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# The genus *Buthus* Leach, 1815 (Scorpiones: Buthidae) in France with description of a new species from the Sainte-Baume Massif

ERIC YTHIER (1, \*) & LÉO LABORIEUX (2)

(1) BYG Taxa, 382 rue des Guillates, 71570 Romanèche-Thorins, France.

– E-mail : [contact@bygtaxa.com](mailto:contact@bygtaxa.com)

– ZooBank: <http://zoobank.org/06FD0852-A88E-49E5-B8E6-E1494B86C4E1> – Orcid : <https://orcid.org/0000-0002-3194-5184>

(2) 763 Route de Mazaugues, 83470 Saint-Maximin-la-Sainte-Baume, France.

– E-mail : [leo.laborieux@evobio.eu](mailto:leo.laborieux@evobio.eu)

– ZooBank: <http://zoobank.org/1968268F-8B8D-4C4D-B276-E6BDAA7C5D42> – Orcid : <https://orcid.org/0000-0001-7060-8108>

\* Corresponding author

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Scorpion;  
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morphology;  
France;  
Sainte-Baume.

**Abstract.** – A new species of *Buthus* is described on the basis of three specimens collected on the mountain crest of the Sainte-Baume Massif, in the South of France. *Buthus balmensis* sp. n. is mainly characterized by a general coloration yellowish with a dark univittate pattern on tergites, chela fingers with lobe/notch combination obsolete, a size slightly larger than other species occurring in France (*B. occitanus* (Amoreux, 1789) and *B. pyrenaicus* Ythier, 2021), the male slightly smaller than female but with metasoma longer and heavier than in female, pedipalp chela manus swollen and wider than patella in both sexes, metasomal segment I as wide as long in male and longer than wide in female, and a reduced granulation on body and metasoma. The new species shows affinities with *B. pyrenaicus* (most similar species) and *B. occitanus* but can be easily distinguished from these two species by a combination of several key characters. This new scorpion taxon represents the 3<sup>rd</sup> known species of the genus *Buthus* reported from France and the 18<sup>th</sup> reported from Western Europe. Maps of the geographical distribution of *Buthus* species in France is presented and a key for their identification is provided. The presence of *B. pyrenaicus* in Spain is also herewith confirmed.

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## Introduction

As already outlined in a recent publication (Ythier, 2021), until the unexpected description of two new species of *Buthus* from Spain (*B. ibericus* Lourenço & Vachon 2004 and *B. montanus* Lourenço & Vachon 2004) only one nominal species of the genus *Buthus* Leach, 1815 was generally considered to occur in Western Europe, *B. occitanus* (Amoreux, 1789). A few years later, several other species were described or revalidated from Spain (*B. ajax* C. L. Koch 1839, *B. elongatus* Rossi 2012, *B. alacanti* Teruel & Turiel, 2020, *B. baeticus* Teruel & Turiel, 2020, *B. delafuentei* Teruel & Turiel, 2020, *B. garcialorcai* Teruel & Turiel, 2020, *B. manchego* Teruel & Turiel, 2020, *B. serrano* Teruel & Turiel, 2020, *B. pedrosousai* Teruel & Turiel 2021 and *B. iaspis* Teruel & Turiel 2022), Portugal (*B. halius* C. L. Koch 1839, *B. lusitanus* Lourenço 2021 and *B. gabani* Ythier 2021) and France (*B. pyrenaicus* Ythier, 2021), showing a high degree of microendemism, as already demonstrated in the genus *Buthus* in other regions of complex topography (e.g.

northern Africa) with mountain ranges providing the prerequisites for extensive speciation in geographically limited areas (e.g. Lourenço, 2002; Husemann et al., 2012; Klessler et al., 2018; Ythier et al., 2021).

In France, *B. occitanus* is known to occur in low altitude areas, most of the time under 300 m a.s.l. (82% of reported observations) and almost always under 500 m a.s.l. (95% of reported observations) (Ythier, 2021). The situation is the same in Spain where the known distribution of the species is limited to the Ebro basin (Teruel & Turiel, 2020, 2021). With such low altitude habitat preference, in France *B. occitanus* has been historically considered to be absent (i.e. no reports) from the mountain range of the *Parc Naturel Régional de la Sainte-Baume*, spreading between the departments of Var and Bouches-du-Rhône (Fig. 19-20).

The recent discovery of an isolated *Buthus* population on the mountain crest of the Sainte-Baume Massif (1000 m a.s.l.) and its morphological comparison with *B. occitanus* (from 13 different localities covering the known distribution of the species in France) and *B. pyrenaicus* from the Pyrenees, led to the description of a new species, *Buthus balmensis* sp. n. The

## Reviewers:

Gérard Dupré (Rédacteur du Journal ARACHNIDES, France). - <http://zoobank.org/B3DFB480-9253-4C7C-80EC-FCD7310DFD78>



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new species shows affinities with *B. pyrenaicus* (most similar species) and *B. occitanus* but can be easily distinguished from these two species by a combination of several key characters. This new scorpion taxon represents the 3<sup>rd</sup> known species of the genus *Buthus* reported from France and the 18<sup>th</sup> reported from Western Europe. The presence of *B. pyrenaicus* in Spain is also herewith confirmed.

## Methods

Illustrations and measurements were made with the aid of a Motic SMZ-1713 stereo-microscope with an ocular micrometer, together with a digital camera Tucsen HD Lite, a Canon EOS 7D camera, an Apple iPad and a Wacom Intuos drawing tablet. Maps were made using Géoportail, Adobe Photoshop and Procreate softwares. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974) and morphological terminology mostly follows Vachon (1952) and Hjelle (1990). Specimens studied herein are deposited in the MNHN (Muséum national d'Histoire naturelle, Paris, France) and EYCP (Eric Ythier Private Collection, Romanèche-Thorins, France). Collecting authorisation was obtained from the City of Riboux, in the *Parc Naturel Régional de la Sainte-Baume*, France.

## Composition of the genus *Buthus* in France (in order of description)

- *Buthus occitanus* (Amoreux, 1789) (Alpes-de-Haute-Provence, Ardèche, Aude, Bouches-du-Rhône, Drôme, Gard, Hérault, Pyrénées-Orientales, Var, Vaucluse)
- *Buthus pyrenaicus* Ythier 2021 (Pyrénées-Orientales)
- *Buthus balmensis* sp. n. (Var)

## Taxonomic treatment

Family **Buthidae** C. L. Koch, 1837

Genus ***Buthus*** Leach, 1815

***Buthus occitanus*** (Amoreux, 1789)

(Fig. 17, Tab. II-III)

### **Material examined** (54 ex.)

- Alpes-de-Haute-Provence, Gréoux-les-Bains, VII/2002 (E. Ythier, C. Benros-Ythier, G. Roy, J.-M. Chambon, M. Boutin), 1 ♀, 4 juvenile ♂, 8 juvenile ♀, EYCP (EY0011).
- Alpes-de-Haute-Provence, Manosque, VII/2002 (E. Ythier, C. Benros-Ythier, G. Roy, J.-M. Chambon, M. Boutin), 1 ♀, EYCP (EY0109).
- Ardèche, Saint-Remèze, Les Costes, 26/IV/2004 (S. Rojkoff), 1 ♀, MHNL (47036304).
- Aude, Lapalme, Cap, 01/IV/1974 (N. Jean-Pierre), 1 ♀, MHNL (47023111).
- Bouches-du-Rhône, Marseille, ca. 1840-1860 (J. M. Perret / C. Jourdan), 2 ♀, 3 juvenile ♂, 5 juvenile ♀, MHNL (44000886).
- Bouches-du-Rhône, Fontvieille, 03/X/1949 (D. Jean), 1 ♀, MHNL (47023174).
- Bouches-du-Rhône, Aix-en-Provence, Col des Portes, ca. 1970-1980 (J.-B. Lacroix), 1 juvenile ♂, J.-B. Lacroix leg. (No. 283), 1993, EYCP (EY0306).

- Drôme, Saint-Restitut, 26/VI/1974 (P. Grivot), 1 ♂, 2 ♀, 2 juvenile ♀, MHNL (47023129, 47023130, 47023133, 47023134, 47023135).

