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Bernhard Seifert. The previous concept of the cosmopolitan pest ant *Tapinoma melanocephalum* (Fabricius, 1793) includes two species (Hymenoptera: Formicidae: Tapinoma). OSMIA, Observatoire des Abeilles, 2022, 10, pp.35-44. 10.47446/OSMIA10.4 . hal-03696331

HAL Id: hal-03696331

<https://hal.archives-ouvertes.fr/hal-03696331>

Submitted on 15 Jun 2022

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ARTICLE

The previous concept of the cosmopolitan pest ant *Tapinoma melanocephalum* (FABRICIUS, 1793) includes two species (Hymenoptera: Formicidae: Tapinoma)

Bernhard SEIFERT¹ 

SEIFERT, B. (2022). The previous concept of the cosmopolitan pest ant *Tapinoma melanocephalum* (FABRICIUS, 1793) includes two species (Hymenoptera: Formicidae: Tapinoma). *Osmia*, **10**: 35–44. <https://doi.org/10.47446/OSMIA10.4>

Abstract

Tapinoma melanocephalum (FABRICIUS, 1793), known under the vernacular name Ghost Ant and being a widely distributed cosmopolitan tramp species with significant pest status, has been considered long-since to represent a single species. Yet, investigation of 83 worker samples from the whole globe provided evidence that the Ghost Ant consists of two species: 8.4 % of the samples belonged to the new species *T. pithecorum* sp. nov. whereas 91.6 % were classified as *T. melanocephalum*. Absence of mixed samples indicates that *T. melanocephalum* and *T. pithecorum* sp. nov. do not represent morphs of the same species. *T. pithecorum* sp. nov. is known from a greenhouse finding in Germany and outdoor populations from the south of the Arabian Peninsula, Pakistan, India, Malaysia and the Fiji and Christmas Islands. The phenotypical separation of the new species from other minute *Tapinoma* species of Orientalic, Indo-Australian and Australasian origin is very clear, allowing identification even by evaluation of z-stack photos. A detailed argumentation is presented that *Tapinoma pellucida* (SMITH, 1857), *T. coronatum* (FOREL, 1908), *T. malesianum* (FOREL, 1913), *T. australis* (SANTSCHI, 1928), *T. australie* (SANTSCHI, 1928), *T. luffae* (KURIAN, 1955), *T. wallacei* (GUERRERO, 2018) and *T. jerdoni* nom. nov. should be considered as synonyms of *T. melanocephalum*. Synonymies of *T. melanocephalum* and *T. pithecorum* sp. nov. with *T. indicum* (FOREL, 1895) and *Tapinoma minutum* (MAYR, 1862) are clearly excluded by morphometric data. Diagrams of principal component analyses, photos, a key as well as a morphometric table to separate these four species are presented. In a concluding section, it is argued that the true number of species related to these four species is much larger than presently known and a warning is given regarding careless use of pigmentation characters in ant identification.

Keywords | Ghost Ant • sister species • tramp species • numeric morphology-based alpha-taxonomy • stereomicroscopy • photo evaluation • color polymorphism • *Tapinoma pithecorum* sp. nov. • *Tapinoma jerdoni* nom. nov.

La précédente conception de la fourmi ravageuse cosmopolite *Tapinoma melanocephalum* (FABRICIUS, 1793) comprend deux espèces (Hyménoptères : Formicidae : Tapinoma)

Résumé

Tapinoma melanocephalum (FABRICIUS, 1793), une espèce cosmopolite connue sous le nom vernaculaire de fourmi fantôme, au statut de ravageur et largement distribuée, a longtemps été considérée comme n'étant qu'une seule espèce. Pourtant, une enquête sur 83 échantillons d'ouvrières du monde entier a fourni la preuve que la fourmi fantôme se compose de deux espèces : 8,4 % des échantillons appartenait à la nouvelle espèce *T. pithecorum* sp. nov. tandis que 91,6 % ont été classés comme *T. melanocephalum*. L'absence de spécimens intermédiaires indique que *T. melanocephalum* et *T. pithecorum* sp. nov. ne représentent pas des morphes de la même espèce. *T. pithecorum* sp. nov. est connue d'une serre située en Allemagne et par des populations vivant en extérieur du sud de la péninsule arabique, du Pakistan, de l'Inde, de la Malaisie et des îles Fidji et Christmas. La séparation phénotypique de la nouvelle espèce des autres espèces de *Tapinoma* d'origine orientale, indo-australienne et australasienne est très claire. Une argumentation est présentée au sujet de *Tapinoma pellucida* (SMITH, 1857), *T. coronatum* (FOREL, 1908), *T. malesianum* (FOREL, 1913), *T. australis* (SANTSCHI, 1928), *T. australie* (SANTSCHI, 1928), *T. luffae* (KURIAN, 1955), *T. wallacei* (GUERRERO, 2018) et *T. jerdoni* nom. nov. qui doivent être considérées comme des synonymes de *T. melanocephalum*. Les synonymies de *T. melanocephalum* et *T. pithecorum* sp. nov. avec *T. indicum* (FOREL, 1895) et *Tapinoma minutum* (MAYR, 1862) ont été exclues par les données morphométriques. Dans une partie conclusive, il est soutenu que le nombre réel d'espèces en lien avec ces quatre espèces est beaucoup plus grand que ce que l'on connaît actuellement et un avertissement est donné au sujet de l'utilisation des caractères de pigmentation dans l'identification des fourmis.

Mots-clés | fourmi fantôme • espèces-sœurs • alpha-taxonomie numérique à base morphologique • stéréomicroscopie • analyse d'image • polymorphisme de couleur • *Tapinoma pithecorum* sp. nov. • *Tapinoma jerdoni* nom. nov.

