New morphological data of the larvae F0 and exuviae of *Brachythemis impartita* (Karsch, 1890), (Odonata, Libellulidae)

MIGUEL A. CONESA GARCÍA[1], ARTURO BERNAL SÁNCHEZ[1], FRANCISCO CANO VILLEGAS[1]
mconesa@libelulas.org ; arturo.libelula@gmail.com; fjcanovi2@hotmail.com

1 Sociedad Odonatológica de Andalucía. (www.libelulas.org)
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ABSTRACT:

There is no original description of the larvae of *Brachythemis impartita* (Karsch, 1890). The limited morphological data published in the literature about *Brachythemis leucosticta* (Burmeister, 1839) for the fauna in Europe and North Africa must be ascribed to *B. impartita* (DIJKSTRA & MATUSKINA, 2009). Our study provides an analysis of 22 morphological parameters measured in F0 larvae and exuviae of samples which undoubtedly belong to *B. impartita*. Larval morphology is described in different stages and the results obtained are compared with those for known species of *Brachythemis lacustris* (Kirbyi, 1889) and *Brachythemis leucosticta* (Burmeister, 1839), both of African distribution.

Key words: Odonata; larvae; *Brachythemis impartita*; morphology; biometry; distribution.

RESUMEN

No existe una descripción original de la larva de *Brachythemis impartita* (Karsch, 1890). Los escasos datos morfológicos aparecidos en la bibliografía referentes a *Brachythemis leucosticta* (Burmeister, 1839) correspondientes a fauna de Europa y el norte de África, hay que adjudicarlos a *B. impartita* (DIJKSTRA & MATUSKINA, 2009). En nuestro estudio se aporta el análisis de 22 parámetros morfológicos medidos en larvas F0 y exuvias de ejemplares que indudablemente pertenecen a *B. impartita*. Se describe la morfología larvaria en diversos estadios y se comparan los resultados obtenidos con los conocidos de

Brachythemis lacustris (Kirbyi, 1889) y *Brachythemis leucosticta* (Burmeister, 1839) ambas de distribución africana.

Palabras clave: Odonata; larva; *Brachythemis impartita*; morfología; biometría; distribución.

INTRODUCTION

Two species of the genus *Brachythemis* (Brauer, 1868) which share an incredible similar external morphology were recently found in Africa. This similarity confused specialists and naturalists, until a thorough study of the species in Africa and Europe revealed the existence of two twin species: *Brachythemis leucostista* (Burmeister, 1839) and *Brachythemis impartita* (Karsch, 1890), (DIJKSTRA & MATUSKINA, 2009). The results of the assay have been later ratified by genetic studies (Dijkstra, com. pers., 2013). This large study demonstrated that, in the Iberian Peninsula, *B. impartita* is the only species present; therefore it should be considered that all Western European literature references, before 2009, citing adults or larvae of *B. leucosticta* should be ascribed to *B. impartita*.

The European literature regarding the larvae of *B. leucosticta* provides a description of the lateral abdominal profile taken from the original description by P. Corbet (AGUESSE, 1968); a drawing and description of the mask of specimens collected in Malaga (Spain) (CONESA & GARCÍA, 1985); a drawing of the 'habitus', mask and palp of individuals from Sicily (Italy), (GALLETTI & PAVESI & ROMANO, 1987) and a diagram of the abdomen in side view (ASKEW, 2004). All this information should be ascribed to *B. impartita.*
The data provided by HEIDEMAN & SEIDEMBUSCH (2002) of the larva of *B. leucosticta* state *B.impartita* as a synonym of the species and do not specify the origin of the specimens studied, although reference is made to sightings of the species in Israel, Egypt, Namibia and Sicily. Therefore, it is impossible to specify whether the description and drawings presented are applicable to *B. impartita* or *B. leucosticta*, since the three species of the genus *Brachythemis* coexist in Namibia.

Concerning the biometric and morphological study of the larva of *B. impartita*, there are no data allowing the differentiation of it from those of *B. leucosticta* or *B. lacustris*. The original description of the larva of *B. leucosticta* (CORBET, 1957) alludes to two different morphologies which are differentiated by the substrate where the larvae evolve. One of the larva is described as eruciform and inhabits sandy media; the other has a more rounded shape, typical of the Libellulidae family, and inhabits muddy bottoms. Furthermore, intermediate larval forms are observed in places where sand and mud are mixed (CORBET, 1957). Their descriptions are based on one male and one female specimen which emerged in captivity in February 1954 (Lake Mirambi, Kichwamna, Ankole and Jinja, Lake Victoria); one male and four females associated to their emerging exuviae in March 1954 (Butiaba, Lake Albert); and 26 larvae and 83 exuviae from several East African localities.

