SYSTEMATICS AND PHYLOGENY

Revision of the *Aphthona cookei* species group in Sub-Saharan Africa: pests of *Jatropha curcas* L. in biodiesel plantations (Coleoptera, Chrysomelidae, Galerucinae, Alticini)

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Abstract

The *Aphthona cookei* species-group from Sub-Saharan Africa, comprising some pests of *Jatropha curcas* L., is herein analyzed and revised. This species-group includes: *Aphthona cookei* (Gerstaecker, 1871), *A. dilutipes* Jacoby, 1906, *A. nigripes* (Allard, 1890), *A. thikana* Bryant, 1940, *A. usambarica* Weise, 1902, *A. weisei* (Jacoby, 1899b), *A. whitfieldi* Bryant, 1933 and the new species *A. namibiana* sp. n. from Namibia. The following new synonymies are proposed: *Aphthona cookei* (Gerstaecker, 1871) = *Aphthona weisei* abokana Bechyné, 1959 syn. n.; *Aphthona dilutipes* Jacoby, 1906 = *Aphthona damarorum* Weise, 1914 syn. n.; *Aphthona nigripes* (Allard, 1890) = *Pseudeugonotes van-nutellii* Jacoby, 1899a syn. n. A key to the species, micrographs of male and female genitalia, scanning electron micrographs of peculiar morphological characters, and distributional and ecological data are supplied. Finally, the results of a discriminant analysis using six morphological characters are also reported.

Introduction

*Jatropha curcas* L., commonly known as *Physic Nut* or *Purging Nut*, is a bush or small tree (up to 5 m height) belonging to the Euphorbiaceae family and native to Central America. From Central America, this plant was probably spread by Portuguese seafarers via the Cape Verde Islands and former Portuguese Guinea (now Guinea Bissau) to other countries in Africa and Asia (Achten et al., 2008). *J. curcas* is planted as a protection hedge around fields (living fence) by farmers all over the tropical world, because it is not browsed by animals. Seeds are also used to make soap and as a medicinal plant. However, in recent years, plantations of *J. curcas* have been promoted worldwide to produce biodiesel from oil extracted from pressed seeds (Jongh & van der Putten, 2010). *Jatropha curcas* represents new opportunities as cash crop for farmers and rural entrepreneurs and as sustainable energy source for communities. In addition, *J. curcas* seed cake, a by-product of the biodiesel trans-esterification process can be used as a rich organic fertilizer (Srinophakun et al., 2012).

In Africa, the most important *J. curcas* plantations are located in Egypt, Ethiopia, Sudan, Ghana, Mali, Tanzania, Mozambique and Republic of South Africa (Robinson & Beckerlegge, 2008). However, its cultivation is often hampered by pests, one of the most important in Sub-Saharan Africa being *Aphthona* flea beetle species (Coleoptera Chrysomelidae) belonging to the alticine genus *Aphthona* Chevrolat, 1836 (Gagnoux, 2009; Nielsen, 2009; Anitha & Varaprasad, 2012). *Aphthona* is a widespread flea beetle genus found in Australian, Nearctic, Oriental and Palaearctic regions (Biondi & D’Alessandro, 2012). In Sub-Saharan Africa and Madagascar, it consists of about 100 known species but may likely include many other undescribed taxa (Biondi & D’Alessandro, 2012; Biondi, personal communication). Members of *Aphthona* are found in different environments and associated mainly with plants of Euphorbiaceae but also of Geraniaceae, Cistaceae, Rosaceae, Linaceae, Iridaceae, Malvaceae and Lythraceae (Jolivet & Hawkeswood, 1995; Biondi & D’Alessandro, 2012).

In this paper, we propose a taxonomical revision of the eight species of *Aphthona* attributed to the *cookei* group, *Aphthona cookei* (Gerstaecker, 1871), *A. dilutipes* Jacoby, 1906, *A. nigripes* (Allard, 1890), *A. thikana* Bryant, 1940, *A. usambarica* Weise, 1902, *A. weisei
At least three species, *A. cookei*, *A. dilutipes* and *A. whitfieldi*, are recognized pests for *Jatropha curcas* in the Afrotropical region.

These species, known also as golden flea beetles, are closely related to some Palaeartic species such as *A. cyparissiae* (Koch), *A. flavus* Guillebeau, *A. nigricutis* Foudras and, especially, *A. illigeri* Bedel. However, the Afrotropical species are easily distinguishable mainly for having: hind femora always at least partially strongly blackened; antennae, especially in male, longer and more robust; claw segment of all tarsi shorter and more thickset; pronotal punctuation nearly absent; external margin of hind tibiae generally more deeply and regularly dentate. The species attributed to the *cookei* group are often wrongly or roughly identified (Gagnaux, 2009); correct identifications are instead important not only for taxonomic and biogeographic purposes, but also for developing and implementing control measures against these insects.

All eight the species considered share the following characters: pronotal punctuation nearly absent; elytral punctuation confuse, very weakly impressed; frontal tubercles well delimited (Figure 1A-C); antennae comparatively short, just reaching half of the elytra [length of antennae / (length of elytra + length of pronotum): ♂♂ ≤ 0.70; ♀♀ ≤ 0.64]; first tarsomere of protarsi and mesotarsi not or very weakly enlarged in male; median lobe of aedeagus without any evident ventral sulcus (Figure 2); spermatheca with moderately elongate and uncoiled ductus and well developed distal part (Figure 3). In addition, the species of this group share also: medium or large size (usually 2.50-4.00 mm); dorsal integuments yellowish, pale brown or reddish, never black or metallic; posterior femora at least distally distinctly blackened (Figure 4).

