 6. Females show more smooth and straight pronota than males (see also Finot, 1895).

Length of antenna (A)

As in other *Acrididae*, A was a bit longer in males (7.03 ± 0.16 mm, N= 20) than in females (6.79 ± 0,11 mm, N= 20) (x ± SE) in spite of the smaller size of males. This difference was patent in relation to HP. The ratio A/HP was 1, 50 ± 0, 04 for males and 1.12 ± 0.02 for females, t = - 8.76, df= 38, p< 0.000, clearly indicating that A is obviously larger than HP as Fernandes suggested for *maghrebi*. However, the only male of the *wagneri* form studied from the Museo Nacional de Ciencias Naturales of Madrid with a Russian label has a rela-

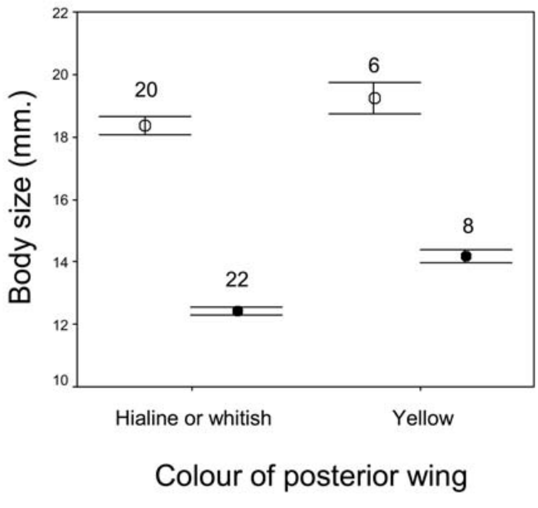

Fig. 4.— Relationship between body size in milimeters (Mean ± 1SE) according to sex and colouration of posterior wing. All data pooled. Number of individuals over the error bars. Full circles, males; open circles, females.

Fig. 4.— Relación entre el tamaño del cuerpo (BS) en milímetros (Media ± 1ES) según sexo y coloración del ala posterior. Todos los datos incluídos. Número de individuos sobre los barras de error. Círculos negros, machos; blancos, hembras.

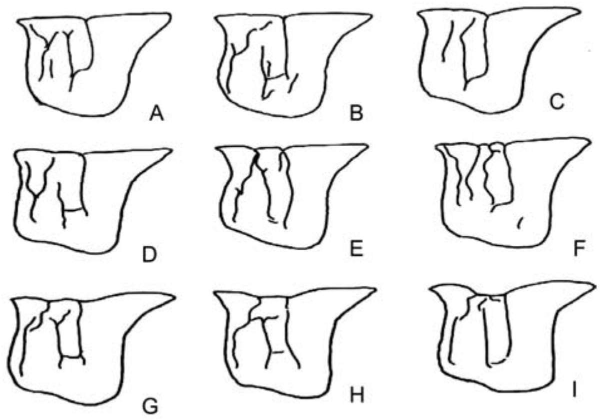

Fig. 5.— Types of pronota in relation to the presence of an anterior sulcus (secondary sulcus) and prozone-metazone profiles. Sample is the same as in Figs. 3 and 4. A= Straight, without differential elevation of median carina, only posterior sulcus presented. B= Profile almost straight in the prozone, but slightly elevated and with small anterior depression at the median carina almost imperceptible but not interrupted. C= Like B, but with prozone a bit more elevated than metazone. D= Slightly undulating profile in the prozone with faint anterior sulcus almost imperceptible. E= Presence of both sulcus but with elevated prozone and metazone at the same level. F= Both anterior and posterior sulcus patent; prozone and metazone at the same level, only the anterior sulcus depress the median carina. G= Marked anterior sulcus forming three knobs including prozone and metazone. H= Both sulcus well defined delimiting a plain mesozone with both prozone and metazone elevated. I, Similar to H, but with both sulcus less defined and extremes of pronotum exageratedly elevated in saddle form.

