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Source: Revue suisse de Zoologie, 125(1) : 155-164

Published By: Muséum d'histoire naturelle, Genève

URL: https://doi.org/10.5281/zenodo.1196046

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Revue suisse de Zoologie (March 2018) 125(1): 155-164 ISSN 0035-418

A European discovery: *Kalliste pavonum* gen. nov., sp. nov., the smallest phalangiid species known to date (Arachnida: Opiliones: Phalangiidae)

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Abstract: *Kalliste pavonum* is described as a new genus and new species of harvestmen based on males and females from the mountains of the island of Corsica, France. The new genus is characterized by male genitalia (massive truncus penis without distinct base, with extended penial muscle, dorsal subapical triangular tooth on stylus), pro-lateral apophyses on pedipalpal femur (female only), patella and tibia, two denticles with filiform apex on ventral side of palpal claw, large ocularium and minute body size. Superficially, the new species appears to be related to European genera with armed pedipalps, both together forming a basked-like structure, as found in *Rilaena*, *Megabunus*, *Metaplatybunus, Lophopilio* and *Platybunus*. However, they all differ from *Kalliste* gen. nov. by male genitalic characters and details of palpal armament. Apparently, *Platybunus* is the least closely related of these genera. *Kalliste* seems to be a rather isolated genus and species without close relatives within the West Palaearctic phalangiid assemblage.

Keywords: Taxonomy - relationships - genital morphology - new genus - new species - endemics - Corsica - France.

INTRODUCTION

During the last decades, very few new genera were established for newly detected and previously undescribed harvestmen species in Europe. Most spectacular was the discovery of a minute, short-range nemastomatid species in the Italian south-western Alps, which was named *Saccarella schilleri* Schönhofer & Martens, 2012. Here I establish another new genus for a recently recognized minute species of Phalangiidae from the island of Corsica, France. It probably escaped detection due to its small size and rather pale coloration, which resembles that of juveniles of co-occurring phalangiids.

MATERIAL AND METHODS

Original line drawings were produced using a camera lucida attached to a Carl Zeiss research microscope. Measurements were taken by means of a micrometer disc attached to a Leitz stereomicroscope. Measurements of the penis were taken from the original drawings. All measurements are given in mm.

In a strict morphological sense, in the Phalangiidae the glans of the penis is always bent to the dorsal side. Consequently, the upper side of the stylus (on the left side in Figs 19 and 21 and 23-24) is ventral; the stylus tooth on the opposite side is on the dorsal side.

Abbreviations of morphological terms:

Apo	apophysis
Cx	coxa
do	dorsal
Fe	femur
la	lateral
Mt	metatarsus
Op gen	operculum genitale
Pt	patella
Rec sem	receptaculum seminis
Ta	tarsus
Ti	tibia
Tr	trochanter
Tu oc	tuber oculorum, ocularium
ve	ventral

Museum acronyms:

CJM	Working collection of J. Martens, Mainz, Germany
MHNG	Muséum d'histoire naturelle de Genève, Switzerland
SMF	Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany

Manuscript accepted 16.01.2018
DOI: 10.5281/zenodo.1196046

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TAXONOMIC PART

Phalangiidae Latreille, 1802
Phalangiinae Latreille, 1802
Kalliste gen. nov.

Type species: *Kalliste pavonum* sp. nov. (by original designation).

Diagnosis: Characterized by male genital morphology: truncus penis stout and massive, penial muscle much extended over more than proximal half of truncus. A subapical triangular tooth on lower (dorsal) side of penial stylus. Pedipalpal claw ventrally equipped with two thin proximal filiform denticles on a broader base. Strong and stout pedipalps with pro-lateral apophyses on femur (in female only), patella and tibia (in both sexes). Large elevated tuber oculorum occupying more than half of prosoma length. Small body size (1.8-2.0 mm in males, 1.9-2.6 mm in females).

Distribution: The single species of the new genus is known from two high-altitude localities in the mountains of central Corsica, France.

Name: Kalliste (τῇ καλλίστῃ) is one of the historical names of Corsica, used in times when the island was colonized by Greeks. It denominates the feminine superlative of kalós (καλός), "the most beautiful". The gender is feminine.

Relationships: See Discussion.

Kalliste pavonum sp. nov.
Figs 1-27

Holotype: SMF; male; France, Corsica, Département Haute-Corse, Col de Verde, 1200 m; J. and B. Martens; leg. 26.8.2012.

Paratypes: CJM 3373; 2 males; France, Corsica, Département Haute-Corse, Col de Verde, 42°01'N, 9°11'E, 1280 m; B. Schröter [later B. Pfau] & K. Pfau; leg. 9.1982. – CJM 7255; 1 female; France, Corsica, Département Haute-Corse, Col de Vizzavona, 42°06'N, 9°06'E, 1000-1200 m; J. and B. Martens; leg. 8.9.2012. – MHNG; 1 male; France, Corsica, Département Haute-Corse, Col de Vizzavona, 42°06'N, 9°06'E, 1000-1200 m; J. and B. Martens; leg. 8.9.2012. – CJM 7267; 1 female; France, Corsica, Col de Verde, 1200 m; J. and B. Martens; leg. 26.8.2012.