### Materials and Methods

Material consisted of dried pinned specimens preserved in the institutions listed below. Specimens were examined and dissected using WILD MZ12.5 and LEICA M205C binocular microscopes. Photomicrographs were taken using a Leica DFC500 camera and the Auto-Montage Pro 2006 software (license number: 15224*syn2459*153a2112maurizio266836). Scanning electron micrographs were taken using a HITACHI TM-1000. Morphometric measures were taken using the image analysis software Image-Pro Insight 8.0 (license number: 03080000-58385). Statistical analyses and graphs were performed using the package NCSS version 8.0.5 for Windows (license number: Z8B8-P3M3-H8Q5-Q4G9-H6V9). Discriminant function analysis (Tabachnick & Fidell, 1989) was used to establish appropriate functions separating the species using morphometric characters as predictors. Geographical coordinates of the localities are reported in degrees and minutes (DMD-WGS84 format); those included in square brackets were added by the authors.

### Abbreviations

- LAED, length of median lobe of aedeagus; LAN, length of antennae; LB, total body length; LE, length of elytra; LP, length of pronotum; LSP, length of spermatheca; WE, width of elytra; WP, width of pronotum.

### Collections and depositories

- BAQ: collection of M. Biondi, Department of Health, Life and Environmental Sciences, University of L’Aquila, Italy; BMNH: The...
Figure 2. Median lobe of aedeagus in lateral, ventral and dorsal view. A) *Aphthona cookei* (Gerstaecker); B) *A. dilutipes* Jacoby; C) *A. namibiana* sp. n.; D) *A. nigripes* (Allard) (Tanzania); E) *A. nigripes* (Allard) (Guinea); F) *A. thikana* Bryant; G) *A. weisei* (Jacoby); H) *A. whitfieldi* Bryant.
Results

Key to species

This key identifies the 8 known Aphthona species attributed to the cookei-group. Only males can be surely identified through examination of the median lobe of the aedeagus. However, this key can be useful also for females since some species show reliable diagnostic characters (e.g. shape of spermatheca, and body size and color).

1. Frontal tubercles (Figure 1C) large and wide, sub-triangular. Spermatheca (Figure 3D) larger (LSP=30 mm in the single type specimen), with clearly more thickset ductus. Male unknown ..........

..........................................................

A. usambarica Weise (Figure 4G)

- Frontal tubercles (Figure 1A,B) small, sub-elliptical or roundish. Spermatheca smaller (18.5 ≤LSP ≤28.0 mm), with thinner ductus (Figure 3A-C, E-H) .................................2

2. Scutellum yellowish .................................................................3

- Scutellum clearly blackened ........................................................7

3. Frontal carina (Figure 1B) apically rounded; interantennal space about as wide as first antennomere length. Pronotum sub-trapezoidal, comparatively smaller (LE/LP: ♂♂ ≥3.10; ♀♀ ≥3.20), with maximum width at base. Median lobe of aedeagus (Figure 2D,E) very elongate (LAED >1.30 mm; LE/LAED <1.95). Spermatheca (Figure 3E) larger (LSP >0.24 mm) ..........................................................A. nigripes (Allard) (Figure 4D,E)

- Frontal carina (Figure 1A) apically sub-acute; interantennal space clearly narrower than first antennomere length. Pronotum sub-rectangular, comparatively larger (LE/LP: ♂♂ <3.10; ♀♀ <3.20), with maximum width in middle. Median lobe of aedeagus (Figure 2A,B,G,H) less elongate (LAED ≤1.30 mm; LE/LAED ≥1.95). Spermatheca (Figure 3A-C,F) smaller (LSP ≤0.24 mm) ................4

4. All femora, metathorax and abdomen generally strongly blackened, often also tibiae and tarsi. Median lobe of aedeagus (Figure 2B) thickset, in ventral view distinctly enlarged in middle part. Spermatheca (Figure 3A) with shorter distal part ..........................................................

..........................................................A. dilutipes Jacoby (Figure 4B)

- Anterior and middle femora, tibiae, metathorax and abdomen always yellowish or reddish never blackish. Median lobe of aedeagus (Figure 2A,G,H) slender, in ventral view sub-parallel in middle part. Spermatheca (Figure 3B,C,F) with longer distal part ........................................5

5. Median lobe of aedeagus (Figure 2A,G) longer (generally LAED >1.00 mm), in lateral view straight. Spermatheca (Figure 3B,C) gen-

![Figure 3. Spermatheca. A) Aphthona dilutipes Jacoby; B) A. cookei (Gerstaecker); C) A. weisei (Jacoby); D) A. usambarica Weise (type); E) A. nigripes (Allard); F) A. whitfieldi Bryant; G) A. namibiana sp. n.; H) A. thikana Bryant.](image-url)
Spermatheca (Figure 3F) generally with basal part more slender and weakly separated from distal part. 

- Median lobe of aedeagus (Figure 2H) shorter (generally LAED ≤1.00 mm), in lateral view clearly bent in ventral direction at apical fourth.

6. Pronotum (Figure 1D) generally with well visible sub-lateral longitudinal sulcus. Antennomere 2-3 longer; antennomere 4 just little

Figure 4. Habitus. A) *Aphthona cookei* (Gerstaecker); B) *A. dilutipes* Jacoby; C) *A. namibiana* sp. n.; D-E) *A. nigripes* (Allard); F) *A. thikana* Bryant; G) *A. usambarica* Weise; H) *A. weisei* (Jacoby); I) *A. whitfieldi* Bryant.
longer than antennomere 3. Median lobe of aedeagus (Figure 2A) in ventral view slender, sub-parallel in whole length; in lateral view, distally not sinuous. Spermatheca in Figure 3B. 