Fig. 5.— Distintos perfiles de pronotos en relación a la presencia de surco anterior y relieve de prozona-metazona. La muestra es la misma que para las Figs. 3 y 4. A= perfil recto, sin elevación diferencial de la quilla media, único surco, el posterior. B= perfil casi recto en la prozona, pero con ligera elevación de la misma y leve depresión, apenas perceptible, no surcada anteriormente. C= como B, pero con la prozona ligeramente más elevada que la metazona. D= perfil ligeramente ondulado en la prozona, con ligera depresión anterior, pero surco anterior casi imperceptible. E= presencia de surco anterior con prozona y metazona elevadas pero a igual nivel. F= surco anterior y posterior presentes, prozona y metazona a igual nivel, dos surcos, sólo el más anterior deprime levemente la quilla media. G= depresión anterior aparente formándose tres abultamientos incluyendo la prozona y la metazona. H, ambos surcos bien presentes delimitando una zona de la mesozona plana, prozona y metazona elevadas. I, parecido a H, pero surcos menos definidos y extremos del pronoto más elevados, pronoto en silla de montar.

tion A/HP of 1.62; a value even larger than those found for our Spanish individuals studied.

Epiphallum

The epiphallum of a male from Aranjuez is depicted in Fig. 7. We did not recognize substantial difference between this epiphallum and that of *maghrebi* or *wagneri* drawn by Fernandes (1968).

Phenology

In 2005, earliest adults were recorded from mid June to October and nymphs were recorded up to the end of July (Toledo province). Nymphs became adults from mid June to the end of July and adults survived up to October. In 2006, year in which we were already aware of the presence of the species, nymphs of first stage were intensively sought in their appropriate habitat before their presumed time of hatching (Table 1). First nymphs hatched were recorded from mid May to the end of the month, and nymphs becoming adults were detected in most localities from mid June. However, in some of the localities adults were present from the first week of June. The species presents a single reproductive cycle in the season as most *Oedipodinae* species in the area. *M. w.* is one of the first species to disappear in their habitat and by the end of October was absent from areas where species like *Dociostaurus jagoi occidentalis* Soltani, 1978, *Oedipoda charpentieri* or *Sphingonotus azurescens* Rambur, 1838 were still common (24th October 2005).

Habitat

M. wagneri occurs in all hipersaline lagoons prospected with stationary hydric regime and low fluctuating salinity. It is found in the vegetation ring around the shores of the lagoons and other hypersaline low grounds with patches of *Suaeda vera*, *Chenopodiacea* on which it depends for food, refuge and breeding. We did not find it on any other plant species in spite of the intense search around the lagoons and *Suaeda* meadows in the Center of its distributional area in Spain (P.J. Cordero *et al. unpublished*.). However, it occurred in *Salicornia* meadows in the shores of the Tinto River, where *Suaeda vera* is currently scarce. Densities up to 4.5 ind/m^2 are not infrequent in patches of preferred habitat (P.J. Cordero *et al. unpublished*.), though lower values are more frequent, with the lowest densities in the mouth of the Tinto river where *Suaeda vera* is rare. Although it seems to be the only acridid species living in its plant community including the bare salted grounds around, other species may accompany it like *Dociostaurus jagoi occidentalis,* particularly in those lagoons with vegetation rings more degraded and eutrophized by grazing where *Suaeda vera* may coexist with small sized grasses like *Hordeum marinum*, *Polypogon maritimus* or *Aeluropus litoralis*. Also, *Sphingonotus azurescens*, accompanies it on occasion in its most unaltered microhabitat though it has a wider niche than *M. w.* On the contrary, *Aiolopus strepens* substitutes it in similar habitats where *M. w.* is lacking. *M. w.* may also be found far from the vegetation rings of hipersaline lagoons, on salty ground covered by extensive prairies of *Suaeda vera*, probably, in reminiscence areas of what in other times might have flooded hipersaline grounds (lagoons).