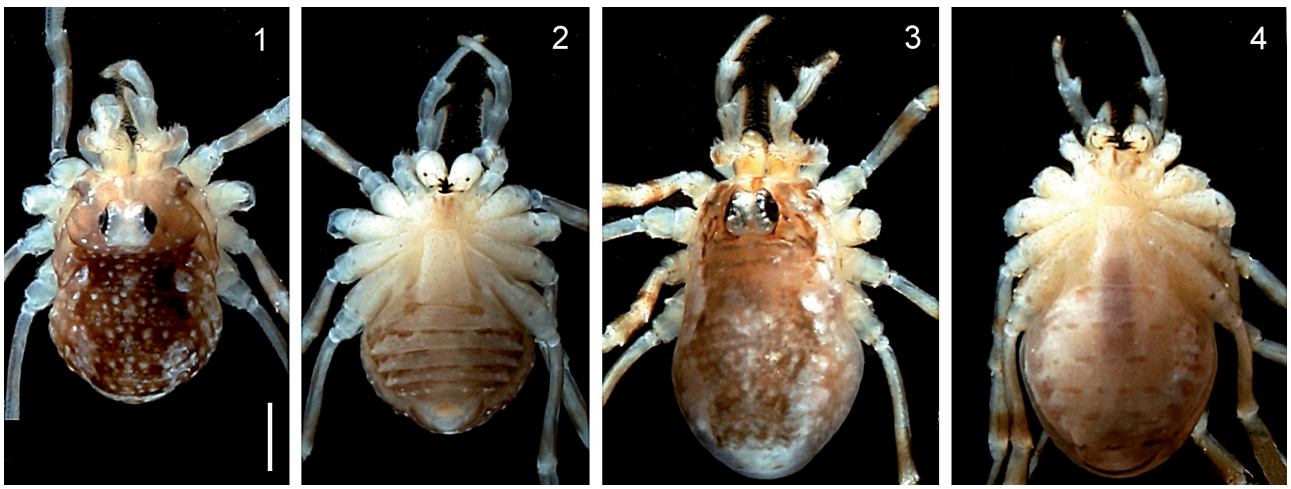
Additional non-type material examined: CJM 7780; 2 juveniles; France, Corsica, Col de Vizzavona, 1000-1200 m; J. and B. Martens; leg. 29.8.2012 and 11.9.2012. – CJM 7781; 1 juvenile; France, Corsica, Col de Verde, 1200 m; J. and B. Martens; leg. 26.8.2012.

Diagnosis: At present, the diagnosis of genus *Kalliste* gen. nov. applies.

Remarks: It is noteworthy that *Kalliste pavonum* sp. nov. represents the smallest phalangiid species known to date. Tsurusaki (2007) mentions 2.2 mm as the minimum size for species of this family; *K. pavonum* sp. nov. is below that limit (see Measurements).

Name: *Kalliste pavonum* sp. nov. honors Beate and Klaus Pfau, distinctive zoologists who first provided specimens of this unusual species and put the material at my disposal. Pfau in Latin is "pavo", peafowl in English, "pavonum" is the plural genitive case referring to both collectors.

Description: MALE: *Body, dorsal side* (Figs 1, 5-6): Small, roundish, dorsal side without marked armament of granules, "hooks" or strong setae; only on 2nd thoracal segment with a loose row of low denticles (and a few setae), latero-distal and lateral rim of prosoma with small spiny protuberances.



Figs 1-4. *Kalliste pavonum* gen. sp. nov. (1) Body of male holotype in dorsal view. (2) Same in ventral view. (3) Body of female paratype in dorsal view. (4) Same in ventral view. Scale: 0.5 mm.

