



A revision of the subgenus *Parasphingonotus* Benediktov & Husemann, 2009 (Orthoptera: Oedipodinae: Sphingonotini)

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Abstract

The recently erected subgenus *Parasphingonotus* is revised. The diagnostic characters are given and the species *Sphingonotus* (*Parasphingonotus*) *radioserratus* **comb. n.**, *Sphingonotus* (*Parasphingonotus*) *femoralis* **comb. n.** and *Sphingonotus* (*Parasphingonotus*) *turkanae* **comb. n.** are assigned to the subgenus. *Sphingonotus* (*Parasphingonotus*) *airensis* is synonymized with *S. (P.) femoralis*, making the latter species the new type species of *Parasphingonotus*. Keys to the subgenera (*Sphingonotus*, *Neosphingonotus*, and *Parasphingonotus*) of the genus *Sphingonotus* and to the species of *Parasphingonotus* are presented. All *Parasphingonotus* species are re-described and further information on the distribution of the species are given.

Key words: *Sphingonotus*, Sphingonotini, Africa, stridulatory organs, intercalary vein, radial vein

Introduction

The genus *Sphingonotus* Fieber, 1852 is a highly diverse and widely distributed group of band-winged grasshoppers, currently including ca. 140 species (Eades *et al.* 2011). The species differ in many characters (e.g. pronotum shape, wing venation, wing shape and coloration), but the most intriguing trait is the diversity of their stridulatory mechanisms (Hochkirch & Husemann 2008). While most *Sphingonotus* species possess a serrate intercalary vein on the fore wing, which is the usual type of stridulatory apparatus in Oedipodinae (Oedipodinae type), there are two apomorphic stridulatory mechanisms found in two well defined subgenera. One group (*Neosphingonotus* Benediktov, 1998) has thickened cross-veinlets between medial vein and radius of the fore wing and the other subgenus (*Parasphingonotus* Benediktov & Husemann, 2009) has a serrated radius instead of a serrated intercalary vein (Johnsen & Schmidt 1982; Johnsen 1985). Due to its high significance for species recognition, the stridulatory apparatus has a great value for taxonomy and phylogeny in the genus *Sphingonotus* (Hochkirch & Husemann 2008).

Discussions about the taxonomic and systematic status of Sphingonotini with specialized stridulatory apparatus reach back to Bey-Bienko's (1948) description of *Sphingonotus paradoxus* Bey-Bienko, 1948. This species shares most of its general morphology with *Sphingonotus savignyi* Saussure, 1884, but differs in the structure of its stridulatory apparatus (Johnsen 1985). While *S. savignyi* shares the serrate intercalary vein with most other Oedipodinae, *S. paradoxus* has elevated cross veinlets between radius and media (*Neosphingonotus* type). After more than half a century of repeated systematic reorganization (reviewed in Benediktov 1998, 2009), twelve species with this stridulatory structure are meanwhile grouped in the subgenus *Neosphingonotus* (Benediktov 2009).

In contrast to the *Neosphingonotus* type, the third type of stridulatory apparatus has received relatively little attention. Johnsen and Schmidt (1982) first noted that *Sphingonotus turkanae* Uvarov, 1938 possesses an epiproct unique to the genus, as well as a smooth intercalary vein and a serrate radius. The same authors mentioned that this trait is shared with a species from Tunisia, which was later described as *Sphingonotus radioserratus* Johnsen, 1985 (Johnsen 1985). Johnsen (1985) also added *Sphingonotus airensis* Chopard, 1950 to this species group without for-

mally describing a new genus or subgenus. Benediktov (2009) erected the subgenus *Parasphingonotus* for *Sphingonotus* species with a serrate radial vein and assigned *S. airensis* as type species.

Here, we revise the subgenus *Parasphingonotus* and provide a key to subgenera of *Sphingonotus* as well as to the species within *Parasphingonotus*.

Material and methods

Morphological analyses. We studied the *Sphingonotus* material in the collections of the Natural History Museum London (NHM), the Academy of Natural Sciences Philadelphia (ANSP), the Zoologisch Museum Amsterdam (ZMA), the Muséum national d'histoire naturelle Paris (MNHN), the Lund Zoological Museum (LZM), the Natural History Museum Berlin (MfN). We also studied some specimens in the private collections of MH, AH and Claudia Hemp (Bayreuth) as well as some specimens provided by Tim McNary (Fort Collins, CO). In total, we examined the stridulatory mechanism of 123 species and subspecies of *Sphingonotus*. In addition we investigated specimens of several related genera belonging to the tribe Sphingonotini (*Thalpomena* Saussure, 1884, *Leptopternis* Saussure, 1884, *Granada* Koçak and Kemal, 2008, *Trimerotropis* Stål, 1873, *Cophotylus* Krauss, 1902, *Asphingoderus* Bey-Bienko, 1950, *Eusphingonotus* Bey-Bienko, 1950, *Eusphingoderus* Bey-Bienko, 1950, *Sphingoderus* Bey-Bienko, 1950, *Heliapteryx* Uvarov, 1914, *Helioscirtus* Saussure, 1884, *Vosseleriana* Uvarov, 1924). Biometric measurements were obtained using a digital calliper (range 0–150 mm). After microscopic inspection, we examined the wing structures of selected species and specimens using Scanning Electron Microscopy (SEM). We used a Zeiss DSM 962 (Oberkochen, Germany) at the University of Osnabrück and a Leo 1455 VP (Zeiss, Oberkochen, Germany) at the NHM (London) to photograph the stridulatory structures. The Leo 1455 VP was also used for examining type material as the specimens do not need to be dissected.

The epiproct of males and ovipositors of females were photographed using a Canon EOS 450D with a Canon EF 100 mm macro lens. The genitalia of males of all available *Parasphingonotus* species were dissected. For this, either whole specimens were softened in a refreshment box containing water and naphthalene or the abdomen of dried specimens were soaked in water or in a 0.2 M NaOH solution. We then extracted the phallic complex (aedeagus and epiphallus) with a bent pin and forceps. Spare tissue was removed via incubation in 0.2 M NaOH and removal with a forceps. The sclerotized structures were stored in 100% ethanol and then photographed using a stereo-microscope with attached camera. The epiproct and epiphalli of all species were drawn. In addition to *Parasphingonotus* species, the epiprocts and epiphalli of *S. S. caeruleans* from France and *S. N. azurescens* from Morocco were drawn as reference for the other subgenera.

Results and discussion

The examination of the museum specimens revealed that four species possess a serrated radius and, therefore, have to be assigned to the subgenus *Parasphingonotus*: *S. airensis* Chopard, 1950, *S. femoralis* Uvarov, 1933, *S. radioserratus* Johnsen 1985, and *S. turkanae* Uvarov 1938. A preliminary phylogenetic analysis of mitochondrial and nuclear sequences revealed that the above mentioned species indeed form a monophyletic clade (Hochkirch & Husemann unpublished data). The investigation of the type specimens of *S. airensis* and *S. femoralis*, as well as the original species descriptions, revealed no distinctive differences between these two species. As all specimens of *S. airensis* studied fell into the range of variation of *S. femoralis*, we here synonymize *S. airensis* with *S. femoralis*.