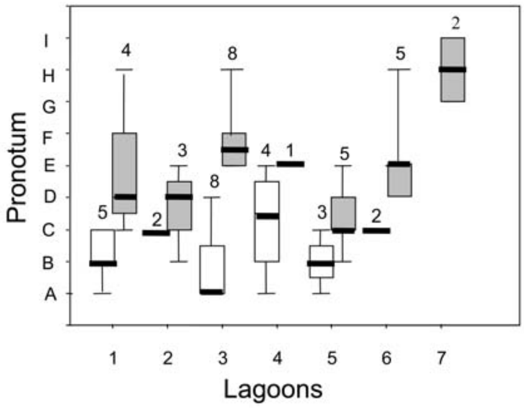

Fig. 6.— Pronotum profiles according to sex and locality (N= 52). Boxes with bars representing the median; interquartile ranges and extreme types. Open boxes females, dark boxes males. Lagoon numbers like in Figs 3 and 4.

Fig. 6.— Distribución de pronotos según sexo y localidad, (N= 52). Rectángulos con barras representan la mediana, rangos interquartiles y tipos extremos. Rectángulos vacíos hembras, oscuros machos. Número de lagunas como en Figs 3 y 4.

Discussion

On the basis of our results, we think that morphometric characters used by Fernandes to separate between subspecies *wagneri* and *maghrebi* are insufficient provided the vast variation between small close populations. Because *M.w. maghrebi* has been assumed for Granada, Madrid, Zaragoza, Lleida and Huesca, we disagree with the establishment of this subspecies on the basis of the following points:

(1) Body size of the Spanish populations studied is within the range of variation given for *wagneri* and it is not intermediate between this subspecies and *rogenhoferi* as Fernandes suggested. Further, we include the smallest individuals known for the species.

(2) The extraordinary variation of pronotum within close populations makes it impossible to consider it as a valid character for separating *maghrebi* and *wagneri* forms at least on the basis that Fernades (1968) proposed. The presence of a straight pronotum like that attributed to *wagneri* by Fernandes (see also Chopard, 1943, pág 290, fig. 452) is also seen in a high proportion of Iberian females and in some males (Fig. 5A-C). Bei-Bienko & Mishchenko (1951) described the possibility of a slight notch in *wagneri* before the main sulcus of the pronotum: *"sometimes the median carina has a slight notch above the anterior transverse groove"* (pag. 231) that Fernandes (1968) also considers in his key to subspecies. We found that this second sulcus (anterior) of the pronotum occurs in most males, contrary to Fernandes. We also found the most atypical pronotum such as those with saddle shape not mentioned by any author for this species (Figs. 5, 6). In conclusion, we suggest that there is such an enormous variability in the shape of the pronotum that it is of doubtful taxonomic interest and would require a deeper study with larger sample sizes and wider geographic range.

(3) We found no differences in the length of the antenna (A) in our populations with respect to the form *wagneri*. Fernandes (1968) included in his dicotomic classification that *maghrebi* has longer antennae than the head and pronotum together (HP), though nothing is said with respect to *wagneri*. However, in the only specimen analysed belonging to the form wagneri, the index A/HP was even larger than in our population studied. Thus, we believe that A is also not a good character to consider for taxonomic differentiation between *wagneri* and

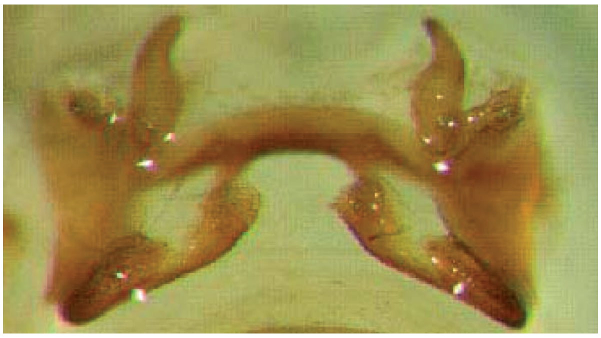

Fig. 7.— Epiphallum of *M. w.* from El Corralejo, Aranjuez (Madrid).