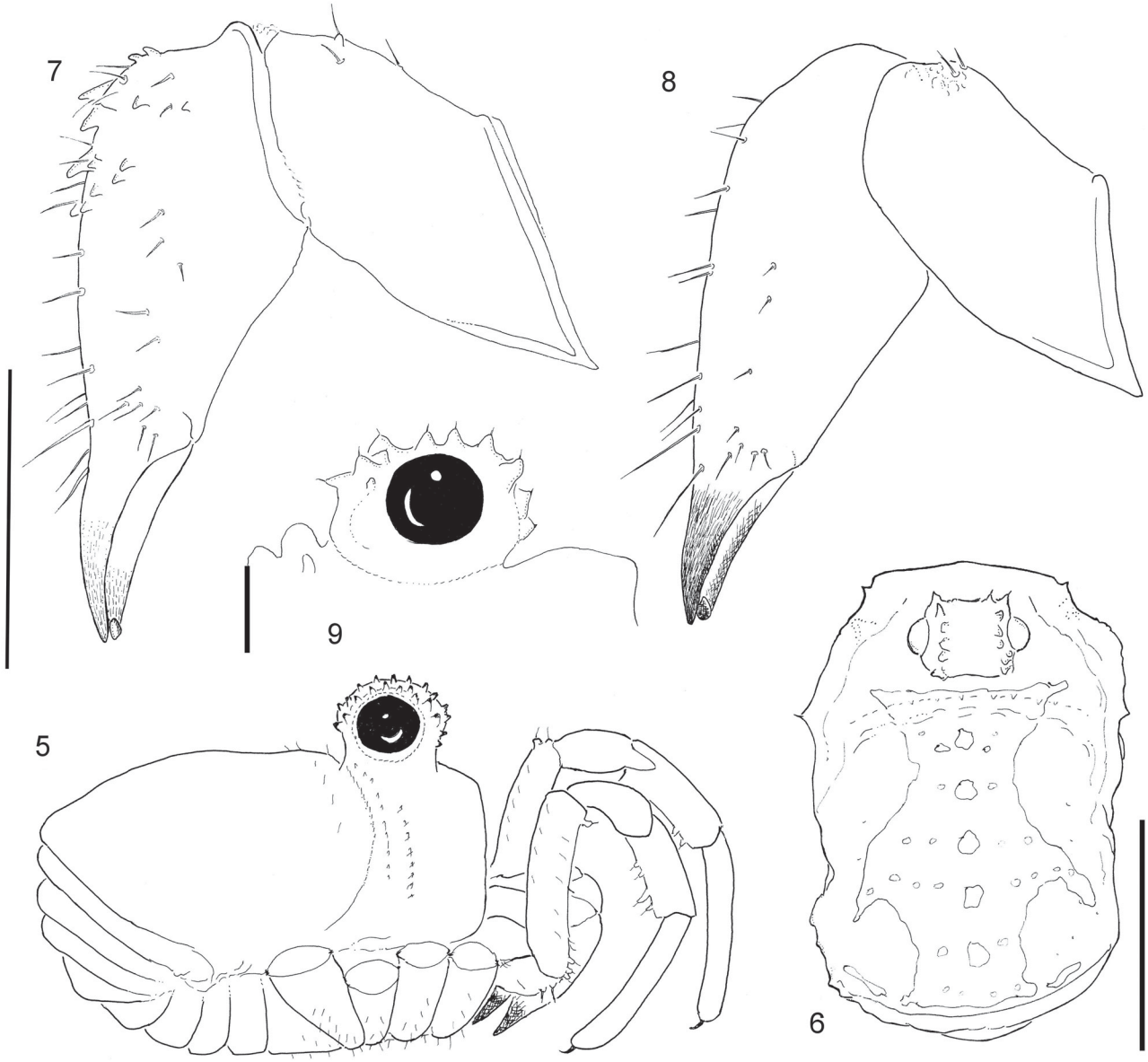
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Colour pattern (Figs 1, 6): Fully grown adults with shiny silvery ground colour and marked saddle pattern extending over dorsal thoracal segments and opisthosoma, broadest on metapeltidium, narrowest on opithosomal segment I, from there broadening to rear rim of segment II, then irregularly tapering toward segments III, IV and V of opisthosoma, causing a brownish appearance. Irregular rows of few light spots of different sizes across metapeltidium and opisthosomal segments, ocularium light silvery, large eyes black.

Tuber oculorum (Figs 1, 5-6, 9): Large (in comparison with other phalangiids), shiny, situated near posterior edge of prosoma, set back from anterior end of prosoma by about half of its length, dorso-laterally armed with two irregular rows of about 10-12 stout denticles, each one carrying a short seta.