- Gard, Souvignargues, VII/2007 (E. Ythier), 1 ♂, 1 ♀, 2 juvenile ♂, 1 juvenile ♀, EYCP (EY005); 28/X/2022 (E. Ythier, C. Benros-Ythier, L. Ythier, L. Ythier), 4 ♂, 2 ♀, EYCP (EY0388).

- Hérault, location unknown, ca. 1930-1950 (G. Favarel), 1 ♀, C. Escudé leg., 06/VI/2017, MHNL (47023162).

- Hérault, location unknown, ca. 1970-1980 (G. Chavanon), 1 juvenile ♀, G. Chavanon leg., 26/02/2004, MHNL (47036256).

- Var, Vidauban, Plaine des Maures, along D48, 25/VII/2011 (P. Escoubas), with collecting permit (*Ministère de l'écologie* SEEIDD-ERNR1-11-11-30334), 2 ♂, EYCP (EY395), 3 ♀, EYCP (EY0362, EY0374).

- Var, between Plan-d'Aups and Mazaugues, along D95, VI/2018 (L. Laborieux), 1 ♂, 1 ♀, EYCP (EY0389).

- Vaucluse, Gordes, Garrigue, 31/III/2002 (S. Rojkoff), 1 juvenile ♀, MHNL (47036320).

**Diagnosis** (emended). – Scorpion of medium to moderately large size for the genus, with a total length of 50-70 mm. General coloration pale yellow to yellowish orange; carapace with ocular tubercle marked with dark pigments; tergites with dark spots on median carina forming a dark univittate pattern; metasoma and pedipalps yellowish with some carinae slightly infuscate; legs yellowish. Carinae and granulations moderately to strongly marked on carapace and tergites. Metasoma with carinae moderately marked; dorsal and dorsolateral weakly subcrenulate to crenulate on segments II-IV; ventral feebly raised distally on II-III, stronger in female; anal arc composed of two lateral lobes and 8-11 ventral teeth; intercarinal spaces minutely granular, especially dorsally and more densely on V. Pedipalps with carinae moderately marked and all faces weakly granular on femur and patella; chela with carinae vestigial, smooth; femur with some macrosetae which are mostly concentrated along ventrodorsal edge, patella with a few macrosetae scattered all over. Leg tibial spurs strongly developed. Pectines with 31-34 teeth in male, 25-30 in female. Sexual secondary dimorphism moderate in habitus with male more slender and smaller than same size-class female (54-64 mm in male, 50-70 mm in female). Sexual secondary dimorphism conspicuous in pedipalps with chela manus slenderer in male (length/width ratio 1.68-1.87, length/depth ratio 1.43-1.61) than in female (length/width ratio 1.44-1.66, length/depth ratio 1.22-1.43) and narrower than patella in male (manus/patella width ratio 0.87-0.99) while wider than patella in female (manus/patella width ratio 1.04-1.22). Chela fingers with lobe/notch combination obsolete; fingers long (movable fingers/manus length ratio 1.76-2.03 in male, 1.55-1.87 in female); fixed finger with 11-13 rows of granules, movable finger with 12-14 rows of granules. Sexual secondary dimorphism inconspicuous in metasoma (very similar in both sexes and with size and shape standard for the genus), conspicuous in telson with vesicle small and sub-globose in male, wider than deep (length/width ratio 1.27-1.39, length/depth ratio 1.37-1.50, width/depth ratio 1.06-1.10), moderately globose in female, wider than deep (length/width ratio 1.15-1.22, length/depth ratio 1.29-1.38, width/depth ratio 1.06-1.17). Metasomal segment I longer than wide in both sexes (length/width ratio 1.03-1.13 in male, 1.02-1.07 in female).

### **Distribution.**

**France.** – Departments of Alpes-de-Haute-Provence, Ardèche, Aude, Bouches-du-Rhône, Drôme, Gard, Hérault, Var, Vaucluse. The species has been historically considered to be absent from the mountain range of the *Parc Naturel Régional de la Sainte-Baume*, where the new species was found (Fig. 19-20).

**Spain.** – Provinces of Navarra, Tarragona, Zaragoza.



**Fig. 1-4.** *Buthus balmensis* sp. n., habitus (Scale bar = 1 cm).

1-2. ♂ holotype. 1. dorsal 2. ventral.

3-4. ♀ paratype. 3. dorsal 4. ventral.

***Buthus pyrenaicus*** Ythier, 2021

(Fig. 18, Tab. II-III)

**Material examined** (7 ex.)

- Pyrénées-Orientales, Cerbère, 1 ♂ holotype, 25/IX/1938 (A. Primot), MHNL (47036301).
- Pyrénées-Orientales, Cerbère, 2 ♀ paratypes, V/1950 (P. Cauchois), MHNL (47023075, 47023076).
- Pyrénées-Orientales, Montauriol, Mas Julia (St Michel), 1 ♀ paratype, 23/VIII/1980 (P. Cauchois), MHNL (47023076).
- Pyrénées-Orientales, Massif des Albères, 2 juvenile ♀ paratypes, ca. 1970-1980 (J.-B. Lacroix), J.-B. Lacroix leg. (No. 111), 1993, EYCP (EY0244).

**Diagnosis.** – Scorpion of medium to moderately large size for the genus, with a total length of 60–67 mm. General coloration pale yellow to yellowish orange; carapace with ocular tubercle marked with dark pigments; tergites with dark spots on median carina forming a dark univittate pattern; metasoma and pedipalps yellowish with some carinae slightly infuscate; legs yellowish. Carinae and granulations moderately to strongly marked on carapace and tergites. Metasoma with carinae moderately marked; dorsal and dorsolateral vestigially to weakly subcrenulate on segments II–IV; ventral feebly raised distally on II–III, stronger in female; anal arc composed of two lateral lobes and 10–12 ventral teeth; intercarinal spaces minutely granular, especially dorsally and more densely on V. Pedipalps with carinae moderately marked and all faces weakly granular on femur and patella; chela with carinae vestigial, smooth; femur with some macrosetae which are mostly concentrated along ventrodistal edge, patella with a few macrosetae scattered all over. Leg tibial spurs strongly developed. Pectines with 31 teeth in male, 26–28 in female. Sexual secondary dimorphism moderate in habitus with male more slender and slightly larger than female (67 mm in male, 60–66 mm in female). Sexual secondary dimorphism conspicuous in pedipalps with chela manus slenderer in male (length/width ratio 1.42, length/depth ratio 1.42) than in female (length/width ratio 1.29–1.42, length/depth ratio 1.21–1.30) and slightly wider than patella in male (manus/patella width ratio 1.04) while wider than patella in female (manus/patella width ratio 1.08–1.14). Chela fingers with lobe/notch combination obsolete; fingers long, slightly longer in male (movable fingers/manus length ratio 1.91) than in female (1.64–1.75); fixed finger with 12–13 rows of granules, movable finger with 13–14 rows of granules. Sexual secondary dimorphism moderate in metasoma (size and shape standard for the genus but longer and heavier in male) and in telson with vesicle slightly less globose in male (deeper than wide; length/width ratio 1.42, length/depth ratio 1.35, width/depth ratio 0.95) than in female (wider than deep; length/width ratio 1.11–1.17, length/depth ratio 1.18–1.35, width/depth ratio 1.06–1.18). Metasomal segment I longer than wide in male (length/width ratio 1.12), wider than long to as wide as long in female (length/width ratio 0.97–1.00).

**Distribution.** – **France:** Department of Pyrénées-Orientales. As suggested in Ythier (2021), the species is now also confirmed to occur in **Spain** (Cap de Creus, Girona Province – Fig. 19). The specific identity of other records from the Provinces of Girona, Lérida and Barcelona should be regarded as confirmation pending until specimens become available for study.

***Buthus balmensis* sp. n.**

(Fig. 1–16, Tab. I–III)

ZooBank: <http://zoobank.org/3C1127BC-9D51-463D-80DE-4781BB072588>

**Holotype**, ♂, France, Var, Sainte-Baume Massif, on the mountain crest, 1000 m a.s.l., 17/VI/2022 (L. Laborieux), deposited in the MNHN.