The investigated species of the genera *Thalpomena*, *Leptopternis*, *Jacobsiella*, *Trimerotropis*, *Cophotylus*, *Asphingoderus*, *Eusphingonotus*, *Eusphingoderus*, *Sphingoderus*, *Heliapteryx*, *Helioscirtus* and *Vosseleriana* all possessed the Oedipodinae type or no stridulatory apparatus on the forewing. The supra-anal plates of *Granada imitans* (Brunner von Wattenwyl, 1882) and a hitherto undescribed species from Spain are rather similar to the one found in *Parasphingonotus*, but their wings possess the Oedipodinae stridulation type or *Neosphingonotus* type, respectively. Only three East Asian species (*S. tsilingensis* Zheng, Tu and Liang, 1963, *S. ningsianus* Zheng and Gow, 1981, *S. mongolicus* Saussure, 1888) have been included in our analysis so far, all of which belong to the subgenus *Sphingonotus*.

Sphingonotus Parasphingonotus femoralis Uvarov, 1933

Synonymy: *Sphingonotus airensis* Chopard, 1950

Material examined. Type material: Holotype: 1 male, ARABIAN PENINSULA, South Arabian Desert, 1931, leg. B. S. Thomas, det. B. Uvarov, Depository: NHM, Paratype 1 female, ARABIAN PENINSULA, South Arabian Desert, 1931, leg. B. S. Thomas, det. B. Uvarov, Depository: NHM, Paratype, 1 female, SOMALIA, Behin, Jan. 1897, leg. F. Gillet, det. B. Uvarov, Depository: NHM.

Additional material examined. 1 male, OMAN, Kabil, 28 Oct. 1970, leg. J. Tunstall, Depository: NHM, 1 female, OMAN, Dhofar, Salalah, Jebel Qara, 23 Oct. 1983, leg. S. D. Gillett, Depository: NHM, 1 female, SAUDI ARABIA, Nejran, 20 July 1962, leg. G. Popov, Depository: NHM, 1 male, SAUDI ARABIA, upper Wadi Alah-siba, Tihma, 10 Feb. 1962, leg. G. Popov, Depository: NHM, 1 male, IRAN, Sarbaz, May 1950, leg. Salvatian, Depository: NHM, 1 female, YEMEN, near Taizz, 8 Oct. 1962, leg. G. Popov, Depository: NHM, 1 male, YEMEN, El'Asr, about 3 miles W of San'a, 14 Feb. 1938, leg. H. Scott & E. B. Britton, Depository: NHM, 1 male, YEMEN, Beit Baus, about 5 miles S of San'a, leg. H. Scott & E. B. Britton, Depository: NHM,

Specimens formerly identified as *S. airensis*: 1 male, 1 ♀, ERITREA, Agra Plain, 07 July 1950, leg. A. J. Wood, Depository: NHM, 1 male, 1 female (former paratypes of *S. airensis*), NIGER, Air, Tésuar, 1947, leg. Chop. Vill., Depository: NHM, 1 male (former Type of *S. airensis*), NIGER, Air, Tésuar, 1947, leg. Chop. Vill., Depository: MNHN, 1 male, 1 female (former Types of *S. airensis*), NIGER, Air, Tassasset, 1947, leg. Chop. Vill., Depository: MNHN, 1 female (former Types of *S. airensis*), NIGER, Air, Tarrouadji, 1947, leg. Chop. Vill., Depository: MNHN, 1 female, NIGER, Tabourax, 27 Oct. 1985, leg. T. McNary, Depository: Timothy J. McNary, private collection.

Distribution. Records exist from Mauritania, Mali, Niger, Chad (former distribution of *S. airensis* (Chopard 1950, Dirsh 1965, Mestre & Chiffaud 2006)), Sudan, Western Egypt (Mistshenko 1936), Eritrea, Somalia (Uvarov 1933), Oman, Saudi Arabia, Yemen, Jordan, and Israel, to Iran and Pakistan (Popov 1980, Massa & Fontana 1998, Ingrisich 1999)

Male. General facies: Habitus as typical for the genus, but fairly slender; medium size: length from fastigium of vertex to end of fore wings 19.6–21.6 mm (*S. femoralis* 19.6–21.6 mm (N=5), formerly identified as *S. airensis* 19.6–21.1 mm (N=3)).

Color: Body coloration variable: sandy to medium brown, sometimes with red tint. Antennae alternating light and dark brown. Outer area of hind femora same color as body, but with dark incomplete fascia 1/3 of the length of the femora away from the knee. Inner side of hind femora beige with dark knee and one full fascia at the level of the outer band, a second fascia is of variable width and can fill the whole medial area or can be absent. Hind tibiae dirty whitish or pale yellowish with dark spines.

Head: Antennae filiform, longer than head and pronotum together. Frontal ridge slightly concave with lateral carinae slightly widened between basis of antennae. Fastigium of vertex concave, lateral carinae elevated, median carinula variable, often slightly developed. Temporal foveolae diffuse, elongate triangular.

Thorax: Pronotum almost as wide as long; pronotal disk smooth with three complete transverse sulci; median carina present in front of first sulcus, often two small elongated tubercles (often of whitish color) between second and third sulcus; posterior margin rectangular to obtuse angular or rounded; lateral carinae slightly developed in metazona. Metazona approximately twice as long as prozona (0.37–0.56) (*S. femoralis* 0.41–0.56 (N=5), formerly identified as *S. airensis* 0.37–0.55 (N=3)).

Wings: Hind wings slightly bluish or hyaline without any trace of a fascia but with darkened veins. Fore wings moderately densely reticulated, relatively narrow: 6.2–7.1 (*S. femoralis* 6.4–7.1 (N=5), *S. airensis* 6.2–7.0 (N=3)) as long as wide. Intercalary vein slightly sinuous or curved with the centre being most distant from the radius, sometimes proximally splitting up into two veins smooth; radius serrated.

Femora: Hind femora 3.2–3.8 (*S. femoralis* 3.2–3.8 (N=5), *S. airensis* 3.3–3.5 (N=3)) times longer than wide; spurs of tibia of normal length for the genus; arolium small (1/3 to 1/2 of length of claws).

Abdomen: Tympanum typical for the genus, as high as long, less than 50% of opening covered by ventral lobe. Epiproct elongate and trilobate, almost reaches the tip of the cerci, lateral margins slightly elevated, basally with small tubercles and two triangular and two linear ridges. Cerci slightly longer than epiproct, slightly conical with blunt rounded tip.