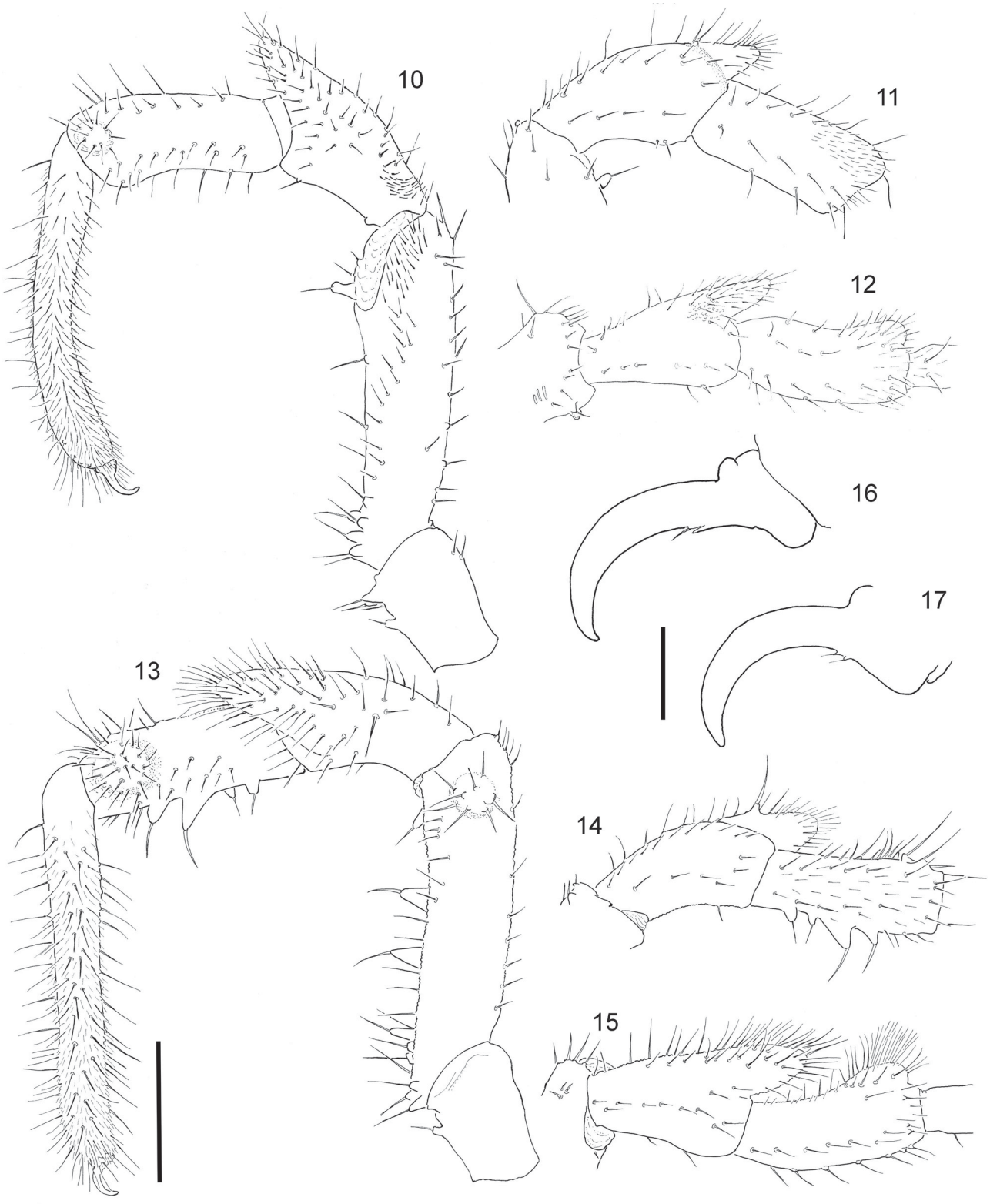
Body, ventral side (Fig. 2): Cx with minute dark distal spot, otherwise like Op gen whitish with a yellow touch; free opisthosomal segments laterally light brown, medially with an irregular white stripe. Body unarmed except for few dark setae scattered on Cx and Op gen, shorter and hardly recognizable setae on opisthosomal segments.

Legs: Generally light to translucent, with broad, light brown, ring-shaped markings on Fe, Pt, Ti and Mt; size normal (in comparison with other phalangiids), with five sharply delimited longitudinal rows of minute, black, closely spaced setae accentuating the pentagonal cross



Figs 5-9. *Kalliste pavonum* gen. sp. nov. (5) Body of male holotype with chelicerae and pedipalps in lateral view. (6) Same (without chelicerae and pedipalps) in dorsal view. (7) Male chelicera in retro-lateral view. (8) Female chelicera in same view. (9) Male tuber oculorum in lateral view. Scales: 1.0 mm (Figs 5-6); 0.3 mm (Figs 7-8); 0.25 mm (Fig. 9).

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Figs 10-17. *Kalliste pavonum* gen. sp. nov. (10-12) Male pedipalp in pro-lateral (10), retro-lateral (11) and dorsal view (12); patella and tibia only (11-12). (13-15) Female pedipalp in pro-lateral (13), retro-lateral (14) and dorsal view (15); patella and tibia only (14-15). (16-17) Palpal claws of male (16) and female (17), both from Col de Verde, lateral view. Scales: 0.3 mm (Figs 10-15); 0.03 mm (Figs 16-17).

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section of Pt and Ti, less so of Fe; Mt and Ta with a rounded cross section; longest setae on tarsal articles; no denticles present on legs.

Pedipalp (Figs 10-12, 16): Translucent shiny, raptorial-clamp-type (by combination of both pedipalps) with strong equipment of Apo on Pt and Ti, massive spines on Fe and Ti ventrally, sexually dimorphic (see below). All articles stout and massive; Tr with few denticles and setae ventrally. Fe slightly bent ventrad, strong setae dorsally, pro-laterally and ventrally, on ventral side setae placed on blunt spines proximally and distally; a field of hairs (setae or microtrichia) present pro-laterally near distal end of Fe, at same position as knob-like Apo of female (see below). Pt large, with a prominent, pointed pro-lateral Apo directed slightly dorsad and distad, covered with strong setae; minute strong setae forming a curved field distally on pro-lateral side of Fe. Ti strong, slightly curved downwards, distinct knob-like pro-lateral Apo at distal end of article covered with few strong setae, longer setae present on dorsal and ventral side of Ti. Ta slender, curved ventrad, most slender in mid-part, tapering distally and proximally, covered all round with setae of different lengths, long and fine setae at distal end around the claw, minute trichomes interspersed. No ventral row (or band) of dark, sclerotized, point-like structures (as present in many species of various Phalangiinae genera). Claw (Fig. 16) well developed, on inner (ventral) side two fine, filiform denticles with a slightly broadened base (not a comb-like row of denticles like in Sclerosomatidae or *Dentizacheus* Rambla, 1956), situated in proximal half.