**Paratypes**, 2 ♀, France, Var, Sainte-Baume Massif, on the mountain crest, 1000 m a.s.l., 17/VI/2022 (L. Laborieux), deposited in the MNHN and EYCP (EY0390).

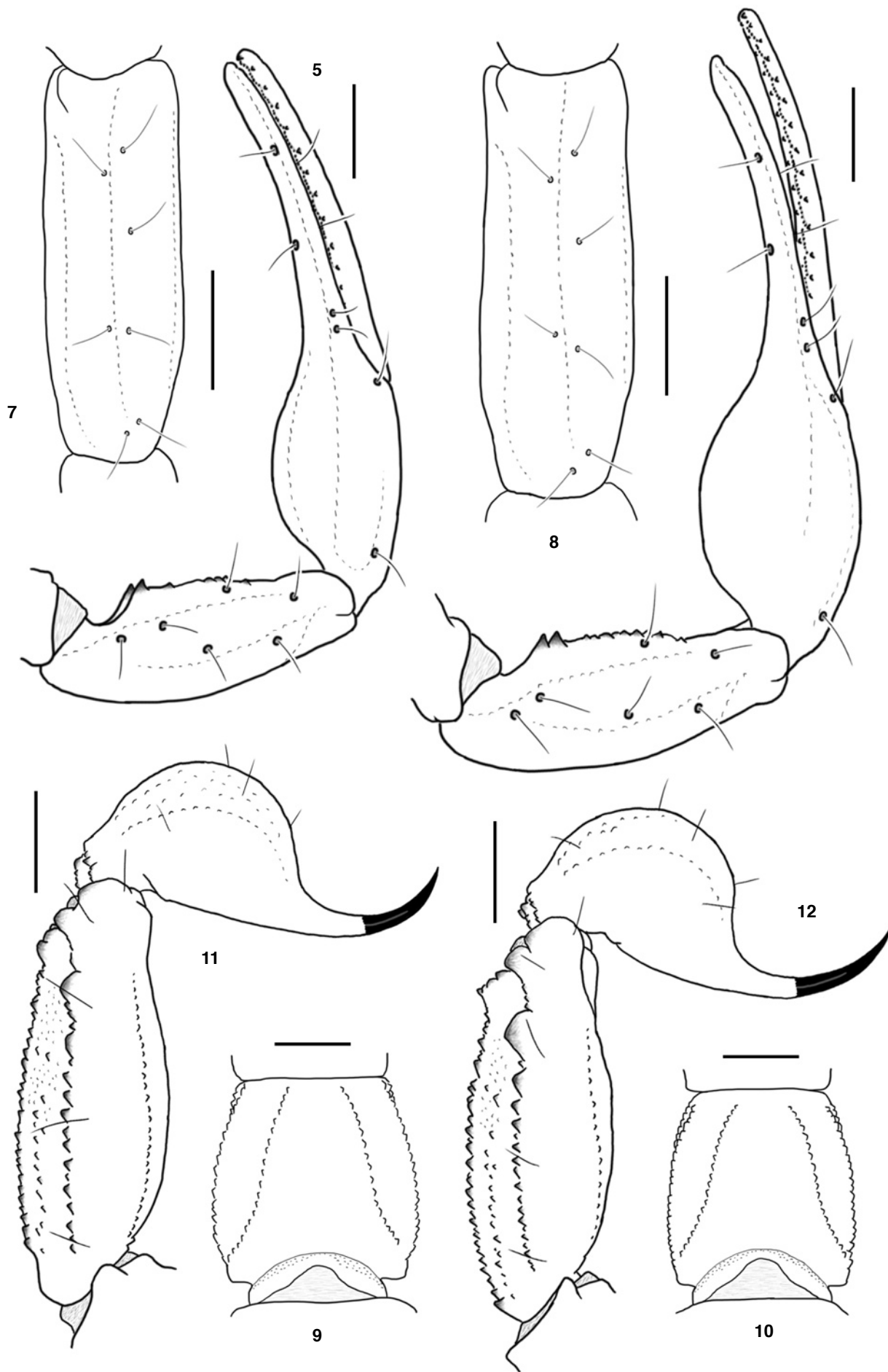
**Etymology.** – The specific epithet refers to the Sainte-Baume Massif (owing its name to the cave - from the Gallic “balma” - of Sainte Marie-Madeleine), where the new species occurs.

**Diagnosis.** – Scorpion of moderately large size for the genus, with a total length of 68–73 mm. General coloration pale yellow to yellowish orange; carapace with ocular tubercle marked with dark pigments; tergites with dark spots on median carina forming a dark univittate pattern; metasoma and pedipalps yellowish with some carinae slightly infuscate; legs yellowish. Carinae moderately to strongly marked on carapace and tergites. Granulations moderately marked on carapace and on lateral sides of tergites I–VI, the central area between lateral carinae almost smooth; tergite VII entirely smooth. Sternites smooth. Metasoma with carinae moderately marked; dorsal and dorsolateral vestigially to weakly subcrenulate on segments II–IV; ventral feebly raised distally on II–III, stronger in female; intermediate carinae complete on segment I, present on distal half of II, on distal third on III, absent on IV–V; anal arc composed of two lateral lobes and 10 ventral teeth; intercarinal spaces minutely granular on segment V, especially dorsally; other segments smooth. Pedipalps with carinae moderately marked and all faces weakly granular on femur and patella; chela with carinae vestigial, smooth; femur with some macrosetae which are mostly concentrated along ventrodistal edge, patella with a few macrosetae scattered all over. Leg tibial spurs strongly developed. Pectines with 32 teeth in male, 26–29 in female. Sexual secondary dimorphism moderate in habitus with male more slender and slightly smaller than female (67 mm in male, 71–72 mm in female). Sexual secondary dimorphism conspicuous in pedipalps with chela manus slenderer in male (length/width ratio 1.52, length/depth ratio 1.37) than in female (length/width ratio 1.40–1.46, length/depth ratio 1.26–1.28) and slightly wider than patella in male (manus/patella width ratio 1.07) while wider than patella in female (manus/patella width ratio 1.16–1.23). Chela fingers with lobe/notch combination obsolete; fingers long, slightly longer in male (movable fingers/manus length ratio 2.00) than in female (1.77–1.86); fixed finger with 12 rows of granules, movable finger with 13 rows of granules. Sexual secondary dimorphism moderate in metasoma (size and shape standard for the genus but longer and heavier in male) and in telson with vesicle slightly less globose in male (length/width ratio 1.42, length/depth ratio 1.46, width/depth ratio 1.03) than in female (length/width ratio 1.14–1.18, length/depth ratio 1.24–1.29, width/depth ratio 1.05–1.13). Metasomal segment I as wide as long in male (length/width ratio 1.00), longer than wide in female (length/width ratio 1.06–1.08).

**Description** (based on male holotype and female paratypes. Measurements in Table I).

**Coloration.** – Basically pale yellow to yellowish orange. Prosoma: carapace yellowish with median and lateral ocular tubercles marked with dark pigments; carinae slightly infuscate. Mesosoma yellowish with conspicuous dark spots on median carina forming a dark univittate pattern. Metasomal segments yellowish with some carinae slightly infuscate; telson vesicle yellowish, aculeus yellowish orange at its base and blackish at its extremity. Venter yellowish; genital operculum and pectines paler than the other zones. Chelicerae yellowish; fingers yellowish with dark red teeth. Pedipalps yellowish without spots; fingers with the oblique rows of granules dark red. Legs yellowish.