Due to the fact that the diversity of morphologies observed by P. Corbet in the *B. leucosticta* larvae has never been observed again, it is possible that it could be due to the presence of two different species: *B. leucosticta* present in sandy bottoms and *B.impartita* in muddy bottoms, where it is common to found larvae in our area of study.
The absence of biometric and morphological data about the larvae of *B. impartita*, the differences found with respect to the original description of *B. leucosticta* and *B. lacustris* and the fact that the larvae of the Iberian fauna that we have studied are unambiguously of the species *B.impartita* have allowed us to contribute with data in order to perform an unambiguous description of this larvae at the F0 stage and its exuvia which permit a comparison between African species of the *Brachythemis* genus, Brauer.

MATERIAL AND METHODS

During 2010 and 2012 a series of field sampling were programmed, in order to study the morphology of the wings and fences of the adult specimens.
The main purpose was to confirm the existence of *B. impartita* and the absence of *B. leucosticta* in our area of study.
Concurrently, a pentagonal bag of 26 cm of side with a "syntex" net of 30cm depth and 3mm of mesh size was used for larvae collection from sandy and muddy areas surrounding lagoon vegetation. The exuviae were collected manually from the branches of vegetation which was between 5 and 90 cm away from the water.
The F0 larvae collected were settled in aquariums, later photograph and the measurements were obtained using a Leica S3 binocular loupe and the LASS© software. The exuviae obtained from the aquarium and collected from the sampling area were equally measured.

Parameters of study: Antenna length; head length; head width; prementum length; prementum width; setae of prementum; setae of palp; total length including pyramid flow; length of the abdomen; width of abdomen; length of previous pterotecas ; length of later pterotecas ; length of front femora; previous tibias length; means femora length; means tibias length; hind femora length; hind tibias length; distance between the lateral spines of the 8th segment; distance between the lateral spines of the 9th segment; epiproct length; epiproct width; paraprocts length; fences length. Standard deviation and coefficient of variation were calculated according to the results obtained.

RESULTS AND CONCLUSIONS

Recent studies on the fauna of the Algarve (Portugal) (KNIJF & DEMOLDER, 2010); on the fauna of Sardinia (Italy) (HARDERSEN & LEO, 2011); and the fauna of the RIF (EL HAISSOUFI & EL MOHDI & MILLÁN, 2010) describe only *B. impartita*. The adult specimens that we founded in Cádiz, Málaga, Córdoba and Sevilla exhibit a color in the

wings (Fig.1) and fences (Fig.2) corresponding to *B. impartita*, in accordance to the description provided by DIJKSTRA & MATUSKINA, 2009. The data obtained corroborate that in the south of the Iberian Peninsula, the Mediterranean region and Magreb only *B. impartita* is distributed.

Specimens studied:

Adults: Tail end of the Arcos de la Frontera Marsh, Cadiz (UTM 30S, 251831 4073744): 30♂♂, 31♀♀. Tail of the Barbate Marsh, Cadiz (UTM 30S 234492 4017041): 14♂♂, 11♀♀. Charcoredondo, Cádiz (UTM 30S 267770 4015427): 6♂♂, 10♀♀. Celemín river, Cadiz (UTM 30S 253349 4021864): 1♀. Jautor river (UTM 30S 262497 4027686): 18♂♂, 10♀♀. Hozgarganta river, Cadiz (UTM 30S 277706 4036018): 2♂♂, 1♀. Puerto de Santa Maria (UTM 27S 747330 4058871): 5♂♂, 2♀♀.
Siete Arroyos (Seville) (UTM 30S 245360 4166759): 3 ♂♂ 1♀; Marsh of Guadanuño river (Cordoba) UTM: 30S 342828 4209859: 2 ♂♂ 3 ♀♀; Marsh of San Pedro (Guadiato river - Cordoba) UTM: 30S 295799 4241040: 8 ♂♂ 18 ♀♀; Marsh of Puente Nuevo (Guadiato river - Cordoba) UTM: 30S 320424 4227583: 11 ♂♂ 8 ♀♀; Laguna Amarga (Cordoba) UTM 30 S 357007 4131267: 15♂♂, 9♀♀. Laguna del Ojen, Malaga (UTM 30 S 347811 4045705): 9♂♂, 7♀♀. Estuary of the Guadalhorce river Natural Site, Malaga (UTM 30S 370089 4059794): 35♂♂, 39♀♀.