Chelicera (Fig. 7): Stout, 1st article short, with few denticles dorsally, 2nd article comparatively large, with several strong denticles at the proximal knee and on pro-lateral side, scattered setae frontally, pro- and retro-laterally; setae largest close to insertion of movable finger.

Penis morphology (Figs 18-26): Truncus penis (Figs 18-22) stout, enlarged base (in do/ve views) comprising about three fifth of whole truncus and containing penial muscle. Truncus from its base towards glans first slightly broadened for a short section, then slightly tapering and continuing more or less parallel-sided and slightly widening towards glans (in ve/do views). Base in la view (Figs 20, 22) much slenderer, less abruptly merging into distal part of truncus. Glans (Figs 23-24): In la view upper edge (i.e. ventral side) slightly concave, lower edge strongly bulging; two pairs of short setae in distal third of glans; in ve view strongly constricted at about mid-length. Stylus (Figs 25-26) strong and relatively long, with a broad triangular tooth sub-distally on lower (i.e. dorsal**)** side.

FEMALE (Figs 3-4, 8, 13-15, 17, 27): Similar to male, Tu oc situated even closer to prosoma frontal rim, shiny and armed as in male.

Coloration and dorsal saddle markings: As in male, segments VI and VII silvery white, ventral side as in male, ovipositor visible through translucent cuticle of Op gen.

Chelicera (Fig. 8): Proportions as in male, no denticles on 2nd article.

Pedipalp (Figs 13-15, 17): Similar to male but with spines, setae and Apo more strongly developed (i.e. the normal phalangiid condition). Fe with long setae and several strong tubercles topped by a seta each spread all over ventral side, distally on pro-lateral side a knob-like Apo covered with few strong setae. Pt with Apo like in male but more pronounced, distally slightly rounded. Ti massive, ventrally with four spines of different sizes topped by a long seta each, pro-laterally at distal end a large knob-like Apo covering nearly entire depth of article (in pro-lateral view, Fig. 13), long setae mainly in distal part of article. Ta being the longest article, straight, slightly tapering towards distal end, covered by long setae all over, longest setae nearly reaching depth of article (in la view), in addition a dense coat of microtrichia. Claw (Fig. 17) generally similar to that of male, lower (concave) side with two small denticles, each carrying a filiform apex, about twice as long as base, located in proximal half of claw.

Legs: Proportions similar to those of male; slightly less strong, black, closely spaced setae present; Pt less pentagonal but more rounded in cross section.

Ovipositor morphology (Fig. 27): Two complete distal segment rings broader than proximal ones, three distal rings more or less distinctly split (last one completely split, second last one split only distally, third last one completely split). Long setae on two distal rings, shorter ones on proximal rings. Rec sem not recognizable. Disto-lateral bulbs on last segment longish, distally covered by long fine setae forming a compound sensillum (Hoheisel & Martens, 1990).