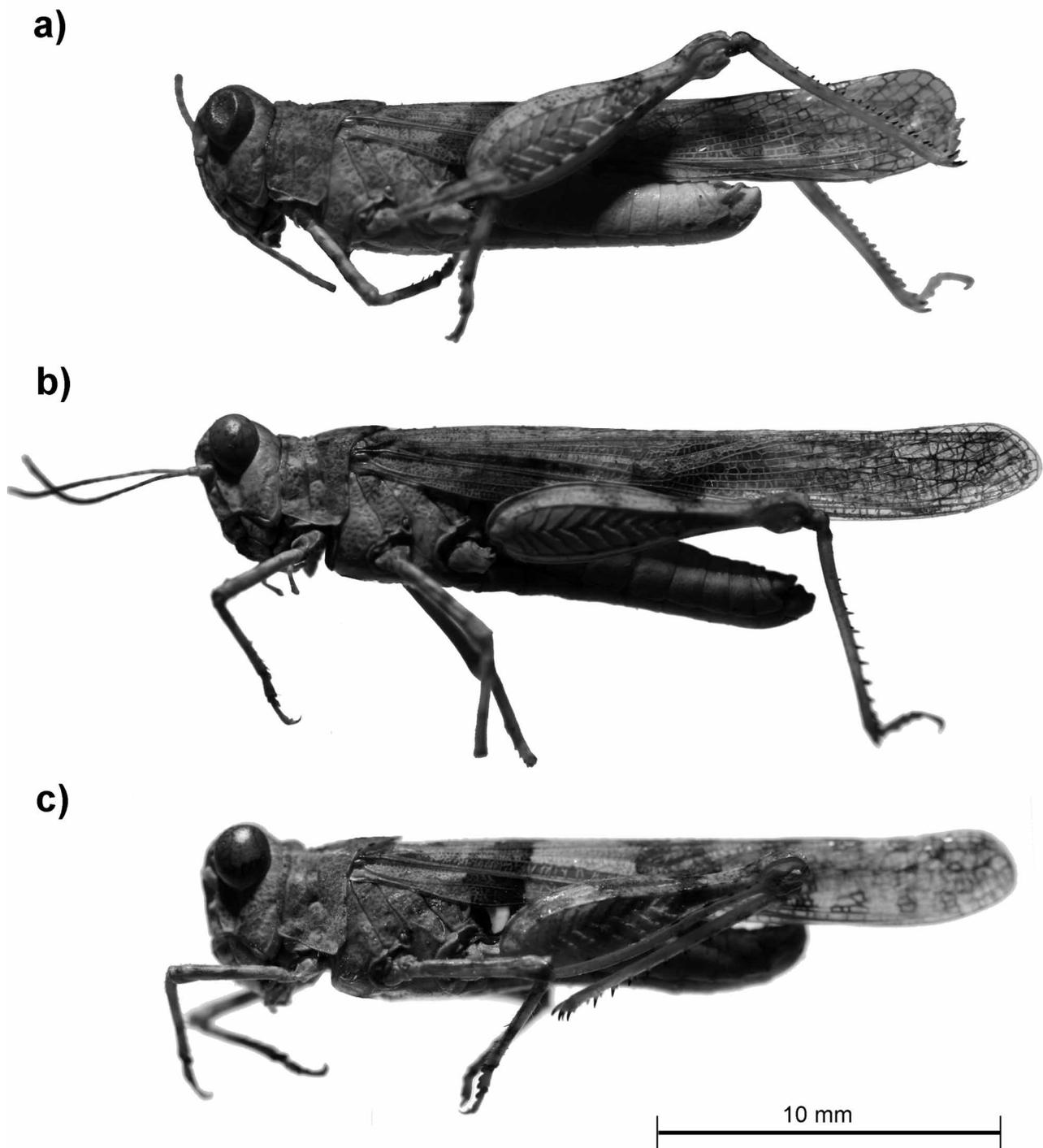


FIGURE 1. Lateral view of male of a) *S. P. femoralis*, b) *S. P. radioserratus*, and c) *S. P. turkanae*.

Inner genitalia: Lophi of epiphallus large and bipartite, internal lobes projecting inside and rounded, external part broad oval; ancrae in- and down-curved, pointed; epiphallic bridge of medium width; anterior projections short, spoon-shape, but pointed; posterior projections short, rounded.

Female. The females are mostly similar to males but differ in the following characters:

Body more stout; body size: 27.1–30.7 mm (*S. femoralis* 28.4–30.7 mm (N=4), *S. airensis* 27.1–29.1 mm (N=4)); cerci conical with broad basis and pointed tip; ovipositor variable, short; valves strongly curved, with rounded or pointed tips; both valves approximately of similar length; lower valve with distinct rounded tooth; lower valve from seen below shows considerable variation (Fig. 5). Although the appearance of the subgenital

plates of the paratypes of *S. femoralis* from Somalia and *S. airensis* from Niger is slightly different, these differences are in the range of variation found among studied individuals within each species. Lower valve from seen below with basal plates of oval shape and variable size covering about half of the valve. Proximal part of valves of medium width, laterally elevated. Subgenital plate with two rounded lobes.