- Pronotum generally with just visible or incomplete sub-lateral longitudinal sulcus. Antennomere 2-3 shorter; antennomere 4 clearly longer than antennomere 3. Median lobe of aedeagus (Figure 2G), in ventral view more thickset, enlarged in distal third; in lateral view, distally slightly sinuous. Spermatheca in Figure 3C. 

- First tarsomere of metatarsi not distinctly enlarged in male. Median lobe of aedeagus (Figure 2C) in ventral view thickset, laterally sub-parallel, apically acute; in lateral view distally weakly bent ventrad. Spermatheca (Figure 3G) more thickset, with pear-shaped elongate basal part, distinctly separated from distal part. 

- First tarsomere of metatarsi not distinctly enlarged in male. Median lobe of aedeagus (Figure 2F) in ventral view slender, laterally narrowed in middle part, apically more rounded; in lateral view strongly curved in distal third ventrad. Spermatheca (Figure 3H) slender, with sub-remiform basolateral part, not well separated from distal part.

- Other records from literature

**List of species**

*Aphthona cookei* (Gerstaecker) 1871: 85; 1873: 287-288. 

* = *Aphthona weisi* (Jacoby) 1910; 1914: 269 syn. n. 

**Material examined**

KENYA: Zanzibar [6°10'03"S 39°20'26"E], C. Cooke leg., type 7412 (IRSN). 

- First tarsomere of metatarsi not distinctly enlarged in male. Median lobe of aedeagus (Figure 2F) in ventral view slender, laterally narrowed in middle part, apically more rounded; in lateral view strongly curved in distal third ventrad. Spermatheca (Figure 3H) slender, with sub-remiform basolateral part, not well separated from distal part. 

- Other records from literature

**Distribution**

Oman, Yemen, Somalia, Uganda, Democratic Republic of Congo, Kenya and Tanzania (Figure 5A). Northern-Eastern Afrotropical chorotype (NEA) with extensions in Arabian Peninsula (Biondi & D'Alessandro, 2006).

**Ecological notes**

This species was collected in Kenya (Kilifi Mavueni) in *Jatropha curcas* plantations.


**Material examined**


**Other records from literature**

YEMEN: Usaifira [13°34'52"N 44°00'53"E], M. Rejcek leg., 5 specimens leg. (MDAG). 

**Morphological remarks**

<table>
<thead>
<tr>
<th>n=10; mean and standard deviation:</th>
<th>LE=2.16±0.08 mm (2.03±LE ≤ 2.28 mm); WE=1.56±0.08 mm (1.44±WE ≤ 1.69 mm); LP=0.77±0.04 mm (0.72±LP ≤ 0.84 mm); WP=1.06±0.05 mm (0.97±WP ≤ 1.13 mm);</th>
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Figure 5. A) Map of distribution of *Aphthona cookei* (Gerstaecker), *A. namibiana* sp. n., *A. usambarica* Weise and *A. whitfieldi* Bryant; B) Map of distribution of *Aphthona dilutipes* Jacoby, *A. nigripes* (Allard), *A. thikana* Bryant and *A. weisei* (Jacoby).
A. thikana, from which it can be easily distinguishable by: first tarsomere of metatarsi distinctly enlarged in male; median lobe of aedeagus (Figure 2C) in ventral view more thickset, laterally sub-parallel, apically acute, and in lateral view distally just weakly bent ventrad; spermatheca (Figure 3G) more thickset, with pear-shaped elongate basal part, distinctly separated from distal part.

Description

Holotype ♀. Dorsal integuments pale brown without metallic reflection (Figure 4C); elytra slightly paler than head and pronotum; scutellum distinctly blackish. Body shape oval elongate (LB=3.44 mm), moderately convex. Maximum pronotal width at base (WP=1.25 mm); maximum elytral width at middle (WE=1.81 mm).

Frons and vertex with sub-smooth surface, laterally with a setiferous puncture near ocular margin; frontal tubercles small, elliptical elongate, well delimited; frontal grooves clearly impressed; interantennal space about as wide as first antennomere length; frontal carina wide, apically rounded; labrum sub-rectangular, distally rounded, blackish; palpi strongly darkened; eyes sub-elliptical, normally sized; antennae clearly shorter than body length [LAN=1.88 mm; LAN/(LE+LP)=0.55] with yellowish antennomeres 1-4 and gradually darkened antennomeres 7-11; length of each antennomere proportional to numerical sequence 20:11:14:12:17:14:16:15:18 (left antenna; 1=0.01 mm).

Pronotum sub-trapezoidal, anteriorly narrower, moderately transverse (LP=0.78 mm; WP/LP=1.60), laterally straight, basally narrower than elytra; lateral and basal margin finely bordered; punctuation very superficially impressed, apparently absent. Scutellum hemispheric with smooth surface.

Elytra elongate (LE=2.63 mm; WE=1.81 mm; LE/ WP=1.36; WE/WP=1.45), entirely covering pygidium, laterally weakly rounded, apically almost jointly rounded; punctuation entirely diffuse, very finely impressed on smooth surface; humeral calli evident; macropterous metathoracic wings.

Legs mostly pale brown with clearly darkened hind femora; hind tibiae slightly curved, distally gradually enlarged; apical spur small, dark brown. First tarsomere of protarsi, mesotarsi and metatarsi slightly but distinctly enlarged.

Ventral parts light-brown but with blackened metathorax; last abdominal sternite without special preapical impressions.

Median lobe of aedeagus (Figure 2C) elongate (LAED=1.17 mm; LE/LAED=2.24), in ventral view laterally sub-parallel, apically acute but finely rounded; ventral sulcus absent; dorsal ligula short, wide, apically rounded; in lateral view, aedeagus slightly curved ventrad.