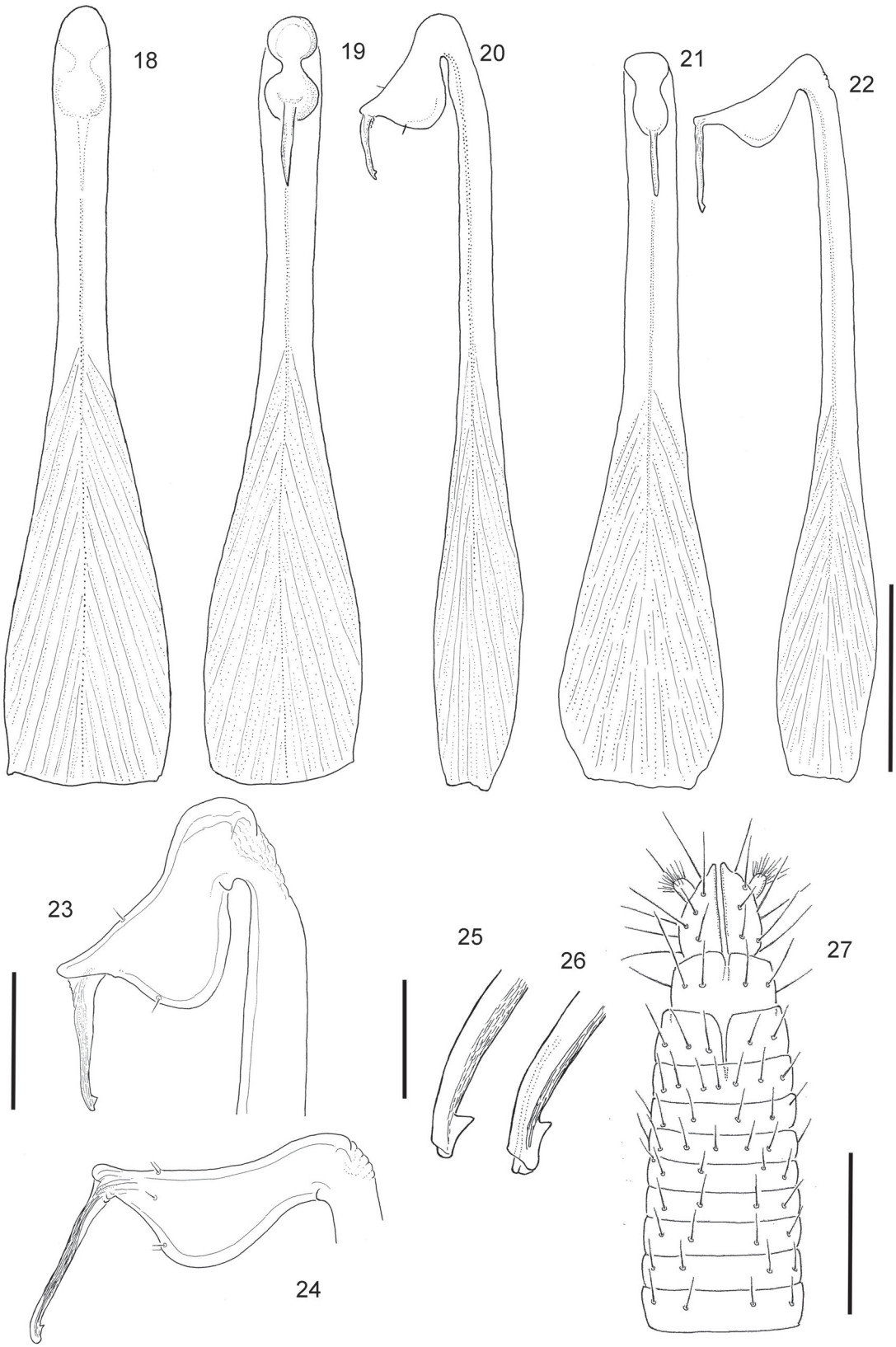
Measurements: Body length of males 1.8-2.0 (n=4), of females: 1.9-2.6 (n=3). Leg II length of male (holotype), in parantheses of female paratype: Fe 2.7 (2.2), Pt 0.7 (0.6), Ti 2.3 (2.0), Mt 1.9 (1.4), Ta 5.3 (4.3). Pedipalp length of male, in parentheses of female: Tr 0.25 (0.25) Fe 0.6 (0.6), Pt 0.35 (0.4), Ti 0.4 (0.4), Ta 0.6 (0.8). Penis length of holotype and of one male paratype (n=2): 0.9, 1.0.

Variation: Shape of glans and length of stylus of glans vary remarkably (Figs 23-26). Due to sparse material, detailed information is presently not available.

Distribution, habitat and phenology: According to present knowledge, *K. pavonum* sp. nov. is confined to the central mountainous parts of the island of Corsica (France) and until now only known from two high-altitude passes, Col de Verde and Col de Vizzavona. These are in easy reach by car on good roads, about 35 km east of Aléria on the eastern coast. The two localities are separated from each other by approximately 12 km linear distance.

The specimens were found on the ground, under stones and dead wood, in forests dominated by beech (*Fagus sylvatica*). Present records lie between 1000-1200 m.

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Figs 18-27. *Kalliste pavonum* gen. sp. nov. Male and female copulatory organs. (18-20) Penis of male from Col de Verde in ventral (18), dorsal (19) and lateral view (20). (21-22) Penis of male from Col de Vizzavona in dorsal (21) and lateral view (22). (23-24) Stylus, glans and distal part of truncus penis in lateral view (23: Col de Verde, 24: Col de Vizzavona). (25-26) Distal part of stylus in lateral view (25: Col de Verde, 26: Col de Vizzavona). (27) Distal part of ovipositor in ventral view. Scales: 0.3 mm (Figs 18-22); 0.05 mm (Figs 23-24); 0.025 mm (Figs 25-26); 0.2 mm (Fig. 27).

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Maturity time is August and September and may extend at least to the onset of frost; juveniles were also collected in August and September (see Material). Because of its small size and light colour, specimens of this species are easily overlooked among juveniles of other species to which adults of *K. pavonum* sp. nov. look similar.