Reçu • Received | 19 December 2021 || Accepté • Accepted | 13 June 2022 || Publié (en ligne) • Published (online) | 17 June 2022
Reviewers | H. JOURDAN • H. WAGNER || <https://zoobank.org/AFFD232F-08FD-4823-9E0C-570C52D868B7>

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INTRODUCTION

The dolichoderine ant *Tapinoma melanocephalum* (FABRICIUS, 1793) is a globally distributed tramp species that is adapted to tropical or subtropical climate and is not frost-resistant. At latitudes greater than 30°, it is confined to greenhouses and other heated buildings providing the high temperature and humidity needed for the survival. At more southern latitudes, outdoor colonies may persist circannually and are, within the introduction range, more frequently found in anthropogenically disturbed areas (WETTERER, 2009). Workers of *T. melanocephalum* are easily recognized by minute size, very rapid, erratic movements and translucent body parts giving them their vernacular name Ghost Ant. Further basic features are intranidal mating, colony formation via budding and supercoloniality (BUSTOS & CHERIX, 1998). Both indoor and outdoor colonies of this polyphagous ant are considered a major pest by promoting mealybugs and scale insects, by exploiting food sources appointed for animals in human custody or by being a major nuisance when occurring in homes (KLOTZ *et al.*, 1995; LEE *et al.*, 2002; KAMURA *et al.*, 2007). As a vector of pathogenic microorganisms and comparable to the situation in *Monomorium pharaonis* (LINNAEUS, 1758), *T. melanocephalum* is also a major threat to public health and hospital hygiene (MOREIRA *et al.*, 2005; OLIVEIRA *et al.*, 2017). This immediate concern for humans is reflected by a search in the Web of Science conducted 27 October 2021 which revealed 90 papers dealing with this ant alone for the last two decades.

In a small taxonomic revision, GUERRERO (2018) synonymized seven taxa with *Tapinoma melanocephalum* (FABRICIUS,

1793): *Tapinoma nana* (JERDON, 1851), *Tapinoma pellucida* (SMITH, 1857), *Tapinoma familiaris* (SMITH, 1860b), *Tapinoma melanocephalum coronatum* (FOREL, 1908), *Tapinoma melanocephalum malesianum* (FOREL, 1913), *Tapinoma australis* (SANTSCHI, 1928) and *Tapinoma luffae* (KURIAN, 1955). After examining z-stack photos of type specimens presented in www.antweb.org and by GUERRERO (2018), these synonymizations appeared reasonable to me in five taxa. In the two remaining taxa, *T. nana* and *T. luffae*, no counterevidence to GUERRERO's statements is possible because of missing type specimens and insufficient original description in the former taxon and presence of only slides of dissected male type specimens in the latter one (SINGH *et al.*, 2021).

Does all that has been written above on the Ghost Ant refer to a single species? A deviating worker sample collected in the primate house of the Hannover Zoo (Germany) prompted me to have a closer look on the problem in a survey considering 83 worker samples from the whole globe. Seven samples, or 8.4 % of the total, turned out to represent the new species *Tapinoma pithecorum* sp. nov. In addition to the Hannover greenhouse finding, the new species is known in outdoor habitats from south of the Arabian Peninsula, Pakistan, India, Malaysia and the Fiji and Christmas Islands. The survey also showed that the phenotypic separation from *T. melanocephalum* and other minute species of Orientalic, Indo-Australian and Australasian origin is very clear, does not need elaborate multivariate analyses and allows an identification even from photos. This will be reported here.

MATERIAL

A total of 89 worker samples was classified. This divided into 33 samples investigated by direct stereomicroscopic morphometry, 23 samples classified by subjective stereomicroscopic inspection and 33 samples classified by photo evaluation. The photo files included 6 samples of *Tapinoma indicum* and *T. minutum*. The basis for morphometric evaluation of pictures were z-stack photographs of workers provided by www.antweb.org and one photo in GUERRERO (2018). Photo evaluation, which inevitably has a lower precision than direct stereomicroscopy, appeared promising because all four species considered here appeared easily separable. With the first number in brackets referring to samples classified by stereomicroscopic morphometry, the second number referring to samples classified by non-metric stereomicroscopic inspection, and the third number referring to samples classified by photo evaluation, this material originated from the following countries.

Australia (1–0–1), Austria (4–0–0), Brazil (0–1–0), Colombia (0–0–1), Costa Rica (1–4–1), Cuba (1–0–1), Ecuador (0–0–1), Equatorial Guinea (0–2–0), Fiji (1–0–2), Florida (0–1–3), French Polynesia: Moorea (0–0–1), Germany (4–0–0), Ghana (0–0–1), Grenadines (1–0–0), Guinea (1–0–0), India (1–1–2), Indonesia (7–1–1), Ivory Coast (0–1–0), Island (3–0–0), Japan (1–0–0), Madagascar (0–1–3), Malaysia (1–4–0), Myanmar (0–1–0), New Caledonia (0–1–2), Oman (1–0–1), Pakistan (1–0–0), Paraguay (0–0–1), Philippines (1–0–1), Reunion (0–0–1), Saudi Arabia (0–0–1), Samoa (1–0–1), Sao Thome & Principe (0–3–0), Seychelles (0–0–2), Singapore (0–0–2), Sri Lanka (0–0–1), Switzerland (1–0–0), Taiwan (3–0–0), United Arab Emirates (0–2–0), Vanuatu (1–0–2), Yemen (1–0–0).

Detailed data on geographic origin and morphology of morphometrically investigated samples are given in the digital supplementary information SI1 and data on the photographed specimens are given in the digital supplementary information SI2.

METHODS

Photo evaluation: equipment and measurement procedures

Digital photos were assessed in the standard viewing positions head in dorsal view, whole ant in dorsal view and

whole ant in lateral view. This allowed a selection of photos for the condition that measurements under the two-dimensional representation of body parts did not deviate substantially from measurements expected under stereomicroscopic measuring of the real specimen in the

three-dimensional space. When a small tilt of a measuring line under an angle α was indicated by a photo from another, orthogonal viewing position, a correction to the real value was done under use of the cosinus function:

$$\text{real value} = \text{apparent value} / \cos \alpha$$

For measuring, the photos were zoomed on the computer screen to a sufficient size and measurements were read directly under use of a transparent ruler.