Paratype ♀ (n=1): LE=2.88 mm; WE=2.00 mm; LP=0.81 mm; WP=1.30 mm; LAN=1.78 mm; LSP=0.24 mm; LB=3.58 mm; WP/LP=1.60; WE/ WP=1.54; WE/LE=0.70; LE/LSP=12.11.

Paratype similar in color and sculpture to the holotype. Female distinguishable by not enlarged first tarsomere of protarsi, mesotarsi and metatarsi; spermatheca (Figure 3G) with pear-shaped elongate basal part; distal part distinctly enlarged and elongate, distinctly separated from basal part; ductus thin, very thin, moderately elongate and uncoiled.

Etymology

The name of this new species refers to the country where it was found, i.e. Namibia.

Distribution

It can be found in Namibia (Figure 5A).

Ecological notes

No information is available about the autoecology of this flea beetle species.
Aphthona nigripes (Allard, 1890)

= Aphthona kindia Bechyné, 1955: 516 (synonymized by Scherer, 1963: 656); Scherer, 1959: 188 (as A. kindia)

Material examined

IVORY COAST: Assinie [5°08’32’’N 3°19’25’’W], C. Alluaud leg., type of Thyamis nigripes Allard (MNHN). GAMBA: Barthurst [=Banjul] [13°26’48”N 16°34’36”W], i,1688, T. Palm leg., 2 specimens (MSNG).

GUINEA: Kindia Region, Mt. Gangan [10°03’23”N 12°53’10”W], i-xii.1899, L. Fea leg., 1 specimen (MSNG).

GUINEA-BISSAU: Bolama, vi-x.1968, T. Palm leg., 2 specimens (MZLU).


Material examined

Aphthona nigripes(Allard, 1890) 1 specimen (MRAC); Thysville [=Mbanza-Ngungu] [5°15’07”S 19°04’22”E], 18.x.1946, Rév. P. Hulstaert leg., 31 specimens (IRSN); Libenge [3°38’60”N 18°37’60”E], 26.ii.1948, R. Cremer & M. Neuman leg., 16 specimens (IRSN); ditto, 28.ii.1948, 11 specimens (IRSN); Libenge, Savane Liki-Bavula [4°29’09”N 21°34’51”E], 16.vi.1912, Dr. Mouchet leg., 3 specimens (MRAC); Parc National de la Garamba, Mission H. De Saeger, II/gd/4, 8.v.1952, loc. 3449 [4°21’58”N 29°15’11”E], H. De Saeger leg., 2 specimens (MRAC); Parc National de la Garamba, Mission H. De Saeger, II/gd/4, 15.ii.1952, loc. 3129 [4°22’02”N 29°15’11”E], H. De Saeger leg., 1 specimen (MRAC).

Other records from literature

SENEGAL [13°59’18”N 14°35’42”E] (locus typicus of A. senegalensis Jacoby, 1903: 10-11). SUDAN: Blue Nile, Inseganga Hills [11°24’36”N 33°59’00”E] (Scherer, 1972 as A. senegalensis). NIGERIA: Pankshin [19°09’40”N 9°25’52”E] (Scherer, 1972 as A. senegalensis). DEMOCRAT-IC REPUBLIC OF THE CONGO: Haute-Sangha [-1°35°50”N 15°27°21”E] (Bechyné, 1968); Kisangani [0°31’09”N 25°11’46”E] (Scherer, 1972 as A. senegalensis). ZAMBIA: Welgelegen [11°40’27”S 29°04’46”E], 16.vi.1912, Dr. Mouchet leg., 3 specimens (MRAC); Kwango, Popokabaka [4°14’33”S 16°35’05”E], xii.1951, L. Pierquin leg., 2 specimens (MRAC); ditto, ii.1952, 1 specimen (MRAC); Moyen Kwilu, Leverville (=Lusanga) [4°49’60”S 18°43’60”E], 1920, P. Vanderijst leg., 2 specimens (MRAC); Ubangi, La Molenge [1°12’30”N 20°35’50”E], i,1930, H. J. Brédé leg., 1 specimen (MRAC); Bas-Uele, Djamba [2°52’N 24°06”E], 25.xi.1924, Dr. H. Schouteden leg., 1 specimen (MRAC); Itoko [0°00’53”S 23°33’01”E], xii.1912, R. Mayné leg., 1 specimen (MRAC); Ubangi: Gemena [3°15’10”N 19°46’38”E], 16.ix.1937, C. Léontovich leg., 1 specimen (MRAC); Bolobo, Makamandelu (N’Kele) [2°10’00”S 16°13’60”E], 1938, Dr. H. Schouteden leg., 1 specimen (MRAC); Wombali [2°19’26”N 17°22’18”E], 17.vii.1913, P. Vanderijst leg., 2 specimens (MRAC); Congo da Lembà [5°42’00”S 13°41’60”E], i-ii.1913, R. Mayné leg., 2 specimens (MRAC). TANZANIA: Ruaha National Park [8°51’23”S 34°03’48”E], 800-1000 m, 2.xii.1989, R. Mourglia leg., 1♀ (BAQ).

Distribution

Senegal, Gambia, Guinea-Bissau, Guinea, Sierra Leone, Ivory Coast, Nigeria, Chad, Sudan, South Sudan, Ethiopia, Gabon, Democratic Republic of the Congo, Southern Tanzania, Zambia and Namibia (Figure 5B). Afric-Antertropical chorotype (AIT) (Biondi & D’Alessandro, 2006).
Ecological notes

No information is available about the host-plants of this flea beetle species.