DISCUSSION

New genera records: During the last decades, new genera of harvestmen were rarely established for newly detected and previously undescribed species in Europe. None of them has been evaluated in a broader context using also molecular genetic analyses; all of them have to be regarded as hypotheses. Most prominent are *Lola insularis* Kratochvíl, 1937 (cavernicolous; Phalangodidae; Croatia), *Paralola buresi* Kratochvíl, 1958 (cavernicolous; Travuniidae; Bulgaria), *Tranteeva paradoxa* Kratochvíl, 1958 (cavernicolous; Sironidae; Bulgaria), *Odontosiro lusitanicus* Juberthie, 1961, *Paramiopsalis ramulosus* Juberthie, 1962 (both surface-dwelling, in litter, Sironidae; Portugal), *Rilaena balcanica* Šilhavý, 1965 (surface-dwelling; Phalangiidae; Bulgaria), *Anarthrotarsus martensi* Šilhavý, 1967 (surface-dwelling, in litter, Trogulidae; Greece), *Ausobskya athos* Martens, 1972 (surface-dwelling, in litter; Phalangodidae; Greece), *Iberosiro distylos* de Bivort & Giribet, 2004 (cavernicolous; Sironidae; Portugal) and *Saccarella schilleri* Schönhofer & Martens, 2012 (surface-dwelling, in litter; Nemastomatidae; Italian south-western Alps). Thus, the present discovery of a surface-dwelling, non-cavernicolous, minute phalangiid species for which a new genus needs to be established comes quite unexpected. The new species lives in remote mountainous areas of Corsica, an island which is known for a number of endemics in various animals groups, including vertebrates, like the famous Corsican nuthatch (*Sitta whiteheadi*). Several endemic opilionid species were described from this island, among them *Parasiro corsicus* (Simon, 1872), *P. minor* Juberthie, 1958, *Trogulus aquaticus* Simon, 1879, *Anelasmocephalus pusillus* Simon, 1879, *Nelima ponticoides* Martens, 1969 and *Dicranopalpus insignipalpis* Simon, 1879. One undescribed species each of the genera *Mitostoma* Roewer, 1951 and *Lacinius* Thorell, 1876, also from Corsica, await formal description. Presumably, *Kalliste pavonum* sp. nov. will turn out to be another insular endemic, and presently its relationships can only be discussed with reservations. Opilionid species assemblage of the neighbouring island Sardinia, larger than Corsica but less mountainous, differs markedly. Marcellino (1982) provided a comparative overview which in the meantime is somewhat outdated.

Genus level systematics: *Kalliste* nov. gen. belongs to a set of phalangiid genera which has the pedipalpal articles patella and tibia armed with a strong distoprolateral apophysis each. Ventrally, the pedipalp articles (namely femur, patella and tibia) of these species are often armed with strong seta-bearing tubercles, but numbers and arrangement vary. This armament forms an effective prey-catching basket, the clamp type of pedipalps, in *Kalliste* better called a "raptorial clamp type" (Wolff *et al*., 2016: fig. 12). Within the European fauna, genera possessing this set of characters belong to *Rilaena* Šilhavý, 1965, *Megabunus* Meade, 1885, *Metaplatybunus* Roewer, 1911, *Lophopilio* Hadži, 1931 and *Platybunus* C.L. Koch, 1839. This congruence of characters may indicate close relationships but convergent development seems more plausible because the similarities in pedipalp morphology seem to be superficial and may even be plesiomorphic for a lineage within the Palangiidae.

Rilaena is a highly heterogeneous genus to which, after its erection by Šilhavý (1965), a number of mainly Near East and Central Asian species was added. Apparently, *Rilaena* does not comprise a monophyletic entity but contains a number of superficially similar but not closely related species (personal observation).

Megabunus is a peculiar genus of rock-face-dwelling species of the Alps (plus two additional species from western Europe and former Yugoslavia) to which recently three alpine species were added following a molecular genetic analysis (Wachter *et al.,* 2015). With respect to *Kalliste* nov. gen. it exhibits similar features in genital morphology, i.e. rather compact form of truncus penis, but details markedly differ, i.e. extent of penial muscle, form of glans and size. Also armament and shape of the ocularium are quite dissimilar.

Metaplatybunus has its main diversity in the Mediterranean and also includes a number of species from the Balkan peninsula, Turkey and the near East. Most of its species are not revised and properly described yet, additional ones await formal description. Generally, *Metaplatybunus* comprises large species with strong denticles and spines on legs and pedipalps and with a heavily armed large, broad ocularium. Presumably also the species currently included in this genus will turn out to be a quite heterogeneous assemblage once molecular genetic analyses are applied.

Lophopilio stands out by a strong and heavy truncus penis which appears triangular in cross section and by a peculiar armament of its ocularium. This is a rather isolated monotypic genus.

Platybunus is not a member of this assemblage because of its distinctly different male genital morphology, especially the extremely slender truncus and glans of its penis, and because of the different shapes of body and ocularium. Staręga (1976) even erected a separate subfamily, Platybuninae Staręga, 1976, to highlight these differences. He also added *Lophopilio* to Platybuninae, its sole species being quite dissimilar to *Platybunus* species.

In addition, all the males and often also females of the

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species of the beforementioned genera have in common a rounded, knob-like apophysis in the distal part of the pro-lateral side of the femur; this character is absent in *Kalliste pavonum* sp. nov. males.

Character development: Most probably the raptorial clamp-shaped pedipalps of these phalangiid genera developed independently several times as a most effective basket-like device for capturing and further manipulating prey prior to intake. This hypothesis is supported by the fact that many interior (copulatory organs) and exterior (pedipalps, ocularium, body form and size, ecology) characters of the species of these genera differ in many details, indicating separate evolutionary units.