Direct stereomicroscopy: equipment and measurement procedures

A pin-holding stage, permitting full rotations around X, Y, and Z axes and a Leica M165C high-performance stereomicroscope equipped with a $2.0 \times$ planapochromatic objective (resolution 1050 lines / mm) was used for spatial adjustment of specimens at magnifications of 150–360 \times . The mean relative measuring error over all magnifications was 0.2 %. A Schott KL 1500 cold-light source equipped with two flexible, focally mounted light-cables, providing 30°-inclined light from variable directions, allowed sufficient illumination over the full magnification range and a clear visualization of silhouette lines. A Schott KL 2500 LCD cold-light source in combination with a Leica coaxial polarized-light illuminator provided optimal resolution of tiny structures and microsculpture at highest magnifications. Simultaneous or alternative use of the cold-light sources depending upon the required illumination regime was quickly provided by regulating voltage up and down. In order to achieve a sharp visualization of contour lines of cuticle, transmitted-light conditions were generated by directing the light stream of a light-cable on a white reflector plane at the base of the pin-holding stage. A Leica cross-scaled ocular micrometer with 120 graduation marks ranging over 52 % of the visual field was used. To avoid the parallax error, its measuring line was constantly kept vertical within the visual field.

Direct stereomicroscopy: the morphometric characters

Sixteen phenotypic characters were investigated: CL, CW, dAN, EL, ExCly, ExClyW, ExOcc, Fu2, Fu3, Fu2W, MpGr, ML, MW, nExCly, PoOc and SL. All measurements were made on mounted and fully dried specimens. Measurements of body parts always refer to real cuticular surface and not to the diffuse pubescence surface. The reproducibility of data recording in general is strongly dependent from carefully considering the character definitions. In very small structures (such as Fu2) the resolution of the microscope and illumination of the object are also important. The characters are as follows:

CL. Maximum cephalic length measured between points A and B. A is the posteromedian margin point of head capsule. B is an imagined median point situated at the same transversal level as the most anterior points of clypeus left and right of clypeal excision. Bilateral asymmetries are averaged.

CS. Cephalic size. Arithmetic mean of CL and CW.

CW. Maximum cephalic width.

dAN. Minimum distance of the inner (centripetal) margins of antennal socket rings which is best measurable in dorsofrontal view (figure 1).

EL. Eye length: maximum diameter of the compound eye over all structurally defined ommatidia. Bilateral mean.

ExCly. Maximum depth of anteromedian clypeal excision as it appears in frontodorsal view and with median line of head positioned perpendicular in the visual field. Bilateral asymmetries are averaged (figure 1).

ExClyW. Width of clypeal excision at the level of the base centers of the two most apical and largest setae. Note: This is a well-measurable standard character in a majority of *Tapinoma* species (figure 1). Yet, due to the very shallow shape or even complete absence of clypeal excision in the species group considered here, ExClyW is difficult to be measured or, when ExCly = 0, not defined. To circumvent this problem, the distance between the base centers of the two most apical and largest setae was taken as substitute data.

ExOcc. Depth of excavation of posterior vertex. Procedure: adjust head in measuring position for CL, focus both posterior corners of vertex until they form a sharp contour, adjust them to equal horizontal level within the visual field and superimpose the corners with the horizontal line of the cross-scale. Change the focal level until the median part of posterior vertex forms a sharp contour. Read the depth.

Fu2. Median length of second funiculus segment in dorsal view. Dorsal view is given when the swiveling plane of 1st funiculus segment is positioned in the visual plane). Take care to really measure median length (the segment's sides have unequal length!) and to recognize the real distal margin of the segment. The latter has a very thin cuticle, frequently producing a narrow, shining ribbon that seems to be, by optical impression, demarcated from the rest of the segment. The median line of the segment is visualized by center of the patch reflecting the coaxial light.

Fu2W. Median width of second funiculus segment in dorsal view. Use of transmitted-light is important visualize the real cuticular surface.

IFu2. Index Fu2 / Fu2W.

ML. Mesosoma length from the caudalmost point of lateral metapleuron (posterior measuring point) to rear margin of anterior pronotal fringe (anterior measuring point). This character is often not measurable because the anterior measuring point is concealed by the head. In this case, with mesosoma in estimated adjustment for measuring a correct ML, the distance from posterior measuring point to dorsal point of pronotal-mesonotal border is measured and this value multiplied by 1.3422 ($n = 9$).

MPGr. Depth of metanotal groove / depression in lateral view. The upper reference line extends between the highest points of mesonotum and propodeum perpendicular to which depth measuring is performed.

MW. Maximum pronotal width.

nExCly. Bilateral sum of pubescence hairs and smaller setae protruding at a few micron across margin of clypeal excision. The two setae at the lateral margin of the excision are not counted.

PoOc. Postocular distance: distance from the transversal level of posterior eye margin to hind margin of head measured in median line. Bilateral asymmetries are averaged.

SL. Scape length excluding articulatory condyle.

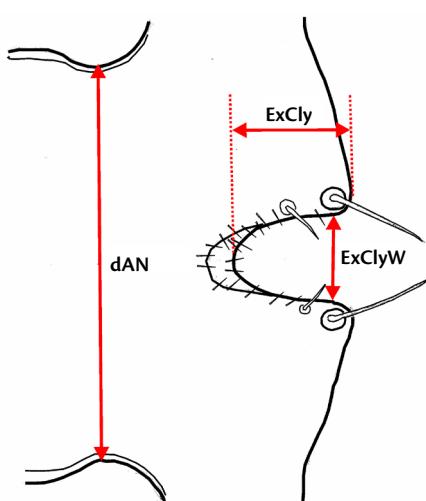


Figure 1. Measuring of the characters dAN, ExCly and ExClyW.

Photo evaluation: the morphometric characters

The characters were the same as in direct stereomicroscopy under exclusion of dAN, EL, ExClyW, ML and nExCly which could not be recorded in the photos with an acceptable error.

Data evaluation

Linear discriminant analysis (LDA), principal component analysis (PCA) and the one-tailed ANOVA test were run with the SPSS 16.0 software package.

RESULTS AND DISCUSSION

In this section, I firstly present a commented account of the synonymies of *Tapinoma melanocephalum* (FABRICIUS, 1793) and of *incertae sedis* presumed in the past to be synonyms of this species. A brief statement by which means a particular taxon has been identified and synonymized is given in square brackets after the original name. After this account, I formally describe the new species *Tapinoma pithecorum* sp. nov., followed by an argumentation for heterospecificity of the four species *Tapinoma melanocephalum*, *T. pithecorum* sp. nov., *T. minutum* and *T. indicum*.