**Morphology.** – Carapace moderately granular; anterior margin with a weak concavity. Carinae moderately to strongly marked; anterior median, central median and posterior median carinae strongly granular, with ‘lyre’ configuration. Furrows deep. Median ocular tubercle located in the centre of the carapace; eyes separated by about two ocular diameters; three pairs of lateral eyes of moderate size in relation to median eyes. Sternum triangular, weakly narrowed, slightly wider than long. Mesosoma: three longitudinal carinae moderately to strongly crenulate in all tergites; lateral carinae reduced in tergites I and II; tergite VII pentacarinat. Tergites I–VI moderately granular on lateral sides; the central area between lateral carinae almost smooth; tergite VII entirely smooth. Venter: genital operculum divided longitudinally, each plate with a semi-oval shape. Pectines: pectinal tooth count 32–32 in male holotype and 26 to 29 in females paratypes; middle basal lamella of the pectines not dilated. Sternites without granules, smooth with elongated spiracles; four moderate carinae on sternite VII; four weak on posterior half of VI; other sternites acarinated and with two vestigial furrows. Metasomal segments with a weak setation; segment I with ten complete carinae, II–IV with eight, V with five; intermediate carinae complete on segment I, present on distal half of II, on distal third on III, absent on IV–V; dorsal and dorsolateral carinae vestigially to weakly subcrenulate on segments II–IV; ventral carinae moderately marked and feebly raised distally on II–



**Fig. 5-12.** *Buthus balmensis* sp. n. (Scale bars = 2 mm).

5-6. Right pedipalp patella and chela, dorsal aspect, showing the trichobothrial pattern. 5. ♂ holotype. 6. ♀ paratype.

7-8. Right pedipalp patella, external aspect, showing the trichobothrial pattern. 7. ♂ holotype. 8. ♀ paratype.

9-10. Metasomal segment I, dorsal aspect. 9. ♂ holotype. 10. ♀ paratype.

11-12. Metasomal segment V and telson, lateral aspect. 11. ♂ holotype. 12. ♀ paratype.



III, stronger in female; segment V with ventrolateral carinae crenulate with 2-3 lobate denticles posteriorly; ventral median carina divided posteriorly, over 1/3 of the total length; anal arc composed of 10 ventral teeth and two lateral lobes. Intercarinal spaces minutely granular on segment V, especially dorsally; other segments smooth. Metasoma size and shape standard for the genus but longer and heavier in male than in female. Metasomal segment I as wide as long in male (length/width ratio 1.00), longer than wide in female (length/width ratio 1.06-1.08). Telson with some vestigial granulations ventrally; aculeus curved and shorter than the vesicle (aculeus/vesicle ratio 0.67 in male, 0.75-0.83 in female), without a subaculear tubercle; telson with vesicle slightly less globose in male (length/width ratio 1.42, length/depth ratio 1.46, width/depth ratio 1.03) than in female (length/width ratio 1.14-1.18, length/depth ratio 1.24-1.29, width/depth ratio 1.05-1.13). Cheliceral dentition as defined by Vachon (1963) for the family Buthidae; external distal and internal distal teeth approximately the same length; basal teeth on movable finger small and not fused; ventral aspect of both fingers and manus covered with long dense setae. Pedipalps with a weak setation, femur with some macrosetae which are mostly concentrated along ventrodorsal edge, patella with a few macrosetae scattered all over; femur pentacarinat; patella with 8 carinae moderately to strongly marked, internal with 9-10 spinoid granules, all faces weakly granular; chela with vestigial carinae, almost smooth; chela manus slenderer in male (length/width ratio 1.52, length/depth ratio 1.37) than in female (length/width ratio 1.40-1.46, length/depth ratio 1.26-1.28) and slightly wider than patella in male (manus/patella width ratio 1.07) while wider than patella in female (manus/patella width ratio 1.16-1.23); fingers with lobe/notch combination obsolete; fingers long, slightly longer in male (movable fingers/manus length ratio 2.00) than in female (1.77-1.86); fixed finger with 12 rows of granules, movable finger with 13 rows of granules; internal and external accessory granules present, stronger than principal granules; three accessory granules on the distal end of the movable finger next to the terminal denticle. Legs: tibial spurs strong on legs III and IV; pedal spurs strong on legs I to IV. Trichobothriotaxy: trichobothrial pattern of Type A, orthobothriotaxic as defined by Vachon (1974). Dorsal trichobothria of femur arranged in  $\beta$  (beta) configuration (Vachon, 1975).

**Distribution.** – Only known from the type locality, on the mountain crest (1000 m a.s.l.) of the Sainte-Baume Massif, Var, France (Fig. 19-26).

**Comparisons.** – *Buthus balmensis* sp. n. shows affinities with *B. pyrenaicus* (most similar species) and *B. occitanus* in respect to four key characters: general coloration yellowish with a dark univittate pattern along tergites, pedipalp chela narrower in males than females, pedipalp fingers with lobe/notch combination obsolete and metasomal segments with ventral carinae feebly raised distally on II-III. Adults of these two species can however be easily distinguished from *B. balmensis* sp. n. notably by the following main features:

- *B. pyrenaicus*

(i) size slightly smaller in female with a total length of 60-66 mm (72-73 mm in *B. balmensis* sp. n.);

(ii) male slightly larger than female (slightly smaller in *B. balmensis* sp. n.);

(iii) granulations moderately to strongly marked on carapace (moderate only in *B. balmensis* sp. n.) and tergites (in *B. balmensis* sp. n., tergites I-VI moderately granular on lateral sides only, the central area between lateral carinae almost smooth and tergite VII entirely smooth);

(iv) male pedipalp chela manus wider with length/width ratio 1.42 (1.52 in *B. balmensis* sp. n.) and less deep with length/depth ratio 1.42 (1.37 in *B. balmensis* sp. n.);

(v) fingers shorter (movable fingers/manus length ratio 1.91 in male, 1.64-1.75 in female) than in *B. balmensis* sp. n. (2.00 in male, 1.77-1.86 in female);

(vi) metasomal intercarinal spaces minutely granular, especially dorsally and more densely on V (in *B. balmensis* sp. n., intercarinal spaces minutely granular on segment V only, especially dorsally; all other segments smooth);

(vii) metasomal intermediate carinae present on distal half of segments II-III (present on distal third in *B. balmensis* sp. n.);

(viii) metasomal segment I wider than long to as wide as long in female with length/width ratio 0.97-1.00 (longer than wide in *B. balmensis* sp. n. with length/width ratio 1.06-1.08) and longer than wide in male with length/width ratio 1.12 (as wide as long in *B. balmensis* sp. n. with length/width ratio 1.00);

(ix) male metasomal segment V narrower with length/width ratio 2.24 (2.14 in *B. balmensis* sp. n.) and telson vesicle deeper than wide with width/depth ratio 0.95 (wider than deep in *B. balmensis* sp. n. with width/depth ratio 1.03);

(x) several other distinct morphometric values (Tab. II-III).

It is interesting to notice a convergence in several key characters between both species, like e.g. the swollen pedipalp chela manus (wider than patella in both sexes) or the male metasoma longer and heavier than in female, which might be related to similarities between their habitats, e.g. the high altitude (between 500-1000 m a.s.l. for *B. pyrenaicus* and 1000 m a.s.l. for *B. balmensis* sp. n.), in comparison with *B. occitanus*, occurring under 500 m a.s.l.

- *B. occitanus*

(i) size slightly smaller with 54-64 mm in male (68 mm in *B. balmensis* sp. n.) and 50-70 mm in female (72-73 mm in *B. balmensis* sp. n.);

(ii) granulations moderately to strongly marked on carapace (moderate only in *B. balmensis* sp. n.) and tergites (in *B. balmensis* sp. n., tergites I-VI moderately granular on lateral sides only, the central area between lateral carinae almost smooth and tergite VII entirely smooth);

(iii) sternites with minute granulations laterally and on anterior half centrally (entirely smooth in *B. balmensis* sp. n.);

(iv) male pedipalp chela manus slenderer with length/width ratio 1.68-1.87 (1.52 in *B. balmensis* sp. n.) and length/depth ratio 1.43-1.61 (1.37 in *B. balmensis* sp. n.);

(v) male pedipalp chela manus narrower than patella, with manus/patella width ratio 0.87-0.99 (slightly wider than patella in *B. balmensis* sp. n. with manus/patella width ratio 1.07);

(vi) metasoma very similar in both sexes (male metasoma longer and heavier than female in *B. balmensis* sp. n.) with intercarinal spaces minutely granular, especially dorsally and more densely on V (in *B. balmensis* sp. n., intercarinal spaces minutely granular on segment V only, especially dorsally; all other segments smooth);

(vii) metasoma with intermediate carinae present on distal half of segments II-III (present on distal third in *B. balmensis* sp. n.) and with dorsal and dorsolateral carinae weakly subcrenulate to crenulate on segments II-IV (vestigially to weakly subcrenulate in *B. balmensis* sp. n.);

(viii) male metasomal segment I longer than wide with length/width ratio 1.03-1.13 (as wide as long in *B. balmensis* sp. n. with length/width ratio 1.00);

(ix) male metasomal segment V narrower with length/width ratio 2.21-2.30 (2.14 in *B. balmensis* sp. n.);

(x) several other distinct morphometric values (Tab. II-III).