Aphthona thikana Bryant

_Aphthona thikana_ Bryant, 1940: 44; Bryant, 1957: 359; Bryant, 1959: 214

Material examined

KENYA: Thika District, Chania Falls [1°01'24"S 37°04'06"E], i.i.1921, 5050 ft, A.F. Gedye leg., type (BMNH). ETHIOPIA: Begemdir Province, Gondar, banks of Angereb river [12°35'60"N 37°28'00"E], 2.xii.1974, G. Jamesonia weisei (Jacoby)

Distribution

Yemen, Ethiopia, Somalia, Kenya, Uganda and Republic of South Africa (?) (Figure 5B), Northern-Eastern Afrotropical chorotype (NEA) (Biondi & D’Alessandro, 2006).

Aphthona usambarica Weise

_Aphthona usambarica_ Weise, 1902: 173

Material examined

TANZANIA: Usambara Mountains, Kwai [4°43'50"S 38°20'50"E], Paul Weise leg., type (MNHUB).

Morphological remarks

♀ (n=1): LE=2.59 mm; WE=1.72 mm; LP=0.78 mm; WP=1.25 mm; LAN=2.03 mm; LSP=0.30 mm; LE/LP=3.32; WP/LP=1.60; WE/LP=1.38; WE/LE=0.60; LAN/(LE + LP)=0.60; LE/LSP=8.65.

Only one known female (Figure 4G) with pale brown dorsal integuments, finely darkened elytral suture and scutellum; ventral parts blackened; legs yellowish with hind femora blackish. Spermatheca (Figure 3D) large with sub-cylindrical basal part; distal part moderately elongate; ductus very thickest, moderately elongate and uncoiled.

Distribution

Tanzania (Figure 5A). Northern-Eastern Afrotropical chorotype (NEA) (?) (Biondi & D’Alessandro, 2006).

Ecological notes

No information is available about the autoecology of this flea beetle species.

Aphthona weisei (Jacoby)

_Jamesonia weisei_ Jacoby, 1899b: 348-349


_Aphthona weisei_ (Jacoby): Bechyné, 1959: 15

Material examined

DEMOCRATIC REPUBLIC OF THE CONGO: Boma [5°52'32"S 13°02'00"E], M. Tschoffen leg., lectotype of _Jamesonia weisei_ Jacoby (Bechyné 1959 des.) (IRSN); Congo da Lema [5°42'00"S 13°14'60"E], i-i.iii.1913, R. Mayné leg., 38 specimens (MRAC); Léopoldville [=Kinshasa] [4°19'54"S 15°18'50"E], 13.x.1933, J. Ghesquière leg., 1 specimen (MRAC); Mayumbe Lemba [4°57'00"S 14°17'60"E], 13.x.1917, R. Mayné leg., 11 specimens (MRAC); Kisanu [5°08'13"S 15°06'15"E], 1932, P. Vanderijst leg., 1 specimen (MRAC).

Morphological remarks

♀ (n=16; mean and standard deviation): LE=2.28±0.13 mm (2.06 ≤ LE ≤ 2.41 mm); WE=1.68±0.13 mm (1.47 ≤ WE ≤ 1.89 mm); LP=0.85±0.04 mm (0.77 ≤ LP ≤ 0.99 mm); WP=1.11±0.07 mm (1.00 ≤ WP ≤ 1.20 mm); LAN=1.90±0.14 mm (1.69 ≤ LAN ≤ 2.13 mm); LE/LP=1.03±0.03 mm (1.00 ≤ LE/LP ≤ 1.06 mm); LB=3.08±0.16 mm (2.84 ≤ LB ≤ 3.36 mm); LE/LAED=2.74±0.05 (2.67 ≤ LE/LAED ≤ 2.85); WE/LP=1.34±0.03 (1.29 ≤ WE/LP ≤ 1.38); WE/LE=1.51±0.13 (1.38 ≤ WE/LE ≤ 1.66); WE/LE=1.61±0.03 (0.58 ≤ WE/LE ≤ 0.90); LAN/(LE + LP)=0.61±0.03 (0.58 ≤ LAN/(LE + LP) ≤ 0.66); LE/LAEDE=2.21±0.10 (2.06 ≤ LE/LAEDE ≤ 2.33). ♀ (n=10): LE=2.46±0.10 mm (2.22 ≤ LE ≤ 2.59 mm); WE=1.81±0.10 mm (1.63 ≤ WE ≤ 1.97 mm); LP=0.84±0.03 mm (0.78 ≤ LP ≤ 0.91 mm); WP=1.17±0.04 mm (1.08 ≤ WP ≤ 1.22 mm); LAN=1.85±0.07 mm (1.75 ≤ LAN ≤ 2.00 mm); SP=0.21±0.01 mm (0.20 ≤ SP ≤ 0.23 mm); LB=3.18±0.17 mm (2.80 ≤ LB ≤ 3.36 mm); LE/LP=2.93±0.11 (2.78 ≤ LE/LP ≤ 3.12); WP/LP=1.39±0.03 (1.34 ≤ WP/LP ≤ 1.44); WE/LP=1.55±0.05 (1.50 ≤ WE/LP ≤ 1.63); WE/LE=0.74±0.03 (0.68 ≤ WE/LE ≤ 0.80); LAN/(LE + LP)=0.56±0.03 (0.53 ≤ LAN/(LE + LP) ≤ 0.61); LE/LSP=11.78±0.36 (11.09 ≤ LE/LSP ≤ 12.34).

Dorsal integuments and ventral parts entirely pale brown (Figure 4H). Anterior and middle legs with yellowish femora, usually distally darkened tibiae and strongly blackened tarsi; hind legs black but with
basally reddish tibiae. Male with slightly but distinctly enlarged first tarsomere of protarsi and mesotarsi. Median lobe of aedeagus (Figure 2G) little elongate, thickset, in ventral view slightly tapered from basal third to apical fifth; distal part sub-triangular, apically sub-truncate; ventral sulcus absent; in lateral view, aedeagus almost straight, slightly sinuous in apical third. Spermatheca (Figure 3C) with sub-cylindrical basal part, sometimes slightly curved; distal part moderately elongate and clearly separated from basal part; ductus little elongate, thin and uncoiled.

**Distribution**

Democratic Republic of the Congo (Figure 5B). Afro-Equatorial chorotype (AEQ) (Biondi & D’Alessandro, 2006).

**Ecological notes**

No information is available about the host-plants of this flea beetle species.

**Aphthona whitfieldi** Bryant

*Aphthona whitfieldi* Bryant, 1933: 253; Bryant, 1957: 359; Pollard, 1957: 76-77; Scherer, 1963: 657


**Material examined**

SUDAN: Kadugu [10°57′42″N 29°41′27″E], 13.i.1931, on *Vicia sinensia*, P.G. Whitfield leg., type (BMNH). MALI: Garalo [10°59′24″N 7°26′13″W], 7.x.2011, on *Jatropha curcas*, M. Kenis leg., 9 specimens (BAQ); Ouesselsebougou [12°00′00″N 7°55′00″W], N’Ptebourougou, 2.x.2011, on *Jatropha curcas*, M. Kenis leg., 6 specimens (BAQ); Ouesselsebougou [12°00′00″N 7°55′00″W], N’Tintoukoro, 2.x.2011, on *Jatropha curcas*, M. Kenis leg., 8 specimens (BAQ). BURKINA FASO: Léo, Ouedesous, 1 specimen (BAQ). GUINEA: Fouta Djalon [10°36′40″N 12°34′25″E], Dalaba, 1200 m (WE), length of pronotum (LP), width of pronotum (WP), length of elytrae (LE), width of elytrae (WE), length of elytrae/LE ≤ 0.78; WE/LE ≤ 1.17 mm); LAN/(LE + LP) ≤ 1.75 mm); LP=0.83±0.06 mm (0.73 ≤ LP ≤ 0.91 mm); WP=1.07±0.07 mm (0.95 ≤ WP ≤ 1.17 mm); LAN=1.85±0.13 mm (1.66 ≤ LAN ≤ 2.00 mm); LSP=0.22±0.01 mm (0.20 ≤ LSP ≤ 0.24 mm); LB=2.98±0.27 mm (2.60 ≤ LB ≤ 3.32 mm); WP/LE=2.69±0.06 (2.59 ≤ WP/LE ≤ 2.79); WP/WE=1.29±0.03 (1.24 ≤ WP/WE ≤ 1.35); WE/WE+LP=1.45±0.07 (1.39 ≤ WE/WE+LP ≤ 1.60); WE/LE=0.70±0.03 (0.67 ≤ WE/LE ≤ 0.75); LAN/(LE + LP) ≤ 0.61±0.02 (0.56 ≤ LAN/(LE + LP) ≤ 0.64); LE/LSP=10.17±0.41 (9.65 ≤ LE/LSP ≤ 11.03).

Species very variable in size and color. Dorsal integuments and ventral parts from yellowish to reddish brown (Figure 4I), never partially blackened. Anterior and middle legs yellowish with darkened tarsi; hind femora mostly distinctly blackened; hind tibiae and metatarsi generally distinctly obscured. Male with very weakly enlarged first tarsomeres of protarsi and mesotarsi. Median lobe of aedeagus (Figure 2H) thickset, in ventral view laterally sub-parallel and apically widely sub-rounded; ventral sulcus absent; in lateral view, aedeagus very weakly curved. Spermatheca (Figure 3F) with pear-shaped elongate basal part; distal part very elongate not distinctly separated from basal part; ductus thin, moderately elongate and uncoiled.

**Distribution**

Mali, Burkina Faso, Guinea, Ghana, Nigeria, Sudan, South Sudan and Democratic Republic of the Congo and Malawi (Figure 5A). Afrotropical chorotype (AITH) (Biondi & D’Alessandro, 2006).

**Ecological notes**

Pollard (1957) reported this species associated with Anacardiaceae (*Mangifera indica* and *Pistacia sp.*), Cucurbitaceae (*Cucumis melo*), Euphorbiaceae (*Ricinus communis*), Fabaceae (*Cassia occidentalis* and *Vigna sinensis*), and Solanaceae (*Nicotiana tabacum*), but these records must be considered with caution since the specimens of Pollard (1957) have not been verified. Recently (2011-2012), *A. whitfieldi* was collected abundantly in Mali and Burkina Faso in *Jatropha curcas* plantations (Marc Kenis, pers. comm.).