Larvae and exuviae: Jautor river, (tail end of the Barbate Marsh), Cadiz (UTM 30S 262678 4027741): 25 larvae at stages F8-F1 and 4 F0 larvae; Barbate Marsh, Cadiz (UTM 30S 254078 4029820) 10 exuviae; Laguna Amarga (Cordoba) (UTM 30 S 357007 4131267): 8 exuviae and 2 F0 larvae; Laguna del Ojén, Malaga (UTM 30 S 347811 4045705): 2 exuviae and 4 F0 larvae, Estuary of the Guadalhorce river Natural Site, Malaga (UTM 30S 370089 4059794): 3 F0 larvae and 4 exuviae
Any larvae have ever been found in rivers, all of them come from Marshs, Marsh tail-ends or saline lagoons. However, adult specimens have occasionally been observed on well-exposed riverbanks located close to marsh.
Only F0 larvae and exuviae (n=37) samples were used for the description of the larvae.

General aspects, colour and body length: The larvae of the specimens founded in swamp tails with abundant decaying organic matter are very dark, almost black. Other specimens, although found in identical substrates, exhibited a pale light brown colour or olive green, abundantly mottled across the entire exoskeleton, which was possibly due to recent moulting, during which the pigments contained in the melanophores are in the aggregating state and only calcareous deposits can be appreciated. In the same substrates it is also common to find specimens with reddish rainfall of oxidized sediment covering the thorax (Fig.3). Measurements in Table I.

Head: Wider than the thorax, the occiput matches the anterior thorax, so that at first glance, the line of separation between the head and thorax is difficult to distinguish. This morphology makes it more similar to *B. lacustris* than to *B. leucosticta* (Fig. 4). The lower basal area of the eyes is strongly black coloured, which subsequently delimits the ommatidial cluster, following the suture line between the vertex and occiput. This band is appreciable at all stages of larval development, from F10 to F0 (Fig. 4). Between the secondary suture and that between the vertex and occiput, two overlapping, symmetrical folds directed towards each eye can be appreciated, creating a central depression between them. A similar structure was described in HEIDEMAN & SEIDEMBUSCH (2002) for *B. leucosticta*. Head measurements in Table I.

Antennae: In F0 and exuviae, these are small and filiform, made of seven segments with abundant hairiness perpendicular to the axis of the antennae (Fig.4). Measurements in Table I.

Jaws: These comprise 4 irregular notches where the right lateral cusp is more prominent that the rest of them (Fig.5). This structure appears different from that of *B. leucosticta* and *B. lacustris* drawn by CORBET (1957), since both figures depict 4 sharp-tipped basal cusps, whereas in our case, there are only two blunt cusps.

Mask: The setae on the palp are long and unpigmented, which renders their observation difficult (Fig.6). Among the specimens studied, most feature 4&4 setae on the palp and 7+7 on the prementum, with the following combinations observed on the palp: 72, 97% (4&4), 13,51% (5&4), 10,81% (5&5), 2,70% (6&6). These data indicate fairly inhomogeneous populations, although palps of the 4&4 type were consistently the most common. Similar results were obtained in the Italian fauna. (GALLETTI & PAVESI & ROMANO, 1987), Table II.

		LA	LC	AC	LM	AM	LT	LAB	AAB	LWA	LWP	LFA
1*	**P.**	2,08	2,48	4,45	2,37	2,51	14,6	9,11	5,22	4,58	4,11	2,22
	DST.	0,07	0,24	0,62	0,14	0,15	0,34	0,63	0,27	0,96	0,76	0,27
2*		15-19										
3*		13,5-15										
1**		15-17										
		LTA	**LFM**	**LTM**	**LFP**	**LTP**	**D8º**	**D9º**	**LEP**	**AEP**	**LP**	**LC**
1*	**P.**	2,55	3,55	3,51	5,83	5,38	5,08	3,01	4,58	4,11	2,22	2,55
	DST.	0,2	0,29	0,13	0,51	0,71	0,32	0,2	0,96	0,76	0,27	0,2