Tapinoma melanocephalum (FABRICIUS, 1793)

Formica melanocephala (FABRICIUS, 1793)
[evaluation of neotype photo]

This taxon has been described from Cayenne in French Guiana. The original description does not allow allocating this name to a certain ant species and in the absence of original material it is unclear on the basis of which arguments later revisers have done this. To stabilize a long naming tradition, GUERRERO (2018) has fixed a neotype in a worker from Calabazo in Colombia. The photo of the neotype given by Guerrero shows the long scape and long funiculus segments that is diagnostic for the cluster named here as *T. melanocephalum* and excludes a synonymy with *Tapinoma pithecorum* sp. nov. (figure 2 and argumentation given below).

Tapinoma pellucida (SMITH, 1857)

Myrmica pellucida (SMITH, 1857)
[evaluation of type photos]

This taxon has been described from Singapore on material collected by A. R. WALLACE. WALLACE noted in a message to SMITH: "House-ant: transparent abdomen: very active, but not destructive." Examined were photos of syntypes from the collections of NHM London (specimen CASENT0903062 in www.antweb.org) and Oxford University Museum (specimen CASENT0901925 in www.antweb.org). The former specimen was assessed to have CL 452 µm, SL 443 µm, PoOc 220 µm, MW 253 µm and the latter one to have CL 496 µm, SL 482 µm, Fu3 56 µm, MW 277 µm. Run as wild-card in a 2-class LDA comparing *T. melanocephalum* and *T. pithecorum* sp. nov. and using these reduced character sets, both the London and the Oxford specimen are allocated to the *T. melanocephalum* cluster with $p = 1.000$.

Tapinoma coronatum (FOREL, 1908)

Tapinoma melanocephalum var. *coronatum* (FOREL, 1908)
[evaluation of type specimen]

This taxon has been described from Punta Arenas (Costa

Rica). Investigated was a type worker from NHM Basel labeled "Costa Rica Bioley" (label of SANTSCHI), "*Tapinoma melanocephalum* v. *coronatum* Costa Rica Bioley (Type)" (FOREL's handwriting). If run as wild-card in a LDA considering the first four factors of a principal component analysis of all characters, the specimen is allocated to the *T. melanocephalum* cluster with $p = 1.000$. The evaluation of the photo of the type specimen CASENT0909775 provided by www.antweb.org confirmed this synonymization (see also figures 2–3).

Tapinoma malesianum (FOREL, 1913)

Tapinoma melanocephalum var. *malesiana* (FOREL, 1913)
[evaluation of type specimen]

This taxon has been described from Soengei Bamban (Sumatra) [3.12°S, 114.74°E]. Investigated was a damaged type worker from NHM Basel labeled "N° 403 fv *T. melanocephalum* FABR. v. *malesiana* FOR.", "Soengei Bambon", and "Cotype". Morphometric data measurable in this specimen were: EL 103.9, ExCly 6.1, dAN 146.8, SL 472.8, Fu2 38.5, Fu2W 41.3, Fu3L 52.7. Run as wild-card in a LDA using these data, the specimen is allocated to the *T. melanocephalum* cluster with $p = 1.000$. The evaluation of the photo of another type specimen in www.antweb.org (CASENT0909776) confirmed this synonymization (see also figure 2).

Tapinoma australis (SANTSCHI, 1928)

Tapinoma melanocephalum var. *australis* (SANTSCHI, 1928a)
[evaluation of type specimen]

This taxon has been described from Samoa. The different names and different type localities demand that *T. australis* (SANTSCHI, 1928a) must be treated separate from *T. australe* (SANTSCHI, 1928b) – even if SANTSCHI most probably meant the same species. Investigated was 1 type worker from NHM Basel, labeled "*Tapinoma melanocephalum* var. *australis* SANTSCHI det. 19", "Amauli 9-6-23", "SWEZEE & WILDER"; "Tutuila Samoa". If run as wild-card in a LDA considering the first four factors of a principal component analysis of all characters, the specimen is allocated to the *T. melanocephalum* cluster with $p = 1.000$ (figure 3).

Tapinoma australe (SANTSCHI, 1928)

Tapinoma melanocephalum var. *australe* (SANTSCHI, 1928e)
[evaluation of type specimens]

This taxon has been described from Santo Island (Vanuatu). Evaluated was one type worker from a series of six workers from NHM Basel, labeled "*Tapinoma melanocephalum* var. *australis* SANTSCHI det. 1927", "NEW HEBRIDES Santo Island,

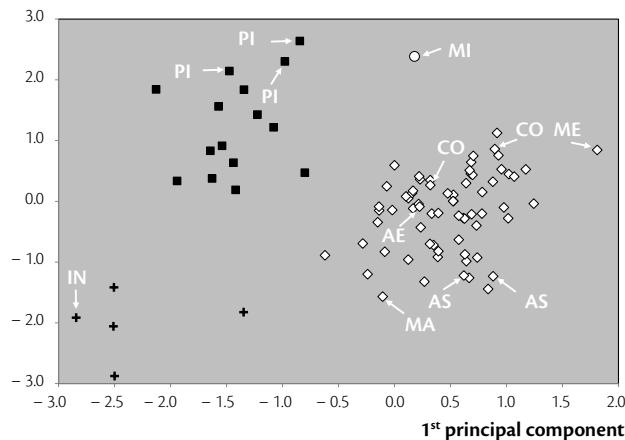
2nd principal component

Figure 2. Principal component analysis of worker specimens using the characters CS, CL / CW, ExCly / CS, ExOcc / CS, PoOc / CL, SL / CS, MpGr / CS, MW / CS, Fu2 / CS, IFu2, and Fu3 / CS, and pooling data from direct stereomicroscopy and photo evaluation.

T. minutum: white dot, only photo evaluation. *T. indicum*: black crosses, only photo evaluation. *T. melanocephalum*: white rhombs, mixed data source. *T. pithecorum* sp. nov.: black squares, mixed data source.

The type specimens have the following abbreviations:

ME *T. melanocephalum*. **AE** *T. australis*. **CO** *T. coronatum*. **IN** *T. indicum*. **MA** *T. malesianum*. **MI** *T. minutum*. **PI** *T. pithecorum* sp. nov.