As already mentioned (Ythier, 2021), all specimens of *B. occitanus* from the 13 different localities studied (Fig. 19-20, including type locality and locality nearby the Sainte-Baume Massif) showed a remarkable homogeneity in morphology in both sexes.

## Distribution and ecological characteristics of the type locality

The Sainte-Baume Massif is a 13 km long limestone mountain ridge, formed as part of the Pyreneo-Provençal orogeny 65 Myr B.P. Stretching from East (Var department) to West (Bouches-du-Rhône department) and with a maximum altitude of 1148 meters a.s.l., the Sainte-Baume Massif displays a combination of rare characteristics that make it stand out as an unusual feature of the local landscape. Due to its altitude, and similarly to other Mediterranean mountains, the Massif is notably cool and humid. The mean annual temperature is 10°C and the mean annual precipitation is 950 mm.



**Fig. 13-18.** Live specimens of *Buthus* species.

**13-16.** *Buthus balmensis* sp. n. **13.** ♂ holotype. **14.** ♀ paratype. **15.** ♂ holotype (right) and ♀ paratype (left) starting to mate. **16.** Juvenile specimen in its habitat in the Sainte-Baume Massif, Var, France.

**17.** *Buthus occitanus* from Manosque, Alpes-de-Haute-Provence, France, ♂ (right) and ♀ (left) mating, showing the difference of sexual secondary dimorphism compared to *B. balmensis* sp. n.

**18.** *Buthus pyrenaicus* in its habitat in Cap de Creus, Gerona, Spain (photo courtesy M. Nadal Calderón).

Moreover, because of the extreme topography of the site, four local ecological units may be distinguished from North to South (Fig. 21):

(i) a northern plateau, dominated by pine (*P. sylvestris* L.) and juniper (*Juniperus* spp. L.),

(ii) a mixed deciduous broadleaf-conifer old-growth forest mainly composed of beech (*Fagus sylvatica* L.), oak (*Quercus ilex* L.), linden (*Tilia platyphyllos* Scop.), maple (*Acer opalus* Mill.) and yew (*Taxus baccata* L.), that has persisted in the area since the mid-Holocene due to the influence of the cliff (Fig. 22-24),

(iii) the comparatively barren mountain crest, on which the new species occurs, with skeletal soils resting on calcareous bedrock, mainly populated by *Genista lobelia* DC., *Santolina decumbens* Mill., *Salvia rosmarinus* Spenn., *Cistus albidus* L. (Fig. 25-26),

(iv) the southern exposure, predominantly composed of Aleppo tree (*Pinus halepensis* Mill.), evergreen oak (*Quercus ilex* L.) and kermes oak (*Q. coccifera* L.) (Fig. 23). The originality of the Sainte-Baume Massif locality extends to its invertebrate fauna, with the notable presence of the *Rosalia longicorn* (*Rosalia alpina* L.) and the near-threatened clouded Apollo (*Parnassius mnemosyne* L.), both protected species.

On the mountain crest, specimens of *Buthus balmensis* **sp. n.** were found in burrows under large, well-exposed stones. Interestingly, on the crest, soil depth varies significantly over short distances, which seems to affect population structure. Indeed, deeper soils are generally preferred for burrowing, which may be essential for successful hibernation (Fig. 16). This would be particularly important for these scorpions, considering that the crest regularly receives significant amounts of snow during the winter months (Fig. 26). Consequently, the distribution of the animals on the crest follows the presence of small patches of suitable habitat. For example, the holotype and paratypes were all collected within a single, visually distinct  $\pm 3500$  m<sup>2</sup> habitat patch, while no scorpions were found in the immediate surroundings. Within such patches, population density appears to be relatively low. The restricted distribution of the new species and its low density suggest paying close attention to the vulnerability of this species.

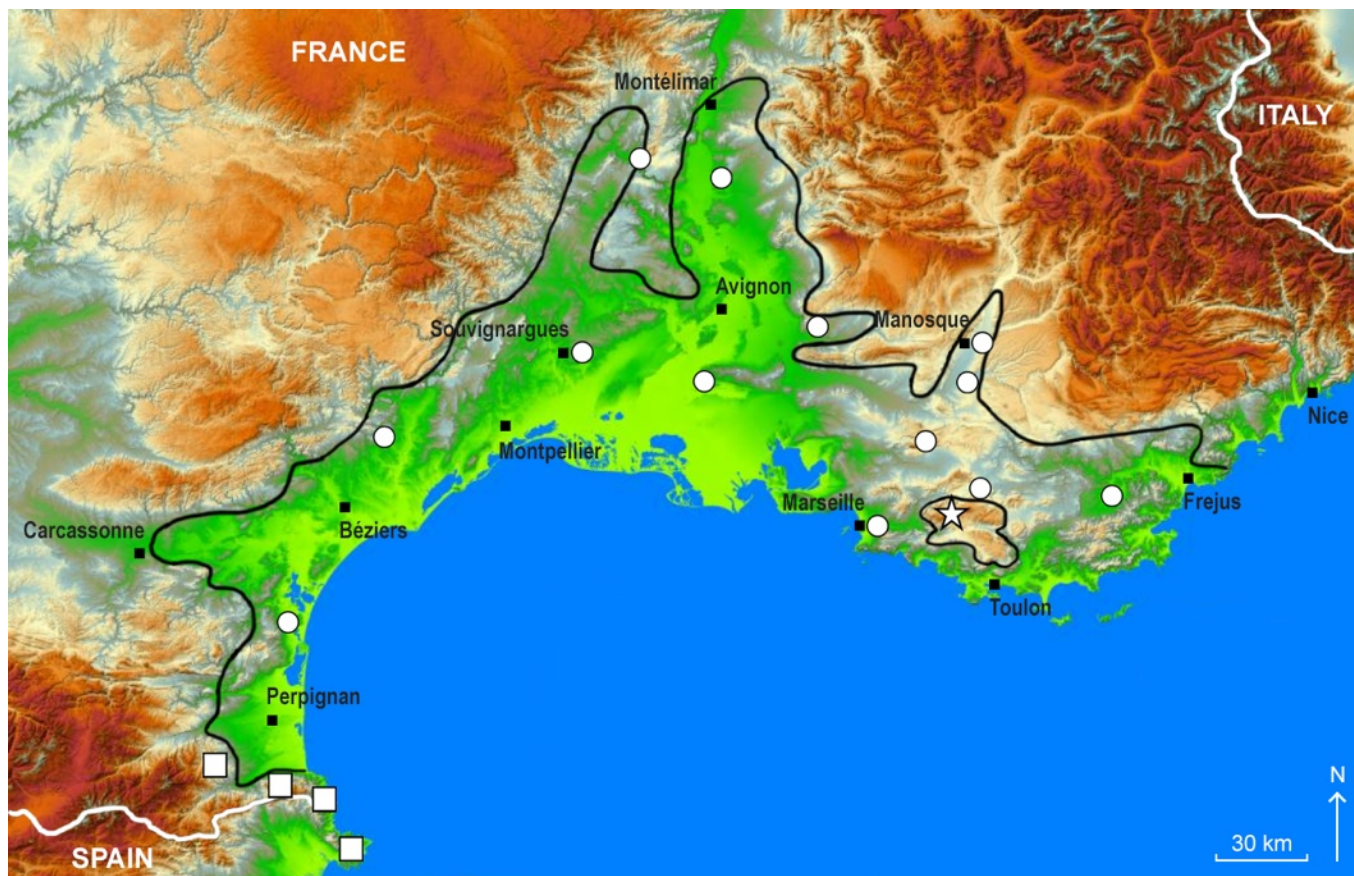
At present, the history of the forest of the Sainte-Baume Massif is not well understood. It is likely that the new species constitutes a case of vicariance, as it has been often demonstrated in the genus *Buthus* in other regions of complex topography (e.g. North Africa, Central and Southern Spain, Pyrenees etc.) with mountain ranges providing the prerequisites for extensive speciation in geographically limited areas (e.g. Lourenço, 2002; Husemann et al., 2012; Klessner et al., 2018; Teruel & Turiel, 2020, 2021; Ythier, 2021; Ythier et al., 2021). Because *Buthus occitanus* has been found to occur at a nearby (< 6km) lower-elevation habitat patch (Fig. 19-20), it can be assumed that a larger population once existed in and around the Sainte-Baume Massif. Dating the isolation of the crest population would be challenging, due to the overall lack of biogeographical data for the area. However, recent work (Robin et al., 2021) highlights a degraded state of the forest assemblages found on the northern plateau and on the southern exposure during the mid-Holocene. This would have allowed for a wider distribution of *B. occitanus* in these areas, potentially including the summit of the mountain ridge. Habitat fragmentation may have occurred once the forest landscapes surrounding the Sainte-Baume Massif ridge regenerated, reproductively isolating the population on the crest as a result. It is important to note that this hypothesis implies rapid speciation, which could be attributed to the strong selective forces associated with a locality displaying such unusual ecological characteristics (Riederer et al., 2022). Indeed, in such a scenario, and assuming a one-year generation time, speciation would have occurred in four to eight thousand generations. The confirmation of such a hypothesis would therefore have significant implications for our understanding of the evolvability of the genus, previous studies having highlighted much longer time scales (Husemann et al., 2012, Klessner et al., 2018, Ythier et al., 2021). Alternatively, the reproductive isolation of the crest population may have occurred as a consequence of older and, to our knowledge, undetermined forest dynamics. This second hypothesis seems more reasonable given the current lack of data, but precisely estimating the divergence time for the *Buthus balmensis* **sp. n.** clade through the use of molecular markers would be an interesting prospect.