**Discriminant analysis**

A forward stepwise discriminant function analysis, considering separately males and females, was performed using six morphometric variables as predictors. The main aim of this analysis was to determine morphometric characters to aid in the identification of the species included by us in the *A. cookei* group [*A. cookei* (10 ♀♂ and 10 ♀♀), *A. dilutipes* (10 ♀♂ and 10 ♀♀), *A. nigripes* (10 ♀♂ and 10 ♀♀), *A. thikana* (6 ♀♂ and 5 ♀♀), *A. weisei* (10 ♀♂ and 10 ♀♀) and *A. whitfieldi* (10 ♀♂ and 10 ♀♀)]. *A. namibiana* sp. n. and *A. usambarica* were not considered in this analysis because of the low number of specimens available (1 ♀ and 1 ♀♀ respectively). Predictor variables used in the analysis were: length of elytrae (LE), width of elytrae (WE), length of pronotum (LP), width of pronotum (WP), length of
Figure 6. A) Box-whisker plots (mean and range) for the variables LE, WE, LP, WP, LAN and LAED in males of the *Aphthona cookei* species-group: *A. cookei* (Gerstaecker) (10 ♂♂), *A. dilutipes* Jacoby (10 ♂♂), *A. namibiana* sp. n. (1 ♂), *A. nigripes* (Allard) (10 ♂♂), *A. thikana* Bryant (6 ♂♂), *A. usambarica* Weise (no ♂♂), *A. weisei* (Jacoby) (10 ♂♂) and *A. whitfieldi* Bryant (10 ♂♂).
Figure 6. B) Box-whisker plots (mean and range) for the variables LE, WE, LP, WP, LAN and LSP in females of the Aphthona cookei species-group: *A. cookei* (Gerstaecker) (10 ♀♀), *A. dilutipes* Jacoby (10 ♀♀), *A. namibiana* sp. n. (1 ♀), *A. nigripes* (Allard) (10 ♀♀), *A. thikana* Bryant (5 ♀♀), *A. usambarica* Weise (1 ♀), *A. weisei* (Jacoby) (10 ♀♀) and *A. whitfieldi* Bryant (10 ♀♀).
antennae (LAN), length of median lobe of aedeagus (LAED) and length of spermatheca (LSP). No data standardization or normalization were performed for these measures. Box and wisker plots showing median, inter-quartile range and range of every variable considered are reported for both sexes in Figure 6 (in this case A. usambarica and A. namibiana sp. n. were also included).

The analysis carried out on the males shows that the variables LAED, LP and LE highly significantly discriminate between males of the different species (Table 1). Also WE show a good discriminating power, while WP and LAN are not significant (Table 1). The classification matrix relative to males (Table 2) shows a high percentage, between 70-100%, of corrected attributions for every species analyzed. In addition, squared Mahalanobis distances matrix (SMD) (Table 3) suggests that the following couples of species can be well discriminated: nigripes-dilutipes (SMD=204.568), nigripes-whitefieldi (SMD=202.112), nigripes-cookei (SMD=141.738), nigripes-weisei (SMD=137.268), nigripes-thikana (SMD=98.904), dilutipes-thikana (SMD=94.926), thikana-whitefieldi (SMD=78.612). In contrast, the couples cookei-weisei (SMD=1.323) and dilutipes-whitefieldi (SMD=1.985) are very weakly discriminated.

To see how the six morphometric variables considered discriminate the different six groups (species) analyzed and to compute the relative discriminant functions, a Canonical Analysis was performed. The first three functions (CVM1, CVM2 and CVM3), representing 99.9% of total explained variance, were considered. Their respective raw coefficients,

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**Table 1. Discriminant Stepwise Analysis for males and females: variables in the model, F to enter, degrees of freedom (df1, df2), P level and Wilk’s Lambda values.**

<table>
<thead>
<tr>
<th>Step</th>
<th>F to enter</th>
<th>df1</th>
<th>df2</th>
<th>P</th>
<th>Lambda</th>
</tr>
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<td>50</td>
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<tr>
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<td>LE</td>
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<td>18.07</td>
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<tr>
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<td>WE</td>
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<td></td>
<td>WP</td>
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<td>LAN</td>
<td>Out</td>
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<tr>
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<td>WP</td>
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**Table 2. Discriminant Stepwise Analysis: classification matrix for males and females. Rows: observed classifications; columns: predicted classifications.**

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<th>♂♂</th>
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<td></td>
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<td>nigripes</td>
<td>thikana</td>
<td>weisei</td>
<td>whitefieldi</td>
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<td>0</td>
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<td>0</td>
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<tr>
<td>weisei</td>
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<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
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<tr>
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<td>2</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

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<table>
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<tr>
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<th>♂♂</th>
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<td></td>
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<td>weisei</td>
<td>whitefieldi</td>
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<td>5</td>
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</tr>
<tr>
<td>weisei</td>
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<td>0</td>
<td>9</td>
<td>0</td>
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<tr>
<td>whitefieldi</td>
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<td>3</td>
<td>0</td>
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<td>7</td>
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</table>
eigenvalues and cumulative percentage of explained variance (%EV) are reported in Table 4; their group centroids are reported in Table 5. The first discriminant function accounts for 87.8% of EV and allows to easily discriminate males of \( A. nigripes \) and \( A. thikana \) from those of the other species considered, and the couple \( dilutipes-whitfieldi \) from the couple \( cookei-weisei \); the second function (11.7% of EV) is mainly useful to discriminate \( A. thikana \), while the third function (0.4% of EV) is not significant (Tables 4 and 5; Figure 7A). The discriminant analysis carried on females has also supplied significant results (Table 1). In this case, the variables with higher discriminating power are LSP, WE, LP and LE, while LAN and WP (Table 1) are not significant. In the classification matrix of females (Table 2), the percentage of corrected attributions is equal to 100% only for \( A. dilutipes \) and \( A. thikana \), while it is 90% for \( A. cookei \) and \( A. weisei \), 80% for \( A. nigripes \) and 70% for \( A. whitfieldi \). For females, squared Mahalanobis distances matrix (SMD) (Table 3) suggests that the following couples of species are well discriminated: \( dilutipes-nigripes \) (SMD=95.996), \( dilutipes-thikana \) (SMD=89.398), \( cookei-nigripes \) (SMD=87.296), \( cookei-thikana \) (SMD=76.182), \( nigripes-weisei \) (SMD=60.304) and \( thikana-weisei \) (SMD=58.061); in contrast, the couples \( dilutipes-whitfieldi \) (SMD=2.324), \( nigripes-thikana \) (SMD=3.381) and \( cookei-weisei \) (SMD=3.721) are very weakly discriminated.