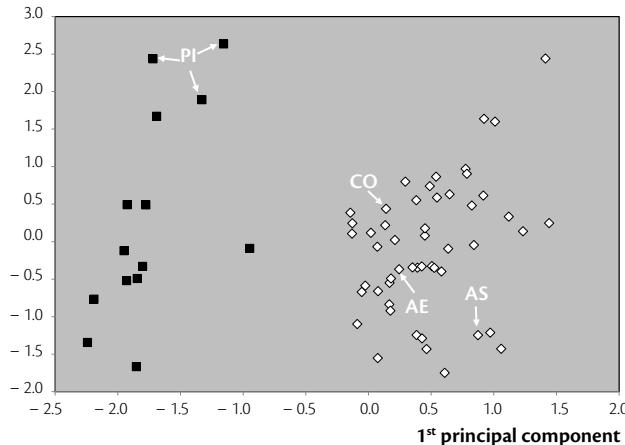
2nd principal component

Figure 3. Principal component analysis of 17 stereomicroscopically recorded phenotypic characters in 65 worker specimens of *Tapinoma pithecorum* sp. nov. (black squares) and *T. melanocephalum* (white rhombs). Abbreviations of type specimens: **AE** type of *T. australis* (SANTSCHI 1928). **AS** type of *T. australis* (SANTSCHI 1928). **CO** type of *T. coronatum* (FOREL 1908). **PI** holotype series of *T. pithecorum* sp. nov.

Hog Harbour 8.VIII.1925, P.A. BUXTON, N.H. 8.A", "Type", and ANTWEB CASENT 0911572. If run as wild-card in a LDA considering the first four factors of a principal component analysis of all characters, the specimen is allocated to the *T. melanocephalum* cluster with $p = 1.000$ (figure 3). The evaluation of the photos of the type specimens CASENT0911572 and CASENT0903063 provided by www.antweb.org confirmed this synonymization (figure 2).

***Tapinoma luffae* (KURIAN, 1955)**

Neoclytospenella luffae (KURIAN, 1955)

[abundance and missing counterevidence]

This taxon has been described as a Bethylidae wasp from Delhi (India). Only microscopic slides of the dissected

holotype and paratype males exist but no specimen of a female caste (SINGH *et al.*, 2021). In the absence of a broad study of male characters in the four species considered here no direct conclusions on species identity are possible. The synonymization with *T. melanocephalum* proposed here is only based on the fact that it is by far the most abundant species of the group and known from India.

***Tapinoma wallacei* (GUERRERO, 2018)**

Formica familiaris (SMITH, 1861b)

[description and missing counterevidence]

Tapinoma wallacei was introduced by GUERRERO (2018) as replacement name for *Formica familiaris* (SMITH, 1861b) that is a primary homonym of *Formica familiaris* (SMITH, 1861a). The type locality of *T. wallacei* is Bacan Island (Indonesia) and the material was collected by Alfred R. WALLACE. The original description reads as follows: "Worker. Length 3/4 line (= 1.59 mm). Pale testaceous, semi-transparent; the thorax at the sides, and behind, more or less dusky; the head dark fuscous, with the mandibles white. Hab. Bachian. This minute Ant is found in houses. Mr. WALLACE says that, when living, its body, legs, and antennae are transparent." This description obviously refers to one of the two known species of the Ghost Ant. The taxon is synonymized here with *T. melanocephalum* alone by the fact that it is the most abundant species and that counterevidence is not possible due to the absence of types of *T. wallacei*. The description of *Formica familiaris* (SMITH, 1861a), based on a winged gyne and stating a total length of 4 1/4 lines (= 9.01 mm), makes clear that it cannot belong to the minute *Tapinoma* species considered here. It probably belongs to the genus *Pseudolasius* (EMERY, 1887).

***Tapinoma jerdoni* nom. nov.**

ZooBank <https://zoobank.org/0AA93B7D-D64F-4EE2-9002-8A61054F5216>

Formica nana (JERDON, 1851)

[description and missing counterevidence]

Tapinoma jerdoni is proposed here as new replacement name for *Formica nana* (JERDON, 1851) that is a junior primary homonym of *Formica nana* (LATREILLE, 1802) that belongs to the subfamily Myrmicinae. *Formica nana* JERDON has been described from Mysore (India). Its original description reads as follows: "Worker, length not 1/12 inch (= 2.1 mm); eyes anterior, thorax wide; abdomen long, elliptical; head and thorax brown; antennae legs, and abdomen pale whitish brown. This very minute species is found in all parts of India and is very abundant in Mysore; from its very small size is noticed with difficulty. It feeds on flowers and vegetable secretion." This description strongly suggests that *Tapinoma jerdoni* nom. nov. belongs to one of the two species of the Ghost Ant. Its synonymization with *T. melanocephalum* proposed here is based on the fact that it is globally by far the most abundant species, that it is known from India and that no counterevidence is possible due to the absence of types.

***Tapinoma pithecorum* sp. nov.**

ZooBank <https://zoobank.org/02C0A98F-87D1-4F97-8EF7-402F57A17F87>

Etymology

Meaning "belonging to the apes" referring to finding of the



Figure 4. Head of a paratype worker of *Tapinoma pithecorum* sp. nov. from Oman. Photo www.antbase.org (CASENT0922866).



Figure 7. Dorsal aspect of a paratype worker of *Tapinoma pithecorum* sp. nov. from Oman. Photo www.antbase.org (CASENT0922866).



Figure 5. Head of a *Tapinoma melanocephalum* worker. Photo www.antbase.org (CASENT0766218).



Figure 8. Dorsal aspect of a *Tapinoma melanocephalum* worker. Photo www.antbase.org (CASENT0766218).

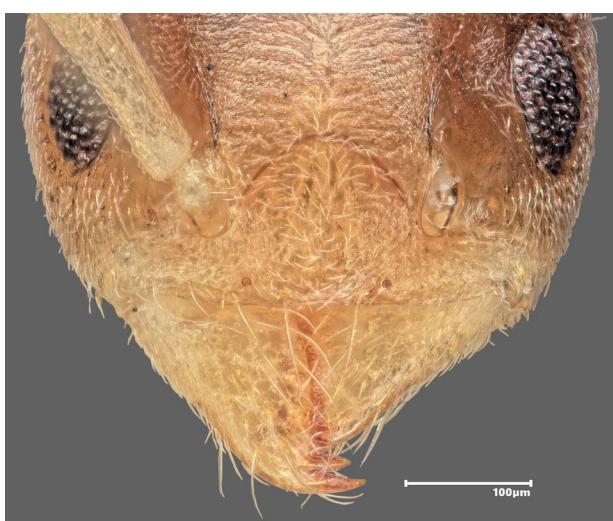


Figure 6. Anterior head and clypeus of the holotype worker of *Tapinoma pithecorum* sp. nov. from Hannover. Photo R. SCHULTZ.



Figure 9. Distal scape and basal funiculus of the holotype worker of *Tapinoma pithecorum* sp. nov. from Hannover. Photo R. SCHULTZ.

first sample in the ape house of the Hannover Zoo.

Type material

Holotype plus two paratype workers labeled "GER:

Hannover, Zoo, Affenhaus, Nest in Rindenmulch, leg. STELLMACHER 2002.09.05"; depository SMN Görlitz. Eight paratype workers labeled "INDIAN OCEAN: Christmas Is. I–IV. 1933."; depositories SDEI Müncheberg (6 paratypes) and

SMN Görlitz (2 paratypes). One paratype worker labeled "INDIA: M. P. KHALGHAT, 200 m 1–13–62" and "Collectors: E. S. ROSS, D. Q. CAVAGNARO"; depository NHM Basel. One paratype worker labeled "Balakot 3500', Kagan Valley 24. V." and "Pakistan 1974, C. BARONI URBANI"; depository NHM Basel. One paratype worker labeled "Penang 5.III.27.", "Dr. EIDMANN legit" and "Nat.Hist.Mus Basel–1972. coll. H. EIDMANN"; depository NHM Basel. One paratype worker labeled "Oman, Dhofar, Salalah, 18.XI.2017, 9 m, M. R. SHARAF" and "ANTWEB CASENT 0922866"; depository CAS San Francisco. One paratype worker labeled "CASENT0095240 ANTC2676", "WEST MALAYSIA: Cameron Highlands 500 m below Tana Rana 6.X.–XXII.2001 Traps A & B O.P. CHOO" depository CAS San Francisco.

Geographic range

Tropical to subtropical species of apparently Orientalic, Indo-Australian and Australasian origin with probably weak tramp species potential and globally much rarer than *T. melanocephalum* (7 against 76 samples). Outdoor populations are known so far from Oman: Salalah [17.02°N, 54.11°E, 9 m], Pakistan: Balakot [34.55°N, 73.35°E, 1070 m], India: Khalgat [22.16°N, 74.45°E, 200 m], Australia: Christmas Island [10.48°S, 105.65°E, 120 m], Fiji: Penang [17.364°S, 178.161°E, 36 m] and Malaysia: Cameron Highlands [4.47°N, 101.37°E, 1400 m]. Greenhouse populations in the temperate zone are so far only known from Germany: Hannover [52.381°N, 9.771°E, 58 m].

Description

Worker (table I, figures 4, 6, 7 and 9). Minute, mean CS=451 µm. Head elongated, CL / CW 1.142. Postocular index larger than in *T. melanocephalum*, PoOc / CL 0.497. Hind margin of vertex usually slightly excavated, ExOcc / CS 0.66 % (compare figures 4 and 5). Anterior clypeal margin in contrast to *T. melanocephalum* not or only very slightly excavated, ExCly / CS 0.44 % (figure 6). Minimum distance of the inner margins of antennal socket rings smaller than in *T. melanocephalum*, dAN / CS 0.324. Scape and 3rd segment of antennal funiculus much shorter than in *T. melanocephalum*, SL / CS 0.846, Fu3 / CS 9.69 % (figure 9). Second funiculus segment very short, always shorter than wide, Fu2 / CS 7.36 %, IFu2 0.759. Maximum eye diameter notably smaller than in *T. melanocephalum*, EL / CS 0.247. Mesosoma more compact, with a larger width and shorter length than in *T. melanocephalum*, MW / CS 0.667, ML / CS 1.158. Pubescence hairs on all body surfaces longer and shaggier than in *T. melanocephalum* but of similar density (figures 4–5). Head and mesosoma medium to blackish brown. Gaster, antennae and legs always notably lighter, in dried specimens very pale yellowish or very pale brownish. Accordingly, it shows basically the same light-dark contrasts as *T. melanocephalum* but it is as a whole darker (figures 7–8). It appears unlikely that gaster and appendages are translucent in living ants as it is observed in *T. melanocephalum* but this remains to be studied.

Differential diagnosis

T. pithecorum sp. nov. is easily separable from other nanitic tropical *Tapinoma* species – both morphometrically (table I) and by subjective visual inspection. It differs from *T. melanocephalum* by a larger postocular index, a shorter

scape and 3rd funiculus segment as well as smaller eye length and smaller or absent clypeal excavation. With all measurements in mm, a simple discriminant $D(2) = 152.56 \times \text{PoOc} - 56.444 \times \text{SL} - 12.5$ offers a perfect separation – with 98.5 % of the 65 specimens classified with posterior probabilities of $p > 0.90$ (figure 10). $D(2)$ is $-3.095 \pm 1.014 [-5.434, -0.608]$ in 51 workers of *T. melanocephalum* and $2.419 \pm 0.945 [0.608, 3.692]$ in 14 workers of *T. pithecorum* sp. nov. According to photo evaluation (table I) it differs from five specimens of *T. indicum* (FOREL, 1895) by longer scape and funiculus segments, shorter postocular distance, absence of clypeal excavation and the color contrast between mesosoma and gaster. These specimens of *T. indicum* included the type specimen from Poona (India) (www.antweb.org: CASENT0909774). A synonymy with *Tapinoma minutum* (MAYR, 1862) is also excluded. The type specimen of homogenously colored *T. minutum* from Sydney (Australia) (www.antweb.org: CASENT0915549) has according to photo evaluation a much longer scape and a much smaller postocular index (table I) and it shows no color contrast on whole body. The clear separation of the four species is summarized by a principal component analysis (figure 2).

Scape length SL [mm]

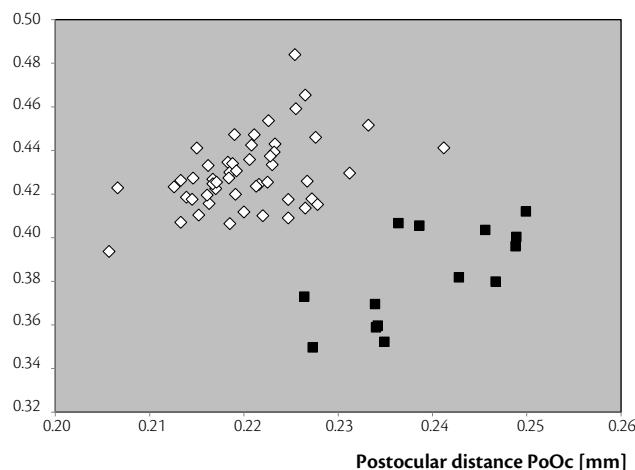


Figure 10. Plotting of scape length against postocular distance in 14 workers of *Tapinoma pithecorum* sp. nov. (black squares) and 51 workers of *Tapinoma melanocephalum* (white rhombs).

In the argumentation presented above, *Tapinoma pellucida* (SMITH, 1857) was excluded from synonymy with *T. pithecorum* sp. nov. and considered as a junior synonym of *T. melanocephalum*. Yet, can we exclude a senior synonymy of *T. pellucida* with *T. minutum* (MAYR, 1862) and *T. indicum* (FOREL, 1895) based on evaluation of photos of two badly mounted type specimens of *T. pellucida*? The answer is that the photos provide enough information in some key characters. A synonymy of *T. pellucida* with the other two taxa is most unlikely as the *T. pellucida* types have a much larger relative length of the 3rd segment of antennal funiculus and show the characteristic Ghost Ant pigmentation. Defining an absolute size indicator SIZE as geometric mean of CL and MW, the index Fu3/SIZE is 0.1509 in the *T. pellucida* type but $0.1042 \pm 0.0061 [0.0962, 0.1134]$ in the six *T. indicum* and *T. minutum* specimens which included the types of the latter two taxa (CASENT0909774, CASENT0915549; see also table I). In contrast, the value of the *T. pellucida* type corresponds very well to the data of 51 stereomicroscopically evaluated specimens of

Table I. Arithmetic mean, standard deviation, upper and lower extreme of morphometric data of four *Tapinoma* species. The column with *F* and *p*-values of a one-tailed ANOVA test is placed between the columns of the species compared. The most separating characters are indicated by *F* values in red heavy type. Photo evaluation was restricted to characters extractable with acceptable error.

	Direct stereomicroscopy		Photo evaluation				
	<i>T. melanocephalum</i> (<i>n</i> = 51)	ANOVA <i>F</i> _{1,58} , <i>p</i>	<i>T. pithecorum</i> (<i>n</i> = 14)	<i>T. melanocephalum</i> (<i>n</i> = 17)	<i>T. pithecorum</i> (<i>n</i> = 1)	<i>T. indicum</i> (<i>n</i> = 5)	<i>T. minutum</i> type (<i>n</i> = 1)
CS	438 ± 15 [409, 493]	7.07 0.010	451 ± 21 [422, 484]	415 ± 35 [352, 472]	420	398 ± 47 [315, 431]	505
CL / CW	1.161 ± 0.027 [1.103, 1.213]	6.06 0.017	1.142 ± 0.018 [1.101, 1.169]	1.133 ± 0.043 [1.106, 1.200]	1.143	1.103 ± 0.041 [1.032, 1.135]	1.142
SL / CS	0.981 ± 0.023 [0.907, 1.025]	368.51 0.000	0.846 ± 0.022 [0.812, 0.907]	0.987 ± 0.022 [0.939, 1.030]	0.845	0.815 ± 0.025 [0.780, 0.851]	0.949
ExOcc / CS [%]	0.21 ± 0.30 [0.00, 1.39]	16.18 0.000	0.66 ± 0.58 [0.00, 1.74]	0.16 ± 0.26 [0.00, 0.98]	1.67	0.23 ± 0.32 [0.00, 0.61]	0
ExCly / CS [%]	1.51 ± 0.49 [0.64, 2.94]	60.03 0.000	0.44 ± 0.30 [0.00, 1.17]	1.23 ± 0.42 [0.58, 2.49]	0	1.99 ± 0.38 [1.70, 2.65]	0
ExClyW / CS [%]	12.66 ± 1.45 [9.80, 15.49]	7.41 0.008	11.52 ± 1.05 [10.30, 13.44]	no data	no data	no data	no data
ExCylL / W [%]	0.119 ± 0.036 [0.05, 0.23]	61.25 0.000	0.039 ± 0.025 [0.00, 0.09]	no data	no data	no data	no data
nExCly	1.88 ± 1.11 [0.0, 5.0]	1.36 n.s.	2.36 ± 2.02 [0.0, 6.0]	no data	no data	no data	no data
dAN / CS	0.339 ± 0.008 [0.318, 0.358]	46.05 0.000	0.324 ± 0.008 [0.313, 0.341]	no data	no data	no data	no data
PoOc / CL	0.469 ± 0.011 [0.434, 0.488]	67.38 0.000	0.497 ± 0.012 [0.476, 0.518]	0.475 ± 0.013 [0.446, 0.495]	0.486	0.536 ± 0.013 [0.522, 0.557]	0.453
EL / CS	0.274 ± 0.010 [0.255, 0.307]	92.39 0.000	0.247 ± 0.008 [0.234, 0.260]	no data	no data	no data	no data
MGr / CS [%]	2.23 ± 0.80 [1.19, 4.52]	15.40 0.000	1.32 ± 0.63 [0.20, 2.35]	2.60 ± 1.07 [0.00, 5.54]	1.35	2.24 ± 1.51 [0.00, 3.65]	2.95
MW / CS	0.635 ± 0.018 [0.594, 0.676]	37.92 0.000	0.667 ± 0.015 [0.650, 0.707]	0.641 ± 0.045 [0.519, 0.702]	0.693	0.640 ± 0.027 [0.610, 0.669]	0.642
ML / CS	1.240 ± 0.040 [1.119, 1.320]	48.05 0.000	1.158 ± 0.034 [1.094, 1.214]	no data	no data	no data	no data
Fu2 / CS [%]	8.60 ± 0.38 [7.62, 9.35]	106.87 0.000	7.36 ± 0.46 [6.58, 8.28]	8.42 ± 0.93 [7.11, 10.17]	6.19	5.20 ± 0.605 [4.82, 6.22]	7.73
Fu3 / CS [%]	12.42 ± 0.73 [10.83, 13.77]	158.02 0.000	9.69 ± 0.67 [9.16, 11.42]	12.22 ± 1.39 [9.98, 15.74]	8.80	8.51 ± 0.65 [7.93, 9.47]	8.77
IFu2	0.873 ± 0.046 [0.775, 0.963]	56.16 0.000	0.759 ± 0.063 [0.671, 0.899]	0.843 ± 0.108 [0.683, 1.123]	0.659	0.631 ± 0.088 [0.556, 0.731]	1.003