## Acknowledgements

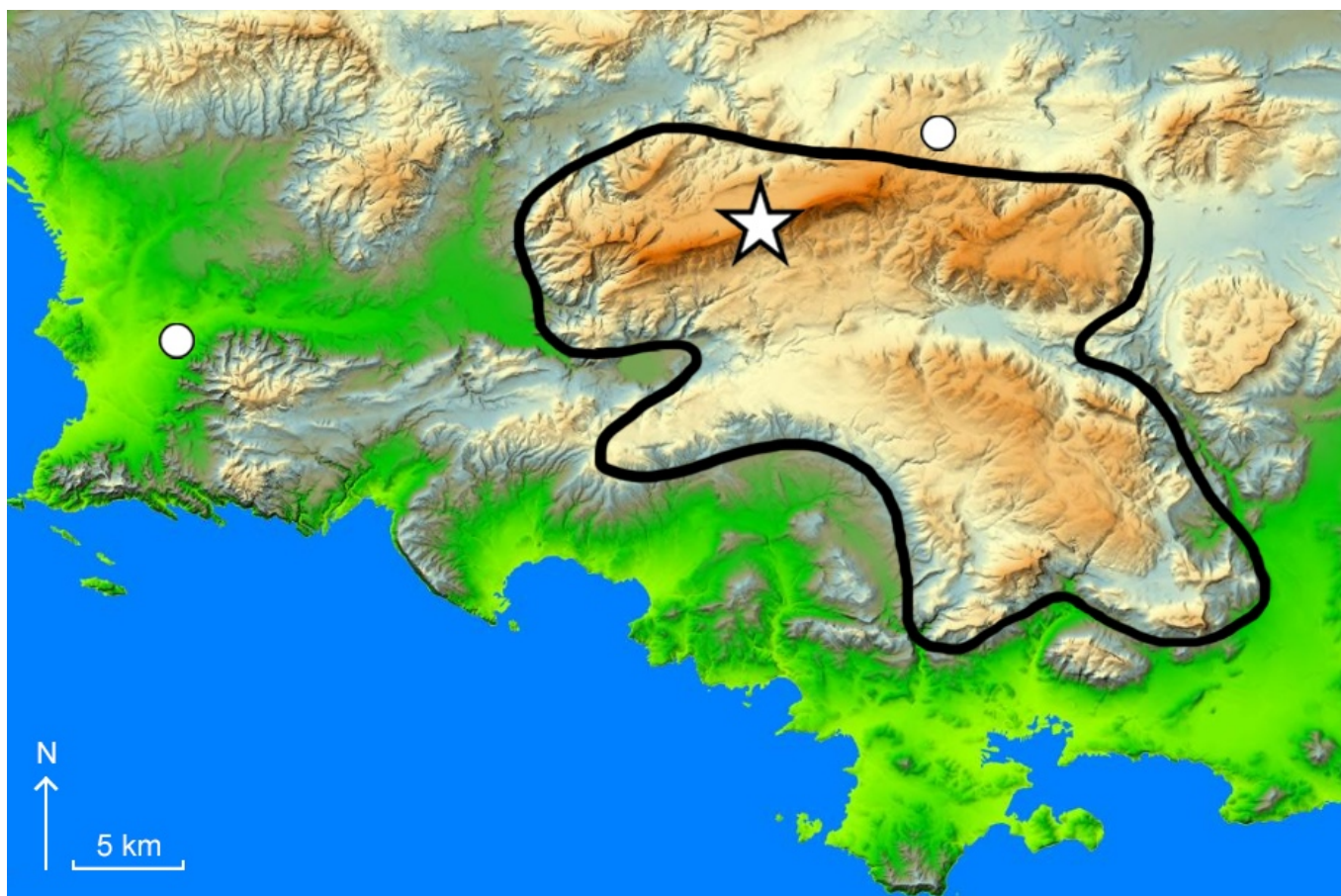
We are very grateful to Mr. Gaëtan Ayache (project coordinator Natura 2000, *Parc naturel régional de la Sainte-Baume*, France) and Mr. Jean-Yves Dolisi (deputy mayor, City of Riboux, France) for the authorization of collection of the type material studied herein. We are also grateful to Marcel Nadal Calderón (Spain) for the photo of the female *B. pyrenaicus* in Cap de Creus, Spain.