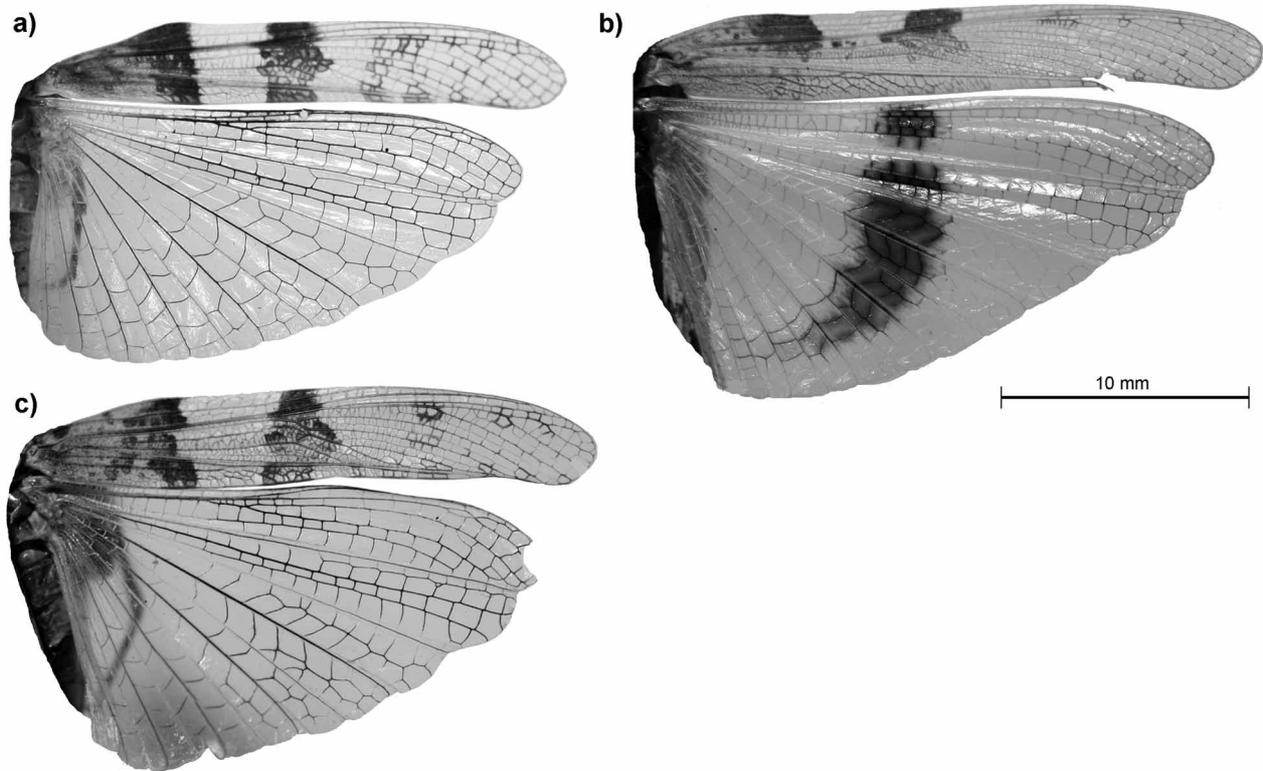


FIGURE 2. Fore and hind wings of a) *S. P. femoralis*, b) *S. P. radioserratus*, and c) *S. P. turkanae*.

Sphingonotus Parasphingonotus radioserratus Johnsen, 1985

Material examined. Type material: Holotype: 1 male, TUNISIA, Gafsa, 01 Aug. 1951, leg. O. Persson, det. P. Johnson, Depository: ZML, Allotype: 1 ♀ female, TUNISIA, Gafsa, 01 Aug. 1951, leg. O. Persson, det. P. Johnson, Depository: ZML, Paratypes: 2 females, 1 male, TUNISIA, Gafsa, 01 Aug. 1951, leg. O. Persson, det. P. Johnson, Depository: ZML

Additional material examined. MOROCCO: 2 males, 1 ♀♀, Tarda, 10 km W of Errachidia (31.48 N, 4.36 W), 20 May 2008, leg. M. Husemann, Depository: NHM, 2 males, 2 females, Tarda, 10 km W of Errachidia (31.48 N, 4.36 W), 20 May 2008, leg. M. Husemann, Depository: M. Husemann, private collection.

Distribution. Tunisia (Johnsen 1985), Morocco.

Male. General facies: Habitat as typical for *Sphingonotus*, but relatively slender; medium size: length from vertex to end of fore wings 23–24.5 mm (N=7).

Color: Color pattern fairly distinct: body light brownish to sand-colored, abdomen sometimes whitish; head of the same color with slightly darker eyes; antennae alternating dark and light brown; pronotum variable: similar color as body or with dark and light x-shaped markings. Outer median area of hind femora light brown; upper carina often with dark spot about 1/3 of the length of the hind femora away from the knee; inner side of hind femora light brown with dark knee and two dark spots, one at the position of the dark spot, one at the beginning of the second third (Fig. 7). Hind tibiae whitish to slightly yellowish with dark spines.

Head: Antennae filiform, longer than head and pronotum together. Frontal ridge slightly concave with lateral carinae, ridges almost parallel, fastigium of vertex concave, lateral carinulae slightly elevated, median carinula missing. Fastigial foveolae small, elongate triangular.

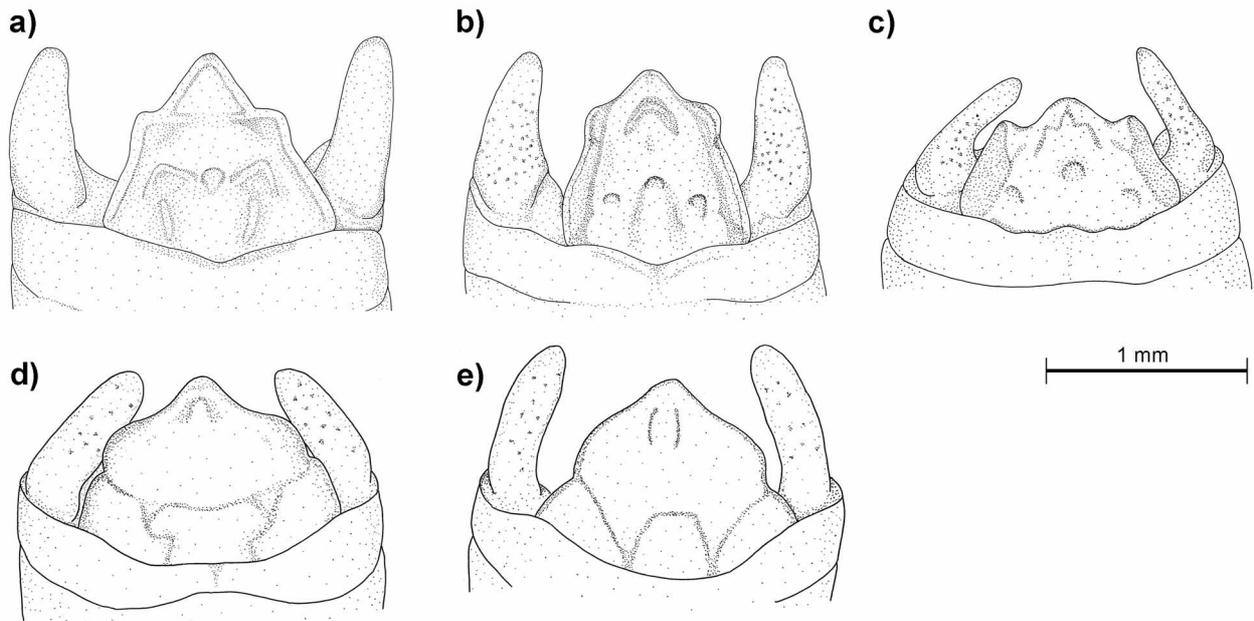


FIGURE 3. Supra-anal plates of a) *S. P. femoralis*, b) *S. P. radioserratus*, and c) *S. P. turkanae*; d) *S. N. azurescens* and e) *S. S. caeruleans*.

Thorax: Pronotum almost as wide as long; pronotal disk smooth with 3 complete sulci, median carina slightly elevated in front of first sulcus. Hind margin rectangular to obtuse angular or rounded; lateral carinae slightly developed in metazona; metazona approximately twice as long as prozona (0.39–0.53, N=7).