TABLE I. Average (P) and standard deviation (STD) F0 and exuviae samples of the following variables: (LA) antenna length; (LC) head length, (AC) head width; (LM) prementum length; (AM) width the prementum; (LT) total length, including the pyramid flow; (LAB) length of the abdomen; AAB (width of abdomen); (LWA) length of previous pterotecas ; (LWP) pterotecas length later; (LFA) length front femora; (LTA) tibiae length; (LFM) femurs length means; (LTM) tibias length stockings; (LFP) hind femora length; (LTP) long hind tibiae; (D8 º) distance between the lateral spines of the 8th segment; (D9 º) distance between the lateral spines of the 9th segment; (LEP) length epiproct; (AEP) width epiproct; (LP) lengths paraprocts; (LC) length fences Variable measures in mm (n=37).. 1* *B.impartita*, present survey; 2* *B.leucosticta* (Corbet,1957); 3* *B.lacustris* (Corbet, 1957). 1** *B.impartita* (Galletti & Pavesi & Romano, 1987).

TABLA I. Promedio (P) y Desviación estándar (DST) de ejemplares F0 y exuvias de las siguientes variables: (LA) longitud de la antena; (LC) longitud de la cabeza; (AC) anchura de la cabeza; (LM) longitud del prementum; (AM) anchura del prementum; (LT) longitud total, incluyendo la pirámide caudal; (LAB) longitud del abdomen; AAB (anchura del abdomen); (LWA) longitud de las pterotecas anteriores; (LWP) longitud de las pterotecas posteriores; (LFA) longitud de los fémures anteriores; (LTA) longitud tibias anteriores; (LFM) longitud de los fémures medios; (LTM) longitud tibias medias; (LFP) longitud fémures posteriores; (LTP) longitud tibias posteriores; (D8º) distancia entre las espinas laterales del 8º segmento; (D9º) distancia entre las espinas laterales del 9º segmento; (LEP) longitud del epiprocto; (AEP) anchura del epiprocto; (LP) longitud de los paraproctos; (LC) longitud de los cercos. Variables medidas en mm, (n=37). 1* *B.impartita*, datos del presente estudio; 2* *B.leucosticta* (Corbet,1957); 3* *B.lacustris* (Corbet, 1957). 1** *B.impartita* (Galletti & Pavesi & Romano, 1987).

	B. leucosticta		*B. lacustris*		*B. impartita*	
	nº SP	nº SM	nº SP	nº SPM	nº SP	nº SM
Corbet, 1957	**4 & 4**	5+6; 5+7; 6+6; 6+7; **7+7;** 7+8; 8+8; 8+9	3 & 3	**7+7**; 7+8; 8+8; 8+9; 9+9.		
Conesa & García, 1985					5 & 5	8+8
Galletti & Pavesi & Romano, 1987					3 & 3; **4 & 4**; 5 &4; 5 & 5	5+6; 5+7; 6+6; **7+7**; 7+8; 8+8
Presente estudio					**4 & 4**; 5 & 4; 5 & 5	6+5; 6+6; 7+5; 7+6; **7+7**; 7+8.

TABLE II. Comparison of the number of setae of the palp (nº SP) and the number of setae of the mentum (nº SM) in the three species of the genus Brachytemis. (Highlighted in red and in a greater size font the major ratio founded).

TABLA II. Comparación del número de sedas del palpo (nº SP) y número de sedas del mentum (nº SM) en las tres especies del género Brachythemis. (Destacada en un tipo mayor y en rojo la mayor frecuencia encontrada).

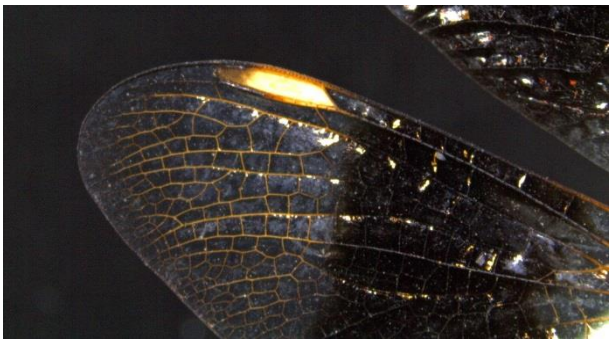

Figure 1. Hind wing coloration of male
Figura 1. Coloración alas posteriores del macho.

Figure 2. Male cerci.
Figura 2. Cercos del macho

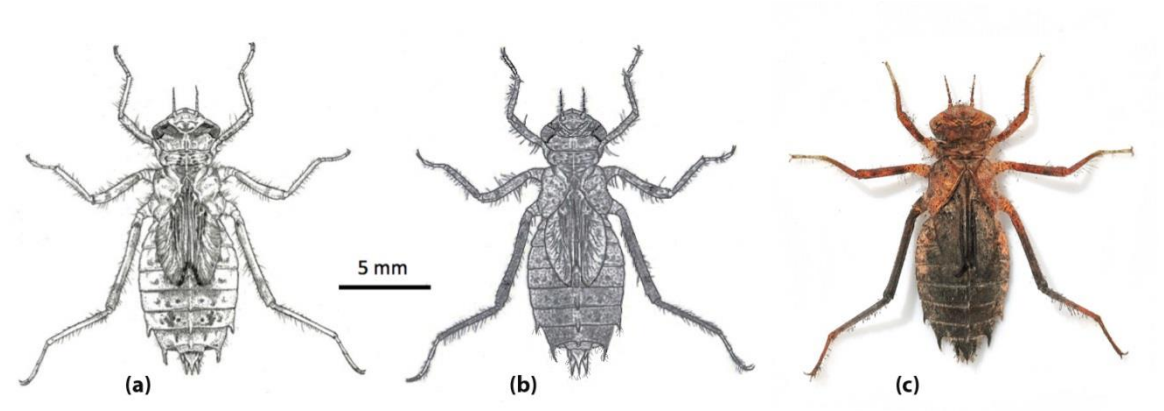

Figure 3. Larval morphology: (a) Exemplary recently moved to F0, (b) Exemplary F0 collected in decaying organic matter, (c) Specimen F0 oxidized sediments covered.
Figura 3. Morfología larvaria: (a) Ejemplar mudado recientemente a F0; (b) Ejemplar F0 recogido en materia orgánica en descomposición; (c) Ejemplar F0 cubierto de sedimentos oxidados.

Figure 4. Head showing marginal lines black eye color.
Figura 4. Cabeza mostrando las líneas marginales oculares de color negro.

Figure 5. Jaw.
Figura 5. Mandíbula.

Figure 6. Mask.
Figura 6. Máscara.

Figure 7. Palp.
Figura 7. Palpos.

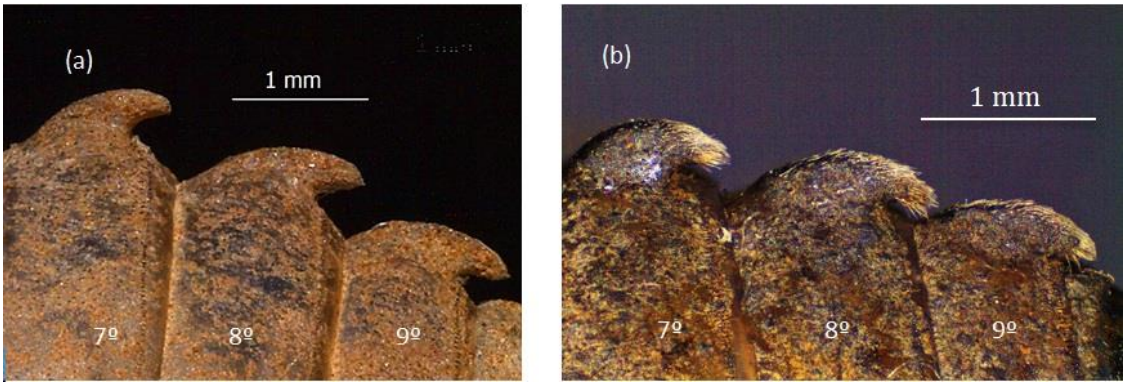

Figure 8. Spines on the exuvia (a), and the larva F0 (b) showing the apical hairy spines.
Figura 8. Espinas dorsales en la exuvia (a); y en la larva F0 (b) mostrando la pilosidad apical de las espinas dorsales.

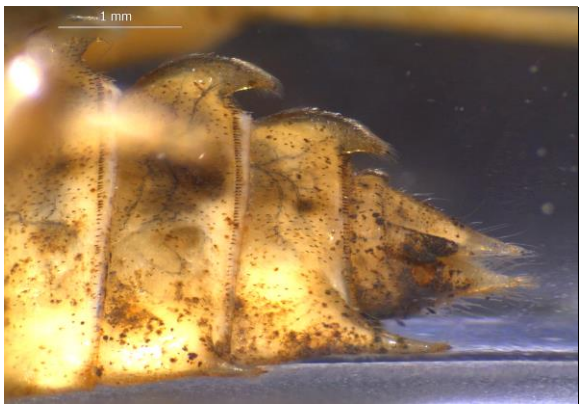

Figure 9. Abdomen, lateral view.
Figura 9. Abdomen en vista lateral.

Figure 10.Caudal pyramid.
Figura 10. Pirámide caudal.

The prementum setae are correctly observed in F0 larvae due to the fact that central setae are barely distinguish in exuviae. In our study, a sample of 37 individuals showed the following combinations for prementum setae: 81.08% (7+7); 2.7% (6+5, 7+5 and 7+8); 5.4% (6+6 and 7+6). As in the palp setae, the structure is not homogeneous in the populations for which there are references, although the upper edge of the prementum features a central prominence, which is absent in African species (Fig.6).
In *B.impartita* the distal edge of the palp comprises 8 crenulations separated by a set of 2 to 6 teeth which can be worn away or disappear altogether, depending on use (Fig.7). Mask measurements in Table I.

Thorax and abdomen: The pterothecae are observed to reach the 7th abdominal segment in F0. The abdomen is typically libelluloid, triangular in cross-section, reaching its maximum width at the distal margin of the pleurite of the 5th segment and progressively reducing in size until the caudal pyramid. Not one eruciform specimen like the one described by CORBET (1957) has ever been found. Neither have any specimens been found in sandy bottoms, nor intermediate forms. Abdominal width/ length ratio = 1.87. Abdominal measurements in Table I.
The measurements of the femora and tibias of the prothoracic, mesothoracic and metathoracic legs are given in Table I. In the early larval stages, the femur-tibia joint extends beyond the 8th abdominal segment, while in F0 it reaches no further than the 7th sternite. The tarsi are whitish. The claws are long and curved.
The dorsal spines from 4th to 9th segment have a rounded tip with a large number of setae (Fig.8). In the emergence this hairiness is clustered in exuviae, which gives the spine a spiky general appearance. The dorsal spine of the 9th segment exceed the distal edge of the tenth abdominal pleurite; in some exuviae specimens it was found that this spine does not exceed the distal edge, this is possibly due to the contractions of intersegmental membrane during emergence (Fig. 8). The abdominal side view drawings provided for *B. leucosticta* in AGUESSE (1968), GALLETTI & PAVESI & ROMANO, 1987 (1987), ASKEW (2004) and probably HEIDEMAN & SEIDEMBUSCH (2002) corresponding to *B. impartita*, describe a dorsal spine on the 9th segment which does not exceed the 10th abdominal segment.
The distance between the two lateral spines of the 8th segment is shorter than the width of the 5th abdominal segment, which is the widest of the abdomen, Table I. The ends of the lateral spines, like the dorsal ones, feature abundant hairiness (Fig. 8)
Concerning the African fauna, it was observed that in *B. leucosticta*, the lateral spine of the 9th segment does not extend beyond the 10th segment, unlike in *B. lacustris*; in this species, the length of the lateral spines on the 9th segment clearly extends beyond the tip of the epiproct (CORBET, 1957), which is not the case in the other two genus species (Fig. 9).

Caudal pyramid: Measurements of the XYZ angle between the tip of the epiproct and the two lateral spines of the 9th abdominal segment found a mean value of 19º for the 37 specimens studied; in *B. leucosticta*, the XYZ angle usually ranges between 25º and 34º (CORBET, 1957).
Length / width ratio of the epiproct: 1.09. In live individuals, both the epiproct and the paraprocts are a white, ivory-like colour on the inner side. This colouring, which is present in all larval stages, may be hidden by organic matter residues and calcareous deposits on the dorsal side (Fig. 10).

We hope that our contribution, based on specimens observed in Andalucia (Spain), will help to separate morphologically the Central African larvae from the genus *Brachythemis* and lead to the suitable incorporation of *B. impartita* in European taxonomic identification manuals.

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