## References

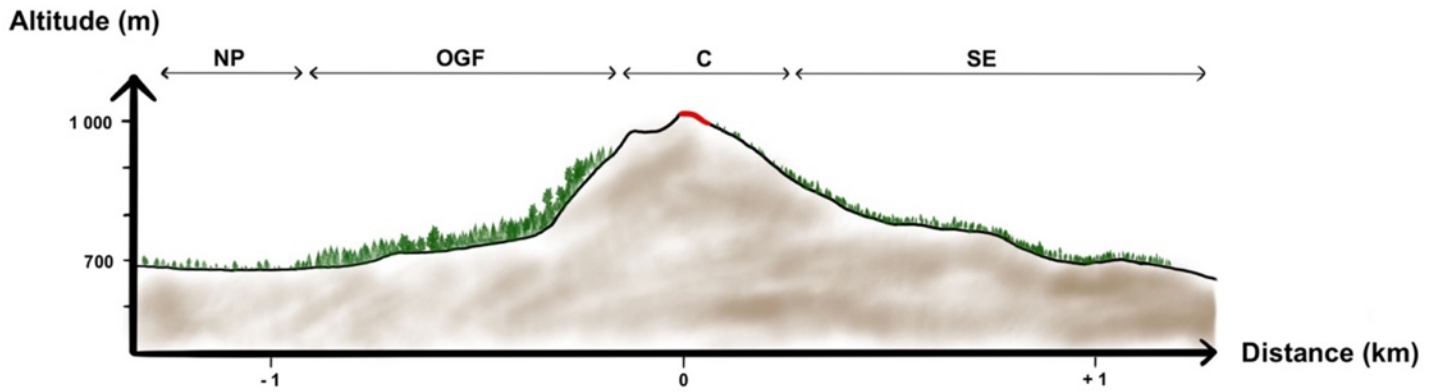
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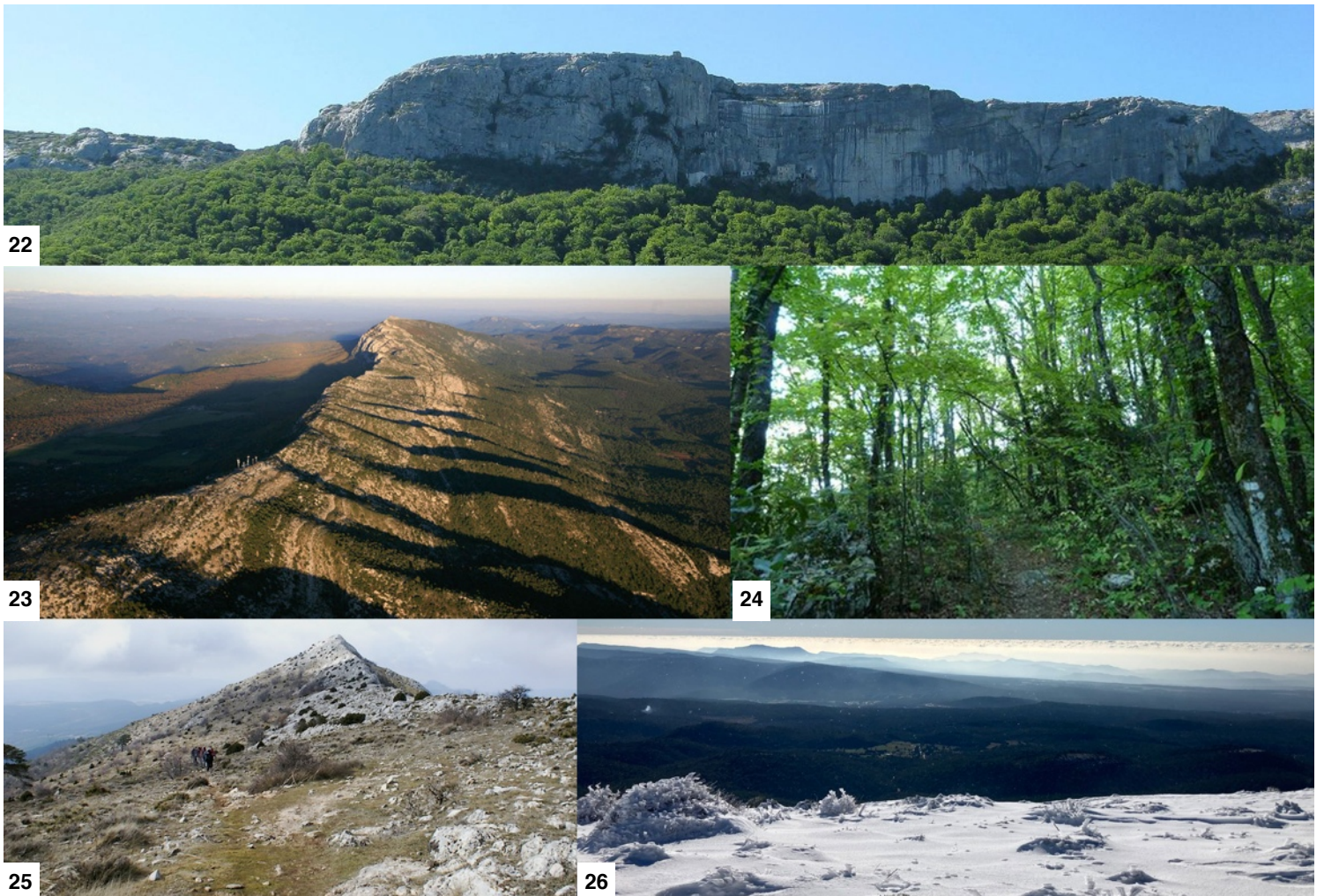
**Fig. 19.** Topographic map of Southern France showing the approximate distribution of *Buthus occitanus* (low altitude area excluding the mountain range of the *Parc Naturel Régional de la Sainte-Baume*, approximately bounded by a black line), the localities of material of *Buthus occitanus* examined in the present study (white circles), the known localities of *Buthus pyrenaicus* (white squares) and the type locality of *Buthus balmensis* sp. n. (white star).



**Fig. 20.** Topographic map of part of the Var and Bouches-du-Rhône departments, showing the approximate distribution of *Buthus occitanus* (low altitude area excluding the mountain range of the *Parc Naturel Régional de la Sainte-Baume*, approximately bounded by a black line), the localities of material of *Buthus occitanus* examined in the area (white circles) and the type locality of *Buthus balmensis* sp. n. (white star).



**Fig. 21.** Schematic relief of the Sainte-Baume Massif showing the distribution of the four main local ecological zones over a North-South transect: Northern Plateau (NP), Old-Growth Forest (OGF), Crest (C) and Southern Exposure (SE). The red line corresponds to the type locality of *B. balmensis* sp. n.



**Fig. 22-26.** The Sainte-Baume Massif.

- 22. Overview of the western part of the Massif, showing the northern old-growth forest and the mountain cliff.
- 23. Aerial view of the Massif, showing the mountain crest surrounded by the northern old-growth forest (left) and southern exposure (right).
- 24. Northern mixed deciduous broadleaf-conifer old-growth forest.
- 25. Mountain crest, natural habitat of *Buthus balmensis* sp. n.
- 26. Mountain crest under snow, with a view on the southern slope and the southern part of the *Parc Naturel Régional de la Sainte-Baume*.

Key to the *Buthus* species occurring in France

1. Male specimen ..... 2  
 – Female specimen ..... 4
2. Pedipalp chela manus slender (length/width ratio 1.68-1.87), narrower than patella (manus width / patella width 0.87-0.99); metasoma similar in size and shape to that of female ..... *B. occitanus* (Amoreux)  
 – Pedipalp chela manus swollen (length/width ratio 1.42-1.52), wider than patella (manus width / patella width 1.04-1.07); metasoma longer and heavier than in female ..... 3
3. Metasomal segment I longer than wide (length/width ratio 1.12); tergites moderately to strongly granular; metasoma intercarinal spaces minutely granular ..... *B. pyrenaicus* Ythier  
 – Metasomal segment I as wide as long (length/width ratio 1.00); tergites I-VI moderately granular on lateral sides only, the central area almost smooth and tergite VII entirely smooth; metasoma minutely granular on segment V only, other segments smooth ..... *B. balmensis* sp. n.
4. Metasomal segment I wider than long to as wide as long (length/width ratio 0.97-1.00) ..... *B. pyrenaicus* Ythier  
 – Metasomal segment I longer than wide (length/width ratio 1.02-1.08) ..... 5
5. Tergites moderately to strongly granular; sternites minutely granular laterally and on anterior half centrally; metasoma intercarinal spaces minutely granular; metasoma similar in size and shape to that of male ..... *B. occitanus* (Amoreux)  
 – Tergites I-VI moderately granular on lateral sides only, the central area almost smooth and tergite VII entirely smooth; sternites entirely smooth; metasoma minutely granular on segment V only, other segments smooth; metasoma smaller and slenderer than in male ..... *B. balmensis* sp. n.