Wings: Fore wings with two incomplete dark bands, both starting at the front margin and reaching up to intercalary vein, moderately densely reticulated, relatively narrow: 6.7–7.2 (N=7) as long as wide. Intercalary vein almost straight and parallel to the radius, smooth; radius serrated. Hind wings slightly bluish to hyaline with central narrow dark band which does not reach the posterior and interior margins.

Femora: Hind femora 3.5–4.7 (N=7) times longer than wide; spurs of tibia of normal length for the genus; arolium small (1/3 to 1/2 of length of claws).

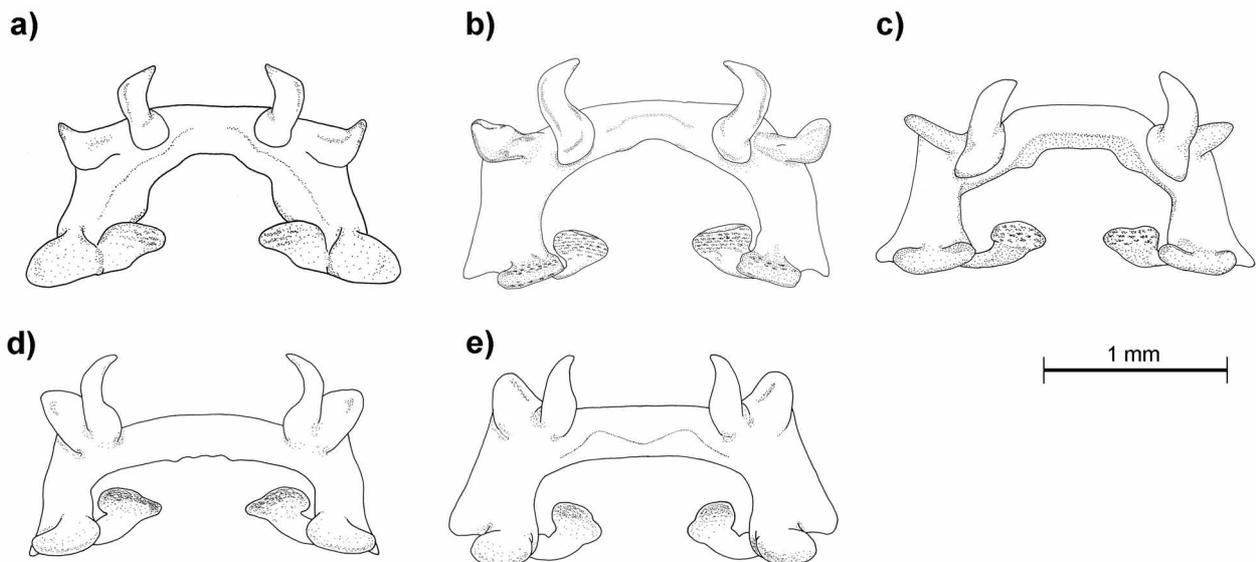


FIGURE 4. Epiphalli from a) *S. P. femoralis*, b) *S. P. radioserratus*, and c) *S. P. turkanae*; d) *S. N. azurescens* and e) *S. S. caeruleans*.

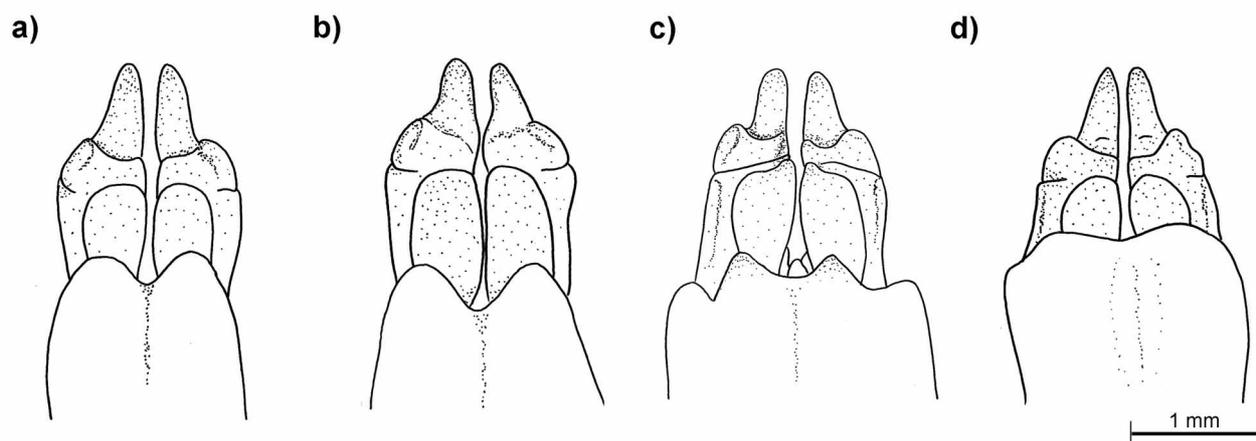


FIGURE 5. View of the lower valve of the ovipositor and the subgenital plate from below: a) a former paratype of *S. airensis* from Niger, b) a paratype from *S. P. femoralis* from Somalia, c) an allotype from *S. P. radioserratus* from Tunisia, and d) a paratype of *S. P. turkanae* from Ethiopia.

Abdomen: Tympanum typical for the genus, as high as long, less than 50% of opening covered by ventral lobe. Epiproct elongate and trilobate, almost reaches the tip of the cerci, lateral margins elevated, basally with several small tubercles, apically with horseshoe-shaped ridge. Cerci slightly longer than epiproct, slightly conical with blunt rounded tip.

Inner genitalia: Epiphallic lophi large and bipartite, internal part bell-shaped, external part oval; ancorae in- and down-curved, pointed; epiphallic bridge of medium width; anterior projections short, spoon-shaped; posterior projections short, pointed.

Female. The females are mostly similar to males but differ in the following characters:

Body more stout; body size: 28.4–31.3 mm (N=5); antennae only slightly longer than head and pronotum together; cerci conical with pointed tip. Ovipositor displays some variation; relatively short, valves strongly curved, with rounded or pointed tips, both valves approximately of similar length, lower valve with distinct rounded tooth. Lower valve from seen below with basal plates of oval shape, internal site proximally with little rounded appendix (Fig. 5), the plate covers slightly more than half of the valve; proximal part of valves of medium width, laterally elevated. Subgenital plate with two lobes of almost rectangular shape.

Sphingonotus Parasphingonotus turkanae Uvarov, 1938

Material examined. Type material: Holotype: 1 male, KENYA, Turkana, Komogin R., 05 Mar. 1934, leg. D. R. Buxton, det. B. Uvarov, Depository: NHM, Paratype: 1 male, KENYA, Lokitang, Turkana Nord, 1932-33, leg. C. Arambourg, P.-A. Chappuis & R. Jeannel, det. B. Uvarov, Depository: NHM, Paratype: 1 female, ETHIOPIA, Bourié, Shore of river Omo, 1932-33, leg. C. Arambourg, P.-A. Chappuis & R. Jeannel, det. B. Uvarov, Depository: NHM.

Additional material examined. 1 female, ETHIOPIA, El Oha, 10 Nov. 1968, leg. J. Tunstall, Depository: NHM, 1 male, ETHIOPIA, Diré-Daoua, Dec. 1934, leg. H. Uhlenhuth, Depository: NHM, 1 male, 1 female, YEMEN, Socotra, R. A. F. Camp, 26–27 Jan. 1953, leg. G. Popov, Depository: NHM, 1 female, YEMEN, San'a, 10–15 Oct. 1937, leg. Dr. C. Rathjens, Depository: NHM, 1 male 1 female, SOMALIA, near Borama, 1934, leg. Capt. R. H. T. Taylor, Depository: NHM, 1 male, 1 female, TANZANIA, Tanganyika Terrain, Mkomasi Station, 60 miles W of Amani, 20 June 1934, leg. E. Burt, Depository: NHM, 1 male, TANZANIA, Mt. Meru, 26 May 2005, leg. C. Hemp, Depository: M. Husemann, private collection.

Distribution. Ethiopia, Kenya, Tanzania, Somalia (Uvarov 1938, Dirsh 1965, Hemp 2009), Socotra, Yemen (Uvarov & Popov 1957, Johnsen & Schmidt 1982)

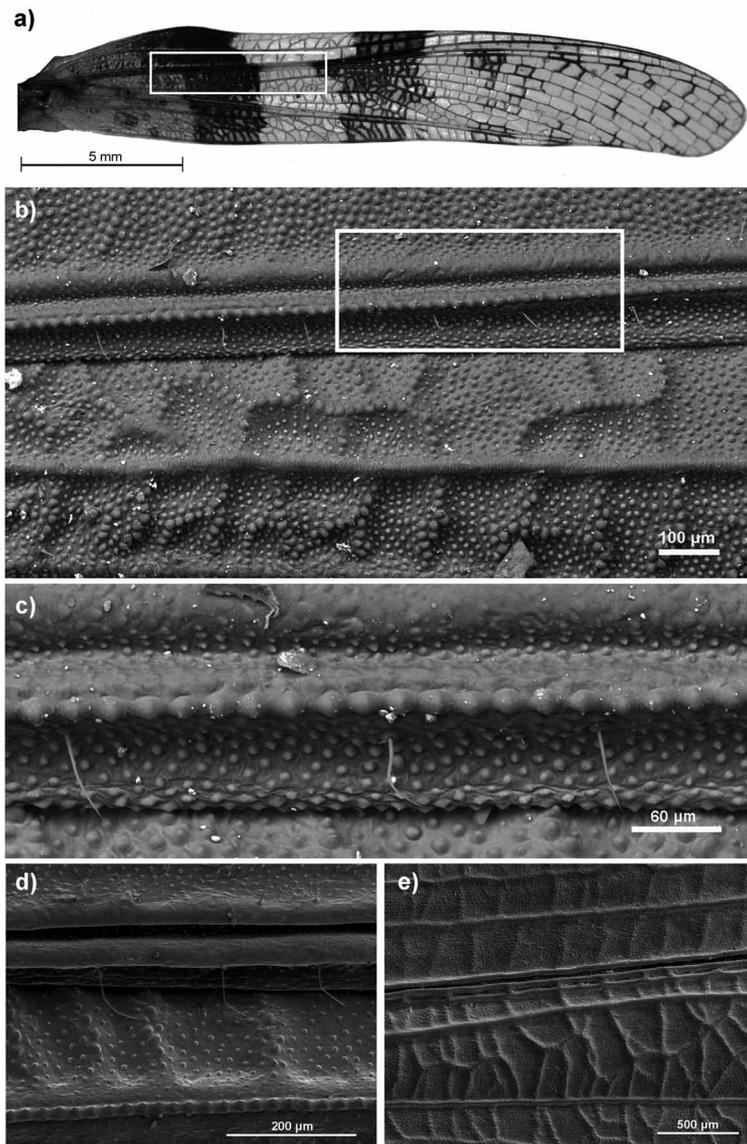


FIGURE 6. a) Fore wing of *S. P. femoralis*, SEM photographs of the stridulatory apparatus of b) *S. P. turkanae*, c) *S. P. turkanae* in detail, d) *S. S. caerulans*, and e) *S. N. azurescens*.

Male. General facies: Habitus as typical for the genus, but fairly slender; medium size: length from fastigium of vertex to end of fore wings 20.7–23.3 mm (N=9).

Color: Body coloration variable: light to medium brown. Antennae alternating light and dark brown. Outer area of hind femora same color as body, but with dark incomplete fascia 1/3 of the length of the femora away from the knee. Sometimes with smoky spot in the middle of the medial area. Inner side of hind femora beige with dark knee and one full fascia at the level of the outer band, in addition the whole medial area is dark. Hind tibiae dirty whitish or pale yellow with dark spines.

Head: Antennae filiform, longer than head and pronotum together. Frontal ridge slightly concave with lateral carinae, widened between basis of antennae. Fastigium of vertex concave, lateral carinae almost parallel, elevated, medial carinula variable, usually distinctly developed, often Y-shaped. Temporal foveolae distinct, elongate triangular.

Thorax: Pronotum almost as wide as long; pronotal disk strongly rugose with elevated tubercles and ridges, 2 complete transverse sulci, the area between the sulci consists of two elevated knobs which form a small plateau and interrupt the third (median) sulcus; median carina distinct in front of first sulcus; posterior margin right angled and weakly rounded at the tip; lateral carinae developed in metazona. Metazona 2–3 times as long as prozona (0.35–0.6, N=9).

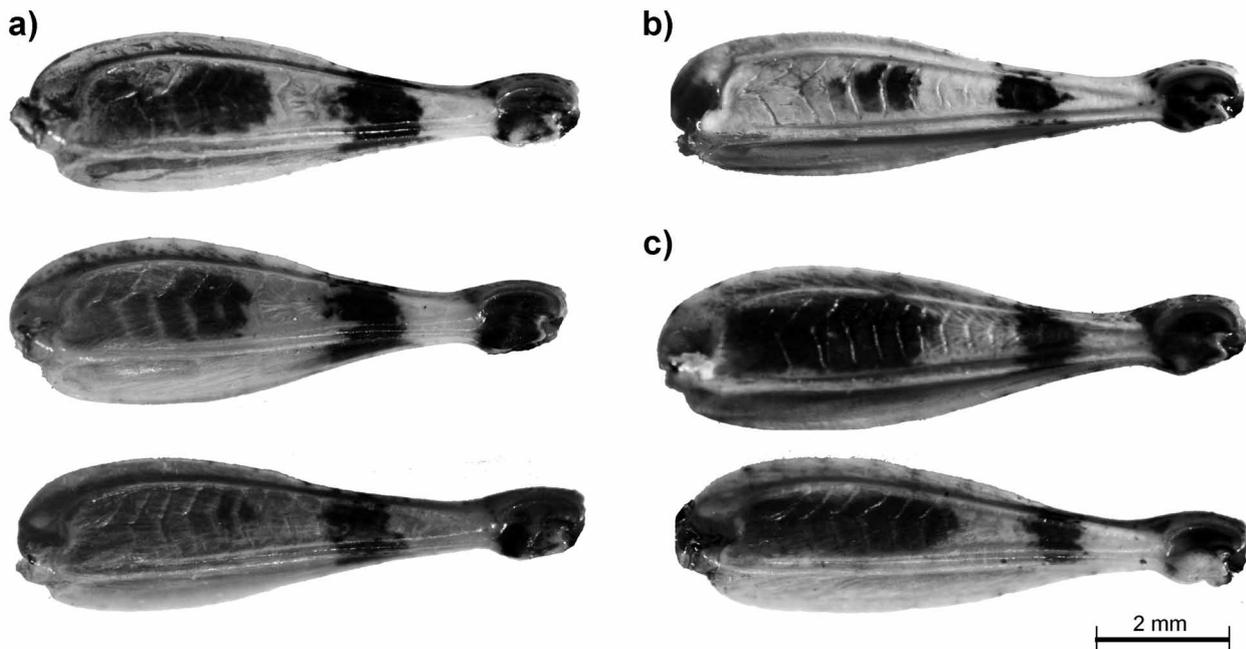


FIGURE 7. Inner side of hind femora of a) *S. femoralis*, b) *S. radioserratus*, c) *S. turkanae*.

Wings: Fore wings moderately densely reticulated, relatively narrow: 5.9–7.4 (N=9) as long as wide. Intercalary vein often almost straight, sometimes curved, then the central part is most distant from the radius, smooth; radius serrated. Hind wings slightly bluish without any trace of fascia but with dark veins.

Femora: Hind femora 3.5–3.9 (N=8) times longer than wide; spurs of tibia of normal length for the genus; arolium small (1/3 of length of claws).

Abdomen: Tympanum typical for the genus, as high as long, less than 50% of opening covered by ventral lobe. Epiproct short and trilobate, about 2/3 the length of the cerci, lateral margins slightly elevated, basally with several small tubercles. Cerci longer than epiproct, slightly conical with blunt rounded tip.

Inner genitalia: Lophi of epiphallus large and bipartite, internal lobes mushroom shaped, projecting inside, external part oval; ancorae in- and down-curved, pointed; epiphallic bridge of medium width; anterior projections short and narrow; posterior projections short, rounded.

Female. The females are mostly similar to males but differ in the following characters:

Body more stout; body size: 25–29.5 mm (N=7); cerci almost cylindrical with rounded tip. Ovipositor displays some variation; short, valves strongly curved, with rounded or pointed tips; both valves approximately of similar length, lower valve with distinct rounded tooth. Lower valve from seen below with basal plates of almost round shape (Fig. 5), covering less than half of the valve. Proximal part of valves relatively narrow, laterally elevated. Subgenital plate without distinct lobes, lobes replaced by two broad curvatures.

Differential diagnosis. *S. radioserratus* is easily distinguished from the other two species of the subgenus by its two incomplete wing bands on the forewing and by the dark band on the hind wing. The males have a very distinctive supra-anal plate, which is longer than in the other species of the subgenus and has a horseshoe-shaped ridge in the apical part. *S. turkanae* and *S. femoralis* are easily distinguished by the sculpting patterns of the pronotum, which is much more rugose and has a higher and more distinctive medial carina in *S. turkanae*. The upper carina of the hind femora has a distinct step in *S. turkanae* (like in *Oedipoda* species). The fastigium of vertex and frontal ridge of *S. turkanae* are much wider than in *S. femoralis* and have a more distinct carina which can be bifurcated in some individuals. Females of all species differ in the shape of the basal lobes of the lower valve of the ovipositor. *S. femoralis* have oval basal lobes, while *S. radioserratus* has an internal small appendix proximal on the basal lobe. *S. turkanae* has very short basal lobes which are of almost round shape. The female subgenital plates of all species differ as well. *S. femoralis* has two rounded lobes, while those are almost rectangular in *S. radioserratus* and only represented by a broad curvature in *S. turkanae*.