Also in other families of Eupnoi, e.g. in the Sclerosomatidae, a family related to Phalangiidae, basked-like structures developed on the pedipalps, but this happened rarely. Wolff *et al.* (2016) illustrated an unnamed juvenile sclerosomatid specimen with distinct patellar and tibial apophysis, and Martens (1973, 1982, 1987) presented several sclerosomatid species of various genera from Nepal bearing such apophyses at least on the palpal patella. As sclerosomatids generally do not possess clamp-type pedipalps with seta-bearing denticles, this may be another indication of parallel evolution of this pedipalp type in Eupnoi.

Another characteristic feature which may prove useful to track relationships in Phalangiidae is the muscle portion of the truncus penis. This muscle, which moves the glans upward into a distal position by means of a muscle-tendon-system (Martens, 1976), is always located in the proximal part of the truncus. However, extent of the muscle and shape of the truncus part harbouring the muscle largely differ between genera, less so between species of single genera. Muscle size is able to influence penis shape, *vice versa* probably also penis shape can influence the extent of the muscle. Generally, truncus penis shape in phalangiids follows a simple pattern: from its base the truncus is tapering towards the glans insertion, the muscle is situated in the base, i.e. the largest, most voluminous part of the truncus. The possible degree of modification is limited; it varies from a largely unmodified truncus to one with a small, bulbous base which is well differentiated from the remainder of the truncus. An extended muscle with a short tendon and, as a morphological consequence, a vaguely enlarged (or undifferentiated) truncus base is generally regarded as plesiomorphic, whereas a shorter muscle, concentrated in a bulbous base and attached to a long tendon, as apomorphic. This assumption is supported by the fact that in molecular genetic analyses of Nemastomatidae, a dyspnoian family, the species of the genus *Mitostoma* Roewer, 1951, characterized by large extended muscles (in this family always two muscles are present) are sister to all other nemastomatid genera so far analysed. In contrast, a distinctly separated base with a small and compact penis muscle, as seen in *Paranemastoma* Redikorzev, 1936 and related genera, form a distantly related clade (Schönhofer & Martens, 2010). *Kalliste* gen. nov. exhibits a large, "heavy" penis with a muscle extending up to the distal part of the truncus, but slight variation in length occurs (two penes examined). In view of this truncus-muscle-ratio, a close relationship of *Kalliste* gen. nov. to any of the above mentioned phalangiid genera seems unlikely. On the other hand, genital morphological characters of *Kalliste* gen. nov. do not match those of any other European or Near Eastern genus, the species of which possess non-raptorial clamp-like pedipalps like in *Phalangium* Linnaeus, 1758 or *Eudasylobus* Roewer, 1911.

Two more characters attribute *Kalliste* gen. nov. an outstanding position within the Phalangiidae: a tooth on the glans stylus and filiform denticles on the palpal claw. A tooth at the stylus tip is known solely in *Phalangium opilio* Linnaeus, 1758, situated sub-distally on the ventral side. In *Kalliste* gen. nov. the hook is on the dorsal side. Šilhavý (1948, 1956) who meticulously illustrated details of glans and stylus of Central European Phalangiidae, found it only in this species.

The two filiform denticles on top of a broader base on the ventral (i.e. inner) side of the palpal claw in *Kalliste* gen. nov. are unique as well. Dentate palpal claws in Phalangiidae have been described in *Rilaena balcanica* Šilhavý, 1965 and *Dentizacheus tinerfensis* Rambla, 1956, but they differ in details. In *Kalliste* gen. nov. the denticles end in a long filiform apex, something not found in any phalangiid or sclerosomatid species. Šilhavý (1961) defined a whole subfamily, the Dentizacheinae, on the basis of strongly dentate palpal claws, which was never accepted as a valid taxon (Crawford, 1992). Staręga (1973) placed it in the synonymy of the Phalangiinae. With regard to the characters discussed above, *Kalliste* gen. nov. thus seems to be a rather isolated genus and species without close relatives within the West Palearctic opilionid assemblage.

ACKNOWLEDGEMENTS

My sincere thanks go to Beate and Klaus Pfau who collected the *Kalliste* gen. nov. specimens back in 1982 and drew my attention to this remarkable phalangiid species. T. Hartmann, photo atelier of Mainz University, kindly took the photographic images. My wife Beate effectively helped with fieldwork in Corsica. Over the years, I was sponsored by the Feldbausch-Stiftung and the Wagner-Stiftung at the Fachbereich Biologie of Mainz University for fieldwork in Europe and Asia. This helped me to find *Kalliste* gen. nov. in the mountains of Corsica. I express my thanks to these institutions and its personnel. J. Gruber (Naturhistorisches Museum Wien, Austria) reviewed an earlier manuscript draft and provided valuable additional information and constructive criticism. P. Schwendinger (MHNG) carefully edited various manuscript versions,

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worked on the colour images and compiled the colour plate (Figs 1-4). F. Martens and H. Pieper gave linguistic advice. Many hearty thanks are due to all of them.

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