Fig. 7.— Epifalo de *M. w.* de El Corralejo, Aranjuez (Madrid).

maghrebi. Assuming sexual differences in A (Finot, 1895; this study) and that many individuals from collections may have lost the antennae or be difficult to measure in dried specimens when not straight, we suggest that the differences of A suggested by Fernandes, being longer than HP in *maghrebi*, could be biased by different proportions of sexes analyzed in his populations rather than by real subspecific differences between *wagneri* and *maghrebi*.

(4) Though we present a single individual epiphallum from an individual of El Corrajelo, Aranjuez, we would expect clear-cut features with larger differences than those observed on the three different forms depicted in Fig. 8. There are not enough visual traits consistent with both those drawn by the author for *wagneri* (Fig. 8A) or *maghrebi* (Fig. 8B) aside from those inherent to possible variations due to genitalia preparation like time of tissue digestion, KOH concentration or angle of presentation of the epiphallum (Figs. 7, 8).

We also provide new localities of distribution of *M. wagneri* in Castilla-La Mancha, Andalucía and Aragón but we suspect that it may also be present in similar habitats in other regions, from the South to the salty lagoons of the East of the country where the habitat could be adequate.

Though our results relating morphometric variables and locality are preliminar because of small sample sizes in some of them and because of the reduced number of sites included, we obtained differences within the small geographical range covered in which individuals (particularly males) from El Corralejo (Aranjuez) are the largest and have a greater proportion of yellow wings than those of hipersaline lagoons of Toledo and Zaragoza. At the opposite extreme is la Laguna Salada (Zaragoza) where males are the smallest recorded, their posterior wings are hyaline and pronotum is saddle shaped (N= 2). It should be noticed that *Suaeda vera* presents its highest cover and leafy plants in Aranjuez, while the contrary occurs in La Laguna Salada of Zaragoza. The colour of the posterior wing may be related not only to body condition, but also to physical characteristics of the microhabitat in each population.

The patchy regional distribution may have contributed to local morphometric variation in this species whose ecological requirements are narrow: hipersaline grounds with *Suaeda vera* distributed in patches that may be separated by hundred of kilo-

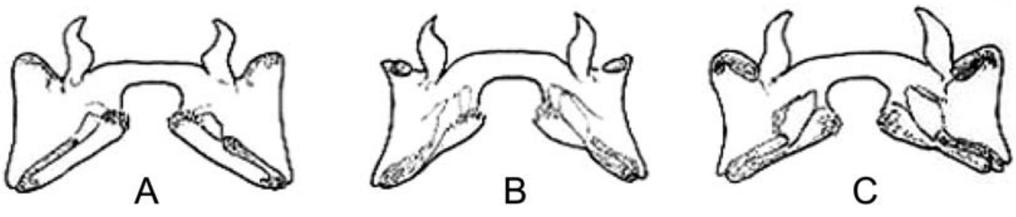

Fig. 8.— Esquematic representation of epiphallum of the forms: *wagneri* (A) and *maghrebi* (B) according to Fernandes (1968). (C) Epiphallum of *M. w.* from El Corralejo, Aranjuez (Madrid).

Fig. 8.— Esquema de los epifalos de las formas *wagneri* (A) y *maghrebi* (B) según Fernandes (1968). (C) Epifalo de *M. w.* de El Corralero, Aranjuez (Madrid).

metres. For this reason and because of its world-wide disjunct distribution, we believe that *M. w.* is a good model species for study from a taxonomic, ecological, evolutionary and conservation perspective. More detailed analyses using larger sample sizes from all localities where it is found and a genetic approach of its populations will provide more definitive information about the relationships between local variation and ecology; dynamics, dispersion and possible substructure of our Spanish populations studied that we prefer to consider for now as *M. w. wagneri* (cf Fernades 1968).

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