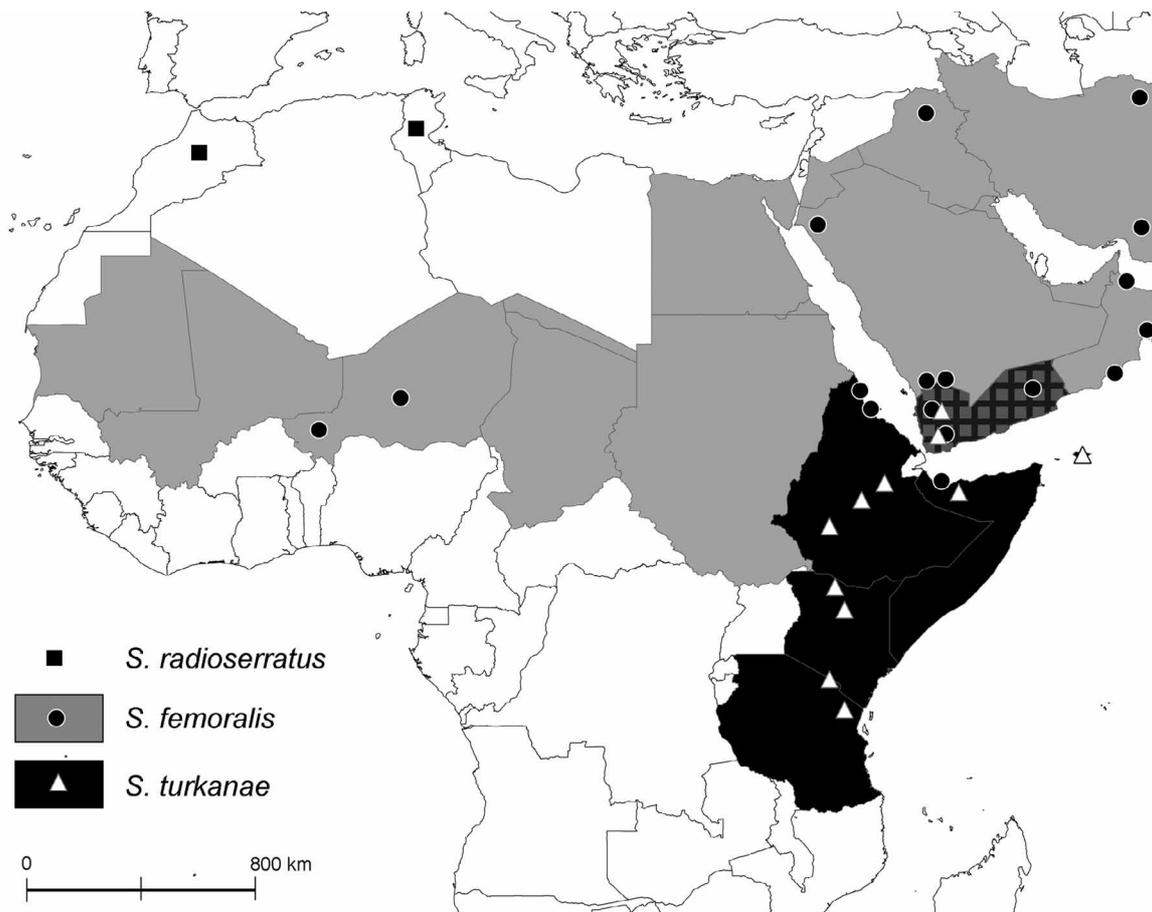


FIGURE 8. Distribution of *Parasphingonotus* species (grey and black coloration indicate country records derived from the literature, symbols indicate locations of examined material).

Key to the subgenera

- 1 Intercalary vein in the medial area of the fore wings serrate, in females sometimes only slightly serrate or smooth (Fig. 6d) *Sphingonotus* s.s.
- Intercalary vein not serrate 2
- 2 Thickened cross veinlets between radial and medial vein of the fore wings present (Fig. 6e), radial vein without serration, supra-anal plate triangular or rounded *Neosphingonotus*
- Without thickened cross veinlets between radial and medial vein, radial vein stronger raised than subcostal vein and serrate (Fig. 6 c, d), supra-anal plate trilobite (Fig. 3a–c) *Parasphingonotus*

Key to the species of the subgenus *Parasphingonotus*

- 1 Hind wings with a dark fascia (Fig. 2b), epiproct elongate, as long as cerci, sides elevated giving it a spoon like appearance (Fig. 3b), with horse shoe shaped ridge in the apical third (North West Africa) *S. P. radioserratus*
- Hind wings without distinct dark fascia, sometimes with blackish veins, epiproct as long as or shorter than cerci, sides not raised, no horse shoe shaped tubercle in apical third 2
- 2 Pronotum strongly rugose with raised ridges and tubercles, hind margin rectangular; inner sides of hind femora yellow with dark knee, distinct dark fascia in apical third and dark medial area (Fig. 7c), epiproct in males much shorter than cerci (less than 2/3), strongly trilobate with variable numbers of raised tubercles (Fig. 3c) (East Africa, Socotra, Yemen) . . . *S. P. turkanae*
- Pronotum smooth, hind margin right or obtuse angled and rounded; upper carina of hind femora continuously lowered, without step; inner sides of hind femora yellow or dirty-yellowish with a distinct dark fascia in the apical third (Fig. 7a), medial area variable, dark spot of variable size can almost fill the whole medial area or can be absent, epiproct more elongate (longer than 2/3 of cerci), trilobate, with two triangular lobes at the basis (Fig. 3a) (Mauritania, Niger, Chad, Northeast and East Africa, Arabian Peninsula, Iran) *S. P. femoralis*

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Literature

- Benediktov, A.A. (1998) On the taxonomy of the tribe Sphingonotini (Orthoptera, Acrididae). *Russian Entomological Journal*, 6, 11–13.
- Benediktov, A.A. (2009) To the taxonomy and bioacoustics of grasshoppers of the genus *Sphingonotus* Fieber, 1852 (Orthoptera, Acrididae, Oedipodinae). *Proceedings of the Russian Entomological Society*. St. Petersburg, 80, 21–33 [In Russian].
- Bey-Bienko, G.Y. (1948) New species and subspecies of locusts (Orthoptera, Acrididae) from Beluchistan. *Doklady Akademii Nauk SSSR*, 60, 497–499 [In Russian].
- Chopard, L. (1950) Contribution a l'étude de l'Air, Orthopteroïdes. *Memoires de l'Institut Francais D'Afrique Noire*, 10, 127–145.
- Dirsh, V.M. (1965) *The African Genera of Acridoidea*. Cambridge University Press, Antilocust Centre, London, pp. 579.
- Eades, D.C., Otte, D., Cigliano, M.M. & Braun, H. (2011) *Orthoptera Species File Online*. Version 2.0/4.0, available from: <http://Orthoptera.SpeciesFile.org> (03-11-2011)
- Hemp, C. (2009) Annotated list of Caelifera (Orthoptera) of Mt. Kilimanjaro. *Journal of Orthoptera Research*, 18, 183–214.
- Hochkirch, A. & Husemann, M. (2008) A review of the Canarian Sphingonotini with description of a new species from Fuerteventura (Orthoptera: Acrididae: Oedipodinae). *Zoological Studies*, 47, 495–506.
- Ingrisch, S. (1999) Orthopteroid Insects of Yemen. *Esperiana*, 7, 349–376.
- Johnsen, P. (1985) Contributions to the knowledge of the genera *Spingonotus*, *Pseudosphingonotus* and *Wernerella* in Africa, with description of four new species (Acridoidea, Oedipodinae). *Natura Jutlandica*, 21, 149–168.
- Johnsen, P. & Schmidt, G.H. (1982) Notes on, and a check-list of Acridoidea (Saltatoria) collected in Somalia (East Africa). *Italian Journal of Zoology*, 3, 69–119.
- Massa, B. & Fontana, P. (1998) Middle Eastern Orthoptera (Tettigoniidae and Acridoidea) preserved in Italian Museums. *Bollettino del Museo Civico Storia naturale di Verona*, 22, 64–104.
- Mestre, J. & Chiffaud, J. (2006) Catalogue et atlas des acridiens d'Afrique de l'Ouest, pp. 349.
- Mistshenko, L.L. (1936) Revision of palearctic species of the genus *Sphingonotus* Fieb. (Orthoptera, Acrididae). *Eos*, 12, 65–282.
- Popov, G.B. (1980) The scientific results of the Oman flora and fauna survey 1977 (Dhofar), Acridoidea of eastern Arabia. *Journal of Oman Studies*, 2, 113–148.
- Uvarov, B.P. & Popov, G.B. (1957) The saltatorial Orthoptera of Socotra. *Zoological Journal of the Linnean Society, London*, 43, 359–389.
- Uvarov, B.P. (1933) Orthoptera collected by Mr. Bertram Thomas in southern Arabia. *Proceedings of the Zoological Society of London*, 103, 259–271.
- Uvarov, B.P. (1938) Mission scientifique de l'Omo. Orthoptera. III. Acrididae. *Mémoires du Muséum National d'Histoire Naturelle*, 8, 145–176.