Using a Canonical Analysis, three functions (CVF1, CVF2 and CVF3)

### Table 3. Discriminant Stepwise Analysis: squared Mahalanobis distances matrix for males and females.

<table>
<thead>
<tr>
<th></th>
<th>cookei</th>
<th>dilutipes</th>
<th>nigripes</th>
<th>thikana</th>
<th>weisei</th>
<th>whitfieldi</th>
</tr>
</thead>
<tbody>
<tr>
<td>cookei</td>
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<td>10.046</td>
<td>141.738</td>
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<td>1.323</td>
<td>6.648</td>
</tr>
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<td>9.537</td>
<td>1.985</td>
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<td>0.000</td>
<td>98.904</td>
<td>137.268</td>
<td>202.112</td>
</tr>
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<td>94.926</td>
<td>88.904</td>
<td>0.000</td>
<td>48.573</td>
<td>78.612</td>
</tr>
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<td>137.268</td>
<td>48.573</td>
<td>0.000</td>
<td>8.174</td>
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<tr>
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<td>89.398</td>
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<td>81.261</td>
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<td>0.000</td>
<td>58.061</td>
<td>76.182</td>
</tr>
<tr>
<td>weisei</td>
<td>3.721</td>
<td>11.066</td>
<td>60.304</td>
<td>58.061</td>
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<td>13.810</td>
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<td>whitfieldi</td>
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<td>2.324</td>
<td>81.261</td>
<td>76.182</td>
<td>13.810</td>
<td>0.000</td>
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</tbody>
</table>

### Table 4. Discriminant Stepwise Analysis: canonical variables: raw coefficients, constants, eigenvalues and cumulative percentages of explained variance (%EV) of the canonical variables considered for males and females.

<table>
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<tr>
<th></th>
<th>CVM1</th>
<th>CVM2</th>
<th>CVM3</th>
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<th>CVF1</th>
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<tbody>
<tr>
<td>LAED</td>
<td>-23.937</td>
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<td>1.463</td>
<td>LSP</td>
<td>68.640</td>
<td>89.282</td>
<td>-1.960</td>
</tr>
<tr>
<td>LE</td>
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<td>-20.625</td>
</tr>
<tr>
<td>WE</td>
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<td>LE</td>
<td>6.880</td>
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<tr>
<td>Constant</td>
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<td>Constant</td>
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<tr>
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<td>0.4</td>
<td>%EV</td>
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<td>1.5</td>
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### Table 5. Discriminant Stepwise Analysis: group centroids for males and females.

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<th>CVM2</th>
<th>CVM3</th>
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<td>whitfieldi</td>
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Figure 7. A) Discriminant Stepwise Analysis: scatterplots (CVM1 by CVM2; CVM1 by CVM3) of the Canonical Variates Analysis for males: *A. cookei* (Gerstaecker) (10 ♂♂), *A. dilutipes* Jacoby (10 ♂♂), *A. nigripes* (Allard) (10 ♂♂), *A. thikana* Bryant (6 ♂♂), *A. weisei* (Jacoby) (10 ♂♂) and *A. whitfieldi* Bryant (10 ♂♂). *A. namibiana* sp. n. and *A. usambarica* Weise were not considered in this analysis.
Figure 7. B) Discriminant Stepwise Analysis: scatterplots (CVF1 by CVF2; CVF1 by CVF3) of the Canonical Variates Analysis for females: *A. cookei* (Gerstaecker) (10 ♀♂), *A. dilutipes* Jacoby (10 ♀♂), *A. nigripes* (Allard) (10 ♀♂), *A. thikana* Bryant (5 ♀♂), *A. weisei* (Jacoby) (10 ♀♂) and *A. whitfieldi* Bryant (10 ♀♂). *A. namibiana* sp. n. and *A. usambarica* Weise were not considered in this analysis.
were extracted (Tables 4 and 5). The first function (87.7% of EV) is mainly useful to separate respectively the couples nigripes-thikana, cookei-weisei and dilutipes-whitfieldi; the second function (10.7% of EV) shows also an high discriminating power for the couple cookei-weisei from the other four compared species; finally the third function (1.5% of EV) is particularly useful to discriminate nigripes from thikana (Tables 4 and 5; Figure 7B).

Conclusions

The Aphthona cookei species-group, widespread in the most part of Sub-Saharan Africa and Southern Arabian Peninsula, comprehends eight species, Aphthona cookei (Gerstaecker, 1871), A. dilutipes Jacoby, 1906, A. namibiana sp. n., A. nigripes (Allard, 1890), A. thikana Bryant, 1940, A. usambarica Weise, 1902, A. weisei (Jacoby, 1899b) and A. whitfieldi Bryant, 1933. The highest species diversity (7) for this group is occurring in the Equatorial belt comprised between latitudes 10° North and 10° South. All eight species are very probably associated with Euphorbiaceae and three of them, A. cookei, A. dilutipes and A. whitfieldi, are recognized pests in biodiesel plantations of Jatropha curcas in the Afrotropical region, where they represent a real problem in the development of this activity in many African countries.

The flea beetle species of the cookei-group are very similar in morphology and in color. Anyway, the shape of the median lobe of aedeagus always allows a sure identification at specific level. In addition, the discriminant analysis performed by us have also supplied an useful tool for the identification of some species on the basis of morphometric variables: LAED for males, LSP for females, while other variables, such as LP, LE and WE, are significant for both sexes.

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References