T. melanocephalum with Fu3/SIZE 0.1505 ± 0.0098 [0.1295, 0.1668].

Comment on biodiversity in the minute tropical *Tapinoma* species

Introducing here *Tapinoma pithecorum* sp. nov. represents a low risk for production of a synonym as the new species is an outstanding entity in its combination of shape and surface structure characters. However, the taxonomic situation within the nanitic tropical species near to *T. melanocephalum*, *T. indicum* or *T. minutum* is far from sufficiently known. A moderate extension of the scope by investigating few samples of other nanitic tropical *Tapinoma* ants near to *Tapinoma wilsoni*, *T. atriceps* and *T. aberrans*, some of these hidden in loans of "*T. melanocephalum*" material, confirmed this view. The resulting total of only about 100 worker samples apparently included at least seven different species. Three of these, putatively undescribed species with extreme characters, were represented by only a single worker specimen. One may build up from these findings a vague idea which biodiversity would be revealed after thoroughly investigating hundreds of samples under a broad geographic coverage. I refrain from doing broad revisionary work as there is no working capacity remaining to do this in a thorough way and I also refrain from describing new *Tapinoma* species based on single specimens.

Comment on the value of simple pigmentation characters in ant determination

Considering what has been written in the previous section, a warning has to be given about the careless use of simple pigmentation characters in ant classification as it is frequently seen in determination keys. Very simple pigmentation patterns, such as variation of light vs. dark, red vs. brown or red vs. black on whole body or certain body parts are frequently unreliable taxonomic characters in insects and other animals. This is because already a point mutation may change pigmentation profoundly whereas complex morphological structures are less easily changed. There are lots of textbook examples demonstrating a rather simple pigmentation genetics (e.g. LUS, 1932; BARRION & SAXENA, 1987; MAJERUS, 1998; ANDRÈS & CORDERO, 1999 and MAJUMDAR *et al.* 2008). The occasional loss of the remarkable ghost ant pigmentation in *Tapinoma melanocephalum* observed in material of the presented study is supposed to represent a mutation. In two out of 76 samples (= 2.6 %) of *T. melanocephalum*, mesosoma, petiole and gaster showed a lot of dark pigment, giving these specimens a nearly homogenous coloration and perfect opaqueness in living condition. The morphometric data of these dark color morphs were close to the mean values of *T. melanocephalum* in any of the 17 characters recorded and they were placed by a PCA near the cluster center of this species. Hence there is

no reason to suppose heterospecificity. Taxonomic failures or pitfalls due to pigmentation characters in ants have been repeatedly reported. SEIFERT (1997, p. 6) and SEIFERT (2018, p. 138) described color dimorphism superimposed by allometric change in species of the *Formica rufibarbis* group. Intraspecific color polymorphism superimposed by geographic clines has been shown for species of the *Formica cinerea* group (SEIFERT, 2003a, pp. 254, 258). Furthermore, extreme intraspecific color polymorphism is documented by SEIFERT (2003b, p. 213) and SEIFERT *et al.* (2017, pp. 340, 348) in several species of *Cardiocondyla*. Furthermore, SEIFERT (2019, pp. 11–12) pointed to taxonomic errors due to color polymorphism in *Camponotus* and finally SEIFERT (2020, p. 22) described color polymorphism superimposed by allometric trends in *Lasius*.

Provisional key to the Orientalic and Australian-Polynesian species

Considering the statements in the two foregoing sections, (a) underrecording of true species numbers and (b) misclassifications by intraspecific color polymorphism, the following key separating four minute *Tapinoma* species of Orientalic and Australasian-Polynesian origin has to be considered as provisional.

1. Heterogenously pigmented, at least parts of mesosoma and/or gaster notably lighter than head 2
 - Homogenously pigmented 3
2. Scape long
 - With measurements in mm, discriminant $152.56 \times \text{PoOc} - 56.444 \times \text{SL} - 12.5 < 0$ [error 0 % in 51 worker specimens].
Anterior clypeal margin slightly excavated.
 3^{rd} funiculus segment long.
 $\text{ExCly} / \text{CS} > 0.7\%$, $\text{Fu3} / \text{CS} > 11\%$
..... *T. melanocephalum*
 - Scape short.
 - With measurements in mm, discriminant > 0 [error 0 % in 14 worker specimens].
Anterior clypeal margin not excavated.
 3^{rd} funiculus segment short.
 $\text{ExCly} / \text{CS} < 0.7\%$, $\text{Fu3} / \text{CS} < 11\%$
..... *T. pithecorum* sp. nov.
3. Postocular index very large.
Scape and 2^{nd} funiculus segment very short.
 $\text{PoOc} / \text{CL} > 0.490$, $\text{SL} / \text{CS} < 0.88$, $\text{Fu2} / \text{CS} < 6.8\%$
..... *T. indicum*
- Postocular index small.
Scape and 2^{nd} funiculus segment long.
 $\text{PoOc} / \text{CL} < 0.490$, $\text{SL} / \text{CS} > 0.88$, $\text{Fu2} / \text{CS} > 6.8\%$
..... *T. minutum*

ACKNOWLEDGEMENTS

This paper was co-financed by tax money on the basis of the state budget passed by the Saxon Landtag. I wish to thank Isabelle ZÜRCHER (NHM Basel, Switzerland), Andrew LISTON (SDEI Müncheberg, Germany) and Brian FISHER (CAS San Francisco, California, USA) for kindly arranging loans of collection material, Roland SCHULTZ (Senckenberg Museum of Natural History, Görlitz, Germany) for producing z-stack photos and Herbert WAGNER (Graz, Austria) as well as Hervé JOURDAN (IRD – IMBE, Marseille, France) for meticulous reading the draft of the manuscript.

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