	♂ holotype	♀ paratype	♀ paratype
<b>Total length</b>	67.76	72.73	71.65
<b>Carapace (L - W)</b>	6.86 - 7.71	7.52 - 8.86	7.24 - 8.76
<b>Mesosoma (L)</b>	17.38	24.25	24.13
<b>Metasoma (L)</b>	35.42	32.77	32.09
<b>Metasomal segment I (L - W - D)</b>	5.33 - 5.33 - 4.67	5.14 - 4.86 - 4.48	5.14 - 4.76 - 4.29
<b>Metasomal segment II (L - W - D)</b>	6.76 - 4.95 - 4.57	6.19 - 4.57 - 4.48	5.81 - 4.57 - 4.29
<b>Metasomal segment III (L - W - D)</b>	6.86 - 4.76 - 4.48	6.29 - 4.48 - 4.29	5.90 - 4.29 - 4.19
<b>Metasomal segment IV (L - W - D)</b>	7.90 - 4.38 - 4.00	6.67 - 4.38 - 4.00	6.95 - 4.19 - 3.71
<b>Metasomal segment V (L - W - D)</b>	8.57 - 4.00 - 3.52	8.48 - 4.29 - 3.52	8.29 - 4.19 - 3.24
<b>Telson (L)</b>	8.10	8.19	8.19
<b>Vesicle (L - W - D)</b>	4.86 - 3.43 - 3.33	4.67 - 4.10 - 3.62	4.48 - 3.81 - 3.62
<b>Aculeus (L)</b>	3.24	3.52	3.71
<b>Pedipalp (L)</b>	25.81	28.47	27.14
<b>Pedipalp femur (L - W)</b>	6.29 - 1.81	6.57 - 2.00	5.71 - 1.90
<b>Pedipal patella (L - W)</b>	6.95 - 2.57	7.90 - 2.95	7.52 - 2.86
<b>Pedipal chela (L)</b>	12.57	14.00	13.91
<b>Pedipal chela manus (L - W - D)</b>	4.19 - 2.76 - 3.05	5.05 - 3.62 - 4.00	4.86 - 3.33 - 3.81
<b>Movable finger (L)</b>	8.38	8.95	9.05

**Table I.** Morphometric values (mm) of the adult types of *Buthus balmensis* sp. n. Abbreviations: length (L), width (W), corresponding to posterior width in carapace), depth (D).

	<i>B. balmensis</i> sp. n.	<i>B. occitanus</i>	<i>B. pyrenaicus</i>
Total L	68	<u>54-64</u>	67
Pedipalp L / Carapace L	3.76	3.59-3.70	3.65
Pedipalp chela L/W	4.89	4.88-5.26	4.13
Pedipalp chela manus L/W	1.52	<u>1.68-1.87</u>	<u>1.42</u>
Pedipalp chela manus L/D	1.37	<u>1.43-1.61</u>	<u>1.42</u>
Pedipalp chela L / Movable finger L	1.50	1.49-1.57	1.52
Pedipalp Movable finger L / Chela manus L	2.00	1.76-2.03	<u>1.91</u>
Pedipalp chela manus W / Patella W	1.07	<u>0.87-0.99</u>	1.04
Metasoma L/Carapace L	5.16	4.66-5.16	5.03
Metasomal segment I L/W	1.00	<u>1.03-1.13</u>	<u>1.12</u>
Metasomal segment I L/D	1.14	1.15-1.29	1.24
Metasomal segment IV L/W	1.76	1.63-1.83	1.86
Metasomal segment IV L/D	1.98	1.86-2.04	2.08
Metasomal segment V L/W	2.14	<u>2.21-2.30</u>	<u>2.24</u>
Metasomal segment V L/D	2.43	2.44-2.65	2.63
Telson L/W	2.36	2.30-2.41	2.48
Telson L/D	2.43	2.44-2.62	2.36
Vesicle L/W	1.42	1.27-1.39	1.42
Vesicle L/D	1.46	1.37-1.50	1.35
Vesicle W/D	1.03	1.06-1.10	<u>0.95</u>

**Table II.** Comparative table of total length and selected morphometric ratios of adult males of *Buthus balmensis* sp. n. (France, n=1; MNHN), *Buthus occitanus* (France and Spain, n=13; MHNL, EYCP, Teruel & Turiel, 2020) and *Buthus pyrenaicus* (France, n=1; MHNL).

Abbreviations: length (L), width (W), depth (D). Ratios underlined are reported in the comparisons of main features in the text.

## Résumé

Ythier E. & Laborieux L., 2022. – Le genre *Buthus* Leach, 1815 (Scorpiones: Buthidae) en France avec la description d'une nouvelle espèce du Massif de la Sainte-Baume. *Faunitaxys*, 10(47): 1 – 13.

Une nouvelle espèce appartenant au genre *Buthus* est décrite sur la base de trois spécimens collectés sur la crête du Massif de la Sainte-Baume, dans le sud de la France. *Buthus balmensis* sp. n. est principalement caractérisée par sa coloration générale jaunâtre avec une tache centrale longitudinale foncée sur les tergites, les doigts des mains des pédipalpes avec un lobe basal obsolète, une taille légèrement plus grande que les autres espèces présentes en France (*B. occitanus* (Amoreux, 1789) et *B. pyrenaicus* Ythier, 2021), le mâle légèrement plus petit que la femelle mais avec un metasoma plus long et plus épais, les mains des pédipalpes plus larges que les patellas chez les deux sexes, le segment I du metasoma aussi large que long chez le mâle et plus long que large chez la femelle, et une granulation réduite sur le corps et le metasoma. La nouvelle espèce montre des affinités avec *B. pyrenaicus* (l'espèce la plus proche) et *B. occitanus* mais peut être aisément distinguée de ces deux espèces par une combinaison de plusieurs caractères. Ce nouveau taxon représente la troisième espèce de *Buthus* décrite pour la France et la 18<sup>ème</sup> décrite pour l'Europe de l'Ouest. La présence de *B. pyrenaicus* en Espagne est également confirmée.

Mots-clés. – Scorpion, *Buthus balmensis*, taxonomie, nouvelle espèce, description, morphologie, France, Sainte-Baume.

	<i>B. balmensis</i> sp. n.	<i>B. occitanus</i>	<i>B. pyrenaicus</i>
<b>Total L</b>	72-73	<u>50-70</u>	<u>60-66</u>
<b>Pedipalp L / Carapace L</b>	3.75-3.79	3.49-3.84	<u>3.51-3.58</u>
<b>Pedipalp chela L/W</b>	3.87-4.18	3.68-4.52	3.54-3.85
<b>Pedipalp chela manus L/W</b>	1.40-1.46	1.44-1.66	1.29-1.42
<b>Pedipalp chela manus L/D</b>	1.26-1.28	1.22-1.43	1.21-1.30
<b>Pedipalp chela L / Movable finger L</b>	1.54-1.56	1.54-1.64	1.57-1.61
<b>Pedipalp Movable finger L / Chela manus L</b>	1.77-1.86	1.55-1.87	<u>1.64-1.75</u>
<b>Pedipalp chela manus W / Patella W</b>	1.16-1.23	1.04-1.22	1.08-1.14
<b>Metasoma L/Carapace L</b>	4.36-4.43	4.08-4.48	4.01-4.37
<b>Metasomal segment I L/W</b>	1.06-1.08	1.02-1.07	<u>0.97-1.00</u>
<b>Metasomal segment I L/D</b>	1.15-1.20	1.06-1.19	1.10-1.17
<b>Metasomal segment IV L/W</b>	1.49-1.66	1.59-1.72	1.58-1.69
<b>Metasomal segment IV L/D</b>	1.67-1.87	1.83-1.94	1.70-1.87
<b>Metasomal segment V L/W</b>	1.98	1.97-2.25	1.92-2.07
<b>Metasomal segment V L/D</b>	2.41-2.56	2.26-2.58	2.38-2.51
<b>Telson L/W</b>	2.00-2.15	1.97-2.32	1.91-2.03
<b>Telson L/D</b>	2.26	2.25-2.56	2.03-2.35
<b>Vesicle L/W</b>	1.14-1.18	1.15-1.22	1.11-1.17
<b>Vesicle L/D</b>	1.24-1.29	1.29-1.38	1.18-1.35
<b>Vesicle W/D</b>	1.05-1.13	1.06-1.17	1.06-1.18

**Table III.** Comparative table of total length and selected morphometric ratios of adult females of *Buthus balmensis* sp. n. (France, n=2; MNHN, EYCP), *Buthus occitanus* (France and Spain, n=21; MHNL, EYCP, Teruel & Turiel, 2020) and *Buthus pyrenaicus* (France, n=3; MHNL).

Abbreviations: length (L), width (W), depth (D). Ratios underlined are reported in the comparisons of main features in the text.



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*Illustration de la couverture :*

*B. balmensis* sp. n. juvenile, alive in its habitat.

Crédits photos:

**Eric Ythier** : Fig. 1-15, 17, 19-20

**Léo Laborieux** : Fig. 16, 21 & couverture

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Fig. 24 (<https://www1.onf.fr/enforet/la-sainte-baume/explorer/specifique/20120521-121650-293728/@@index.html>)

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