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A taxonomic revision of the *Formica rufibarbis* FABRICIUS, 1793 group (Hymenoptera: Formicidae)

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Abstract

The Palaearctic members of the *Formica rufibarbis* FABRICIUS, 1793 group were investigated by means of numeric morphology-based alpha-taxonomy (NUMOBAT). 496 nest samples comprising 1753 worker individuals were analysed in eighteen phenotypic characters and a further 330 samples for only ten characters. Nine morphospecies and one subspecies were recognised: *Formica rufibarbis*, *F. cunicularia* LATREILLE, 1798, *F. clara* FOREL, 1886, *F. clara sinae* EMERY, 1925 stat.n., *F. glabridorsis* SANTSCHI, 1925, *F. orangea* sp.n., *F. tarimica* sp.n., *F. anatolica* sp.n., *F. tianshanica* sp.n., and *F. persica* sp.n. All nine morphospecies were convincingly separable from each other by discriminant analysis (DA) with an error prediction by a leave-one-out cross-validation of 0.4% in the worst case. Type samples of fourteen taxa were available and positioned near to the cluster centres with a-posteriori probabilities of $p > 0.998$ with exception of *F. clara sinae* EMERY, 1925 stat.n. allocated to *F. clara* with only $p = 0.929$. As a consequence, the following synonymisations were stated: *F. fusca* var. *cinereorufibarbis* FOREL, 1874 as synonym of *F. rufibarbis* (sensu BERNARD 1967), *F. fusca* var. *rubescens* FOREL, 1904 as synonym of *F. cunicularia* (sensu YARROW 1954) and *F. cunicularia fuscoides* DLUSSKY, 1967 as synonym of *F. cunicularia* (sensu ARAKELIAN 1994), *F. lusatica* SEIFERT, 1997 as synonym and *F. rufibarbis* var. *sinae* EMERY, 1925 as subspecies of *F. clara*. Neotypes of *F. rufibarbis* and *F. cunicularia* were fixed. A deviating population of *F. tianshanica* sp.n. in the NW Chinese Bogda Shan Mountains, treated in this paper as intraspecific gyne polymorphism, may represent a cryptic species. Extension of sampling and integration of DNA analysis into the study are needed to decide this question. All species are depicted and a simplified identification key is given. Two species seem to be endemic: *F. anatolica* sp.n. is restricted to the south Anatolian Taurus Mountains and *F. persica* sp.n. to the north Iranian Elburs Mountains. These two species are also ecologically remarkable by frequently living in woodland while the other seven species preferentially occur in sun-exposed open land ranging from semi-dry grassland to semi-desert.

Key words: Numeric morphology-based alpha-taxonomy, cryptic species, new species, discriminant analysis, leave-one-out cross-validation, endemism.

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Introduction

The Palaearctic *Formica rufibarbis* FABRICIUS, 1793 group, as it is defined below, comprises species inhabiting different kinds of warm, well-drained, sun-exposed habitats. They occur along a habitat gradient extending from moderately dry meagre meadows and pastures to very dry, vegetation-reduced semi-deserts but they avoid bogs and are rare in woodland. Despite their comparably low numbers per unit area these mainly zoophagous, trophobiotic and nectarivorous ants attract the attention of the observer by their swift and erratic movements over the ground. Their subjection by the spectacular slave raids of dulotic ants put them on the world's literary scene very early (HUBER 1810).

The name-giving species *F. rufibarbis* and the related *F. cunicularia* LATREILLE, 1798 are exemplary for the taxonomic problems in this group – type specimens are not available for both species and the original descriptions allow nothing more than concluding on medium-sized *Formica* ants with some reddish pigment. Further deficiencies, caused by the tradition of subjective colour and structure assessment, are inadequate and erroneous species delimitations and failures to detect cryptic species. A first attempt to demonstrate a cryptic species in this group by means of numeric character description was done by SEIFERT (1997) but this basically successful approach had only a regional scope, its character system was not sufficiently developed and questions on synonymies remained unsolved.

Here we want to clarify the nomenclatural situation in the *F. rufibarbis* group for the whole Palaearctic and will show the existence of nine species by means of numeric morphology-based alpha-taxonomy (NUMOBAT), assisted by zoogeographical and ecological arguments. A credible demonstration of cryptic species is only possible if a sufficiently large sample is available for each considered species. This condition was only given in the worker caste with a total of 3567 NUMOBAT-studied individuals belonging to 827 nest samples. The rarity or lack of gynes and males in the collections does not allow using these castes for reliable statements on the validity of characters. Hence, the scope of this revision is restricted to the worker caste. We apply the unified species concept (USC) of DE QUEIROZ (2007). It considers a separately evolving metapopulation lineage as the only necessary conceptual property of species and recognises the species criteria of other species concepts (e.g., reproductive isolation, niche separation, phenotypic and genetic cohesion and clustering) only as operational criteria. The oversplitting bias of the USC in case of single-source decisions requires that each discipline must find its own remedy against this fault. In case of NUMOBAT data we applied a confidence threshold of $p > 98\%$.

The delimitation of the species groups in this paper is purely phenotypic and serves primarily to allow an entry into the right species determination key. Nevertheless, there is much hope that this phenotypic clustering on the basis of non-cladistic NUMOBAT data (see SEIFERT & SCHULTZ 2008), also reflects to a great degree the true phylogenetic relationships. Three species groups within the subgenus *Serviformica* FOREL, 1913 showing reddish pigmentation on mesosoma, varying in size from small patches to complete surface coverage, are distinguished:

(a) the European to East Asian *Formica rufibarbis* group, characterised by the reduction of setae on posterior vertex and underside of head, smaller eyes and wider petioles;

(b) the West to Central Asian *F. subpilosa* group, characterised by intermediate setae numbers on posterior vertex and underside of head, smaller eyes and wider petioles; and

(c) the Eurocaucasian *F. cinerea* group, characterised by large setae numbers on posterior vertex and underside of head, large eyes and narrow petioles.

The criterion of reddish mesosomal surface patches is usually reliable to distinguish the *F. rufibarbis* group from the dark pigmented species related to *F. fusca* LINNAEUS, 1758, *F. lemani* BONDROIT, 1917, *F. picea* NYLANDER, 1846, *F. gagates* LATREILLE, 1798, *F. fusca tombeuri* BONDROIT, 1917 (which we plan to raise to species status and to establish as a senior synonym of *F. decipiens* BONDROIT, 1918 elsewhere, based on morphometric evidence; B. Seifert & R. Schultz, unpubl.), or *F. pyrenaea* BONDROIT, 1918. As exception from this rule, light yellowish-reddish brown mesosomas occasionally occur among the blackish species in some specimens of the Iberian *F. pyrenaea* and *F. fusca tombeuri* and entirely dark mesosomas exceptionally occur in the *F. rufibarbis* group member *F. cunicularia*.

As in many other ant groups with unsettled taxonomy and confused determination by traditional subjective taxonomy, an uncritical carry-over of literature statements on distribution is not possible. As a consequence, zoogeographic knowledge is badly deficient and the maps presented here should not be interpreted to show a complete distribution picture. They only show the distribution of sampling sites from which we got reliably NUMOBAT-determined material.

Methods

Character recording

The mathematical description used eighteen numerically described phenotypic characters. All measurements were made on mounted and dried specimens using a pin-holding stage, permitting full rotations around X, Y and Z axes. Two high-performance stereomicroscopes, A Leica Wild M10 (used by BS) and a Leica MZ16A (used by RS), each equipped with a 1.6 × planapochromatic front lens, were used at magnifications of 160 - 320 ×. A Schott KL 1500 LCD 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 visualisation of silhouette lines. A Schott KL 2500 LCD cold-light source in combination with a Leica coaxial polarised-light illuminator provided optimum 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 the voltage up and down. A Leica cross-scaled ocular micrometer with 120 graduation marks ranging over 65% of the visual field was used. To avoid the parallax error, its measuring line was constantly kept vertical within the visual field. The mean within-system-within-investigator measuring error was ± 1.1 µm in small and well-defined structures such as eye diameter and ± 2.9 µm for larger structures such as cephalic length or width. The total error over both systems, both investigators, varying ambient temperatures and specimen humidity multiplies to ± 1.6 µm for small and ± 4.2 µm for large distances – these data translate into relative errors of 0.4 and 0.3%. To avoid rounding errors, all measurements were recorded in µm even for characters for which this precision is impossible.

Setae, also called pilosity or simply "hairs", are differentiated from pubescence hairs in having at least twice the basal diameter of neighbouring pubescence hairs. All seta counts (acronyms beginning with "n") are restricted to standing setae projecting > 10 µm from cuticular surface.

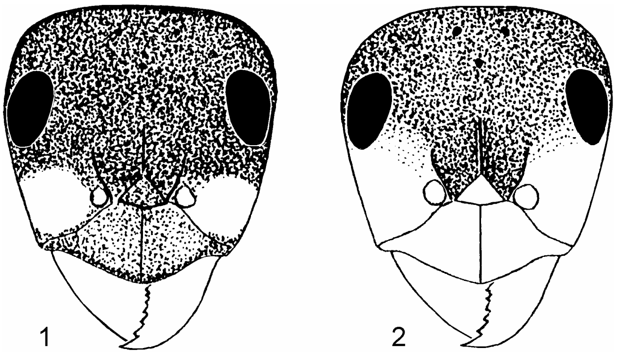
Definition of numeric characters and descriptive terms

CL	Maximum cephalic length in median line; head must be carefully tilted to position yielding true maximum; excavations of hind vertex and / or clypeus reduce CL.
CONT	Contrast between dark and light pigmentation on genae, subjectively interpolated between values 1.0 (Fig. 1) and 0 (Fig. 2). Do not use magnifications > 100 × and test different angles of light incidence.
CS	Cephalic size; arithmetic mean of CL and CW, used as a less variable indicator of body size.
CW	Maximum cephalic width; maximum in *Formica* is found either behind (larger specimens) or across eyes (smaller specimens).
EYE	Eye-size index: arithmetic mean of large (EL) and small diameter (EW) of elliptic compound eye.
Full face view	Dorsal aspect of head with both maximum CL and maximum CW in visual plane.
Gena	Lateral part of head delimited by anterior margin of eye and anterolateral corner of head capsule.
GHL	Length of longest seta on dorsal plane of first gaster tergite excluding row of setae immediately anterior of the hind tergite margin.
nGU	Unilateral number of setae protruding more than 10 µm from underside of head (= "gula") as visible in lateral view.
nHFFL	Arithmetic mean of number of setae protruding more than 10 µm from cuticular surface of flexor profile of hind femora.

nMN	Unilateral number of setae on mesonotum protruding more than 10 µm from cuticular surface.
nOCC	With head in full face view, unilateral number of setae protruding more than 10 µm from posterior margin of vertex and head sides anterior to level of anterior eye margin.
nPE	Unilateral number of setae protruding more than 10 µm from margin of petiole scale dorsal of spiracle in caudal or frontal viewing position.
nPN	Unilateral number of setae protruding more than 10 µm from cuticular surface of pronotum.
nPRME	Unilateral number of setae protruding more than 10 µm from cuticular surface on propodeum and lateral metapleuron (excluding setae fringing metapleural gland orifice and those on ventrolateral edge of metapleuron).
OceD	Distance between inner margins of posterior (lateral) ocelli.
PEW	Maximum width of petiole.
PIGM	Percent ratio of blackish or brownish pigmented surface of mesosoma excluding coxae as perceptible in lateral view. It is, in other words, the percentage of pigmentation which is not light reddish or yellowish red. A value of 0 means that the whole mesosoma is uniformly reddish or yellowish red. Do not use magnifications > 100 × and test different angles of light incidence.
RipD	Average distance of transverse microripples on dorsal plane of first gaster tergite. At least three counts along a 90 µm distance on different surface spots are averaged. Counting is performed at a magnification of 320 ×. Use clean surfaces and light inclined perpendicular to ripples.
Setae	All stronger hairs having at least twice the basal diameter of neighbouring pubescence hairs (typical of *Serviformica* are 3.5 µm diameter for pubescence and > 8 µm for setae)
SL	Maximum straight line scape length excluding articular condyle.
sqPDG	Square root of pubescence distance on dorsum of first gaster tergite. The number of pubescence hairs n crossing a transverse measuring line of length L is counted, hairs just touching the line are counted as 0.5. The pubescence distance PDG is then given by L / n. In order to normalise positively skewed distributions, the square root of PDG is calculated. Exact counting is promoted by clean surfaces and flat, reflexion-reduced illumination directed perpendicular to the axis of pubescence hairs. Counting is performed at a magnification of 320 ×. In each specimen 4 - 6 measuring-lines of 400 µm are averaged under exclusion of surface parts with apparently detached pubescence.

Removal of allometric variance

In most species groups of *Formica*, body ratios are strongly influenced by allometric growth. In order to make body ratios such as CL / CW, SL / CS, EYE / CS or PEW / CS directly comparable in synoptic tables, a removal of allometric variance (RAV) was performed with the procedure described by Seifert (2008). As standard for all members of the subgenus *Serviformica*, RAV was calculated for the assumption of all individuals having an identical cephalic size of 1.4 mm. We applied group specific RAV functions the collective parameters of which were calculated as the arithmetic mean of the species-specific functions of *F. anatolica* sp.n., *F. clara* Forel, 1886*, F. cunicularia*, *F. glabridorsis* Santschi, 1925, *F. persica* sp.n., *F. orangea* sp.n., *F. rufibarbis, F. tarimica* sp.n., and *F. tianshanica* sp.n. Evaluation of scatter plots indicated the use of monophasic linear RAV functions. RAV functions in setae numbers were calculated as mean of the two most hairy species. The RAV functions were



Figs. 1 - 2: Pigmentation pattern of dorsal head in a worker of (1) *F. cunicularia* showing the upper extreme of pigmentation contrast on genae (CONT = 1.0), and pigmentation pattern of dorsal head in a worker of (2) *F. clara* showing the lower extreme of pigmentation contrast on genae (CONT = 0).

CL / CW$_{1.4}$ = CL / CW / (-0.1079 * CS + 1.2894) * 1.1384
SL / CS$_{1.4}$ = SL / CS / (-0.1253 * CS + 1.2568) * 1.0814
EYE / CS$_{1.4}$ = EYE / CS / (-0.0480 * CS + 0.3621) * 0.2948
GHL / CS$_{1.4}$ = GHL / CS / (-0.175 * CS + 7.529) * 7.284
PEW / CS$_{1.4}$ = PEW / CS / (0.0956 * CS + 0.3122) * 0.4460
OceD / CS$_{1.4}$ = OCED / CS / (0.0038 * CS + 0.1596) * 0.1648
sqPDG$_{1.4}$ = sqPDG / (0.2554 * CS + 2.795) * 3.153
RipD$_{1.4}$ = RipD / (0.050 * CS + 5.37) * 5.44
nOCC$_{1.4}$ = nOCC / (0.15 * CS - 0.10) * 0.11
nGU$_{1.4}$ = nGU / (0.02 * CS + 0.34) * 0.36
nPN$_{1.4}$ = nPN / (18.01 * CS - 14.36) * 10.86
nMN$_{1.4}$ = nMN / (11.69 * CS - 7.09) * 9.27
nPRME$_{1.4}$ = nPRME / (0.33 * CS - 0.09) * 0.37
nPE$_{1.4}$ = nPE / (1.43 * CS - 0.52) * 1.48
nHFFL$_{1.4}$ = nHFFL / (1.06 * CS + 0.04) * 1.52
PIGM$_{1.4}$ = PIGM / (-52.17 * CS + 115.6) * 42.6
CONT$_{1.4}$ = CONT / (-0.012 * CS + 0.32) * 0.34

Discriminant analysis and error estimation

A canonical discriminant analysis (DA) was performed using the SPSS 10.0 statistical package based on sample means. All characters passed the tolerance test in a DA to the level of 0.01 as implemented by SPSS both when calculated as primary (crude) or as indexed data. The performance and reliability of a DA was assessed by the degree of coincidence of a-priori and a-posteriori hypotheses (error rate) and by a statistics of a-posteriori probabilities. A parallel run of an ordinary DA and of a "leave-one-out cross-validation" DA (LOOCV-DA, Lachenbruch & Mickey 1968, Lesaffre & al. 1989) was performed to realistically estimate the error rate. The data presented by Seifert & Schultz (2008) show that the means of the pessimistic error indication by the LOOCV-DA and of the optimistic error indication by the ordinary DA are close to the true error rate. This is of particular importance when sample size is lower than triple the character number – a situation in which an ordinary DA is biased to confirm the taxonomist's prejudice. As a further analysis avoiding the prejudice problem in case of small sample sizes we also ran a principal component analysis using SPSS.

Terminology of distribution pattern and mapping

When comparing macrogeographic distribution patterns of ant and plant species similar pictures are not infrequent. This is probably explained by comparable dependencies from certain climatic factors and possibly also by the linkage of some ant species to certain habitat types the structure of which is mainly shaped by plants. We adopted the well-developed terminology of phytogeography as supplementation for describing distribution pattern of ants (see also SCHULTZ & SEIFERT 2007). In this paper we follow the system of floristic zones, regions and provinces as defined by MEUSEL & JÄGER (1992).

The distribution maps exclusively show collecting sites from which we had NUMOBAT-determined material. Samples reasonably determined by simple key decisions and credible literature data were not mapped but this information was considered in the text statements on distribution and habitat selection.

Material

The collections from which material was studied have the following acronyms:

coll. AS: collection of Andreas Schulz, Leverkusen, Germany
coll.RS: collection of Roland Schultz, Görlitz, Germany
MCZ Cambridge: Museum of Comparative Zoology of Harvard University, Cambridge, MA, USA
MHN Genève: Muséum d'Histoire Naturelle Genève, Switzerland
MNHN Paris: Muséum National d'Histoire Naturelle Paris, France
MZ Lausanne: Muséum Zoologique Lausanne, Switzerland
NHM Basel: Naturhistorisches Museum Basel, Switzerland
SMN Görlitz: Senckenberg Museum of Natural History Görlitz, Germany
ZMLSU Moscow: Zoological Museum of the Lomonossov State University, Moscow, Russia
ZMU Copenhagen: Zoological Museum of University of Copenhagen, Denmark
ZMU Kiev: Zoological Museum of the University of Kiev, Ukraine

Results

Key to the workers of the *F. rufibarbis* group

The complex NUMOBAT procedures presented in this paper are indispensable for safe and testable species delimitations but we are aware that these are not easily reproducible by the majority of practitioners doing ecological and faunistic research. As a consequence, we present here a simplified dichotomous key which should enable determinations in the majority of cases. We have tried to find a less time-consuming determination method by strongly reducing the number of required characters and using primary (uncorrected) data. The entry values in the key are arithmetic means of usually three workers per nest. The error estimations given in the discriminant functions refer to this sample size and our accuracy of data recording. To reduce working time when using discriminant functions, we recommend beginning with one worker per sample and only extending the sample size when the resulting discriminant value is close to zero.

1a Unilateral number of standing setae on underside of head 0.7 - 2.8. Petiole scale wide, PEW / CS 0.483 ± 0.017. Eye large, EYE / CS 0.303 ± 0.010. Head short, CL / CW 1.110 ± 0.018. 40 - 90% of mesosomal surface dark brown. Dorsal mesosoma always with setae. Asia Minor (Taurus Mountains) only (Fig. 8). .... ***F. anatolica* sp.n.**

1b Unilateral number of standing setae on underside of head 0 - 0.7. Character combination of petiole width, eye size and head shape different. **2**

2a Distance between transverse microripples on dorsum of 1st gaster tergite very large: RipD 7.9 ± 0.5 µm. Pronotum hairy: nPN 9.2 ± 2.2. Head and scape elongated: CL / CW 1.174 ± 0.018, SL / CS 1.089 ± 0.021. Petiole scale narrow: PEW / CS 0.382 ± 0.018. Head and mesosoma usually reddish yellow. So far only known from the Tarim Basin (Fig. 7). .... ***F. tarimica* sp.n.**

2b Distance between transverse microripples on dorsum of 1st gaster tergite smaller – if occasionally approaching 7.9 µm (in *F. orangea* sp.n.), then CL / CW and SL / CS clearly smaller. **3**

3a 87 - 100% of mesosomal surface orange and distance of transverse microripples on dorsum of 1st gaster tergite large: RipD 6.7 ± 0.5 µm. Head and scape rather short: CL / CW, 1.115 ± 0.017, SL / CS 1.027 ± 0.026. Dry steppes and semideserts from 58° to 104° E (Fig. 6). .... ***F. orangea* sp.n.**

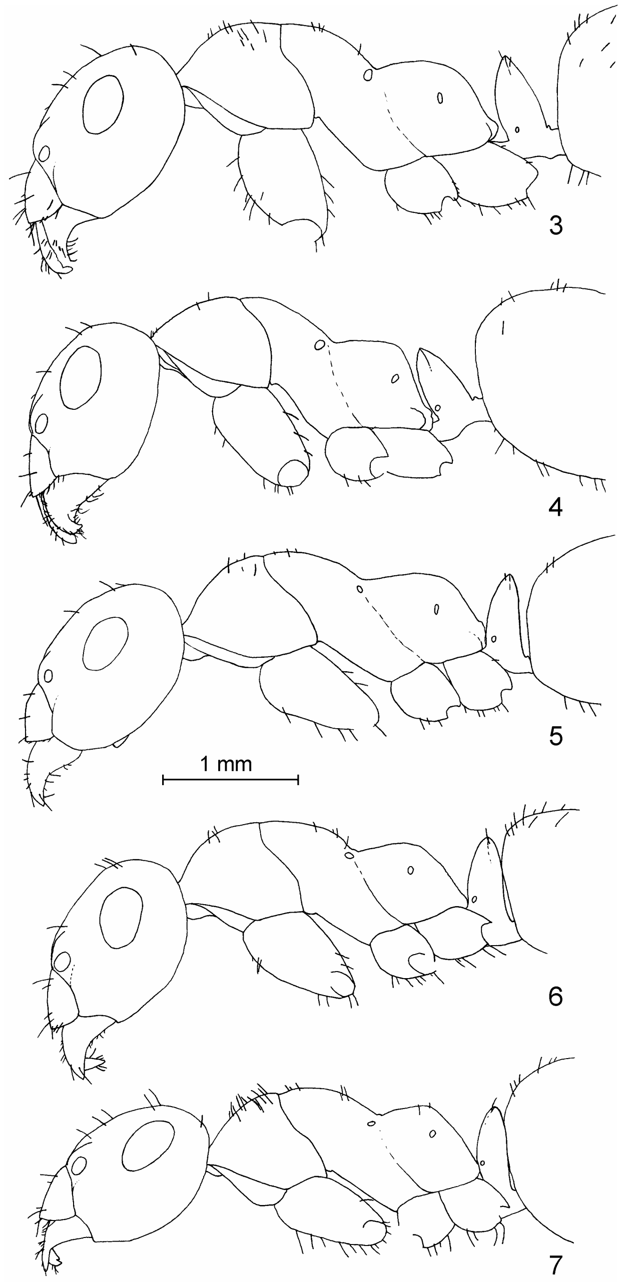
3b Character combination different. If mesosomal surface with more than 85% light reddish pigmentation, then RipD < 5.5 µm. **4**

4a Whole body with numerous standing setae: nPN 10.9 ± 2.9, nMN 6.6 ± 2.8, nPE 3.8 ± 1.1, nHFFL 3.4 ± 1.4 (Fig. 3). Discriminant 0.187 * nPN + 0.041 * nMN + 0.769 * nPE + 0.726 * nHFFL + 0.007 * nPRME - 4.644 * CL + 2.838 > 0 [CL in mm, error rate 0.5%]... ***F. rufibarbis***

4b Whole body with fewer standing setae: nPN 1.7 ± 1.8, nMN 0.7 ± 1.0, nPE 0.4 ± 0.5, nHFFL 0.5 ± 0.5. Discriminant 0.187 * nPN + 0.041 * nMN + 0.769 * nPE + 0.726 * nHFFL + 0.007 * nPRME - 4.644 * CL + 2.838 < 0 [CL in mm, error rate 0.5%]. **5**

5a Distance between transverse microripples on dorsum of 1st gaster tergite large: RipD 6.0 ± 0.4 µm. **6**

5b Distance between transverse microripples on dorsum of first gaster tergite smaller. **7**

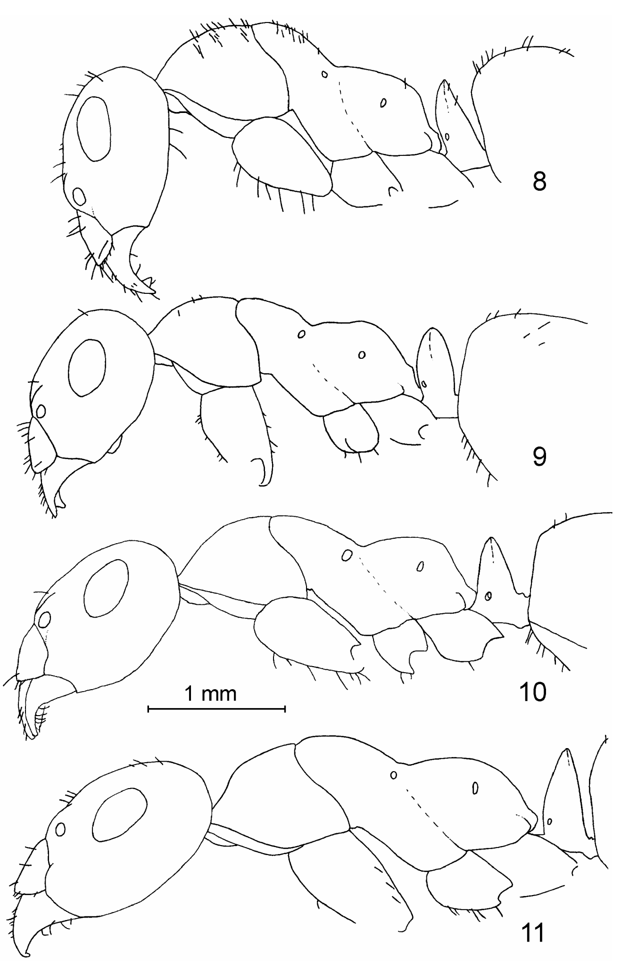


Figs. 3 - 7: lateral aspect of (3) the neotype of *F. rufibarbis*, (4) the neotype of *F. cunicularia*, (5) *F. clara*, (6) the holotype of *F. orangea* sp.n., and (7) the holotype of *F. tarimica* sp.n. Setae numbers in *F. clara* show the average situation.

6a Scape long: $SL > -1.248 * CW2 + 3.774 * CW - 1.27$ [all measurements in mm]. Dorsal crest of petiole scale often obtuse-angled. North Iran (Fig. 10). .... ***F. persica* sp.n.**

6b Scape shorter: $SL < -1.248 * CW^2 + 3.774 * CW - 1.27$. Central Asian mountains from 71° to 109° E and 33° to 47° N (Fig. 9). .... ***F. tianshanica* sp.n.**

7a Scape extremely long: $0.01986 * CW + 1.4442$. E China from 99° to 116° E and 27° to 40° N (Fig. 11). .... ***F. glabridorsis***



Figs. 8 - 11: Lateral aspect of (8) the holotype of *F. anatolica* sp.n., (9) the holotype of *F. tianshanica* sp.n., (10) the holotype of *F. persica* sp.n., and (11) *F. glabridorsis*. Setae numbers in *F. glabridorsis* show the average situation.

7b Scape shorter: $SL / CW < -0.01986 * CW + 1.4442$. **8**

8a Whole body often darker pigmented with stronger pigmentation contrast on genae (Fig. 1); discriminant with error rate 3.4%: $0.066 * PIGM + 2.014 * CONT + 1.641 * SL - 5.891 > 0$. Discriminant with error rate 0.4%: $54.173 * EYE - 7.026 * CW - 3.675 * SL + 896 * RipD + 0.065 * PIGM + 1.624 * CONT - 15.0054 > 0$. Usually in moderately xerothermic habitats with more developed herb layer (Fig. 4). Missing from Pakistan and India. .... ***F. cunicularia***

8b Whole body usually light reddish brown with weak or missing pigmentation contrast on genae (Fig. 2); discriminant with error rate 3.4%: $0.066 * PIGM + 2.014 * CONT + 1.641 * SL - 5.891 < 0$. Discriminant with error rate 0.4%: $54.173 * EYE - 7.026 * CW - 3.675 * SL + 896 * RipD + 0.065 * PIGM + 1.624 * CONT - 15.0054 < 0$. Usually in more xerothermic habitats with weakly developed herb layer (Fig. 5). Also in Pakistan and India. .... ***F. clara***

Figs. 12 - 13: *F. clara*, holotype of *F. lusatica*: (12) lateral aspect, (13) head.

Taxonomic treatment: descriptions, diagnoses, nomenclature and biology

Diagnosis of the *Formica* (*Serviformica*) *rufibarbis* group

Within the Palaearctic members of the subgenus *Serviformica*, the *Formica rufibarbis* group (typical example *F. clara*, Figs. 12 and 13) is diagnosable by the following character combination: mesosoma showing 25 to 100% reddish pigmentation; moderate to large body size (nest means of CS 1.075 - 1.731 mm); moderate eye size (nest means of EYE / CS$_{1.4}$ 0.274 - 0.312); posterior margin and underside of head normally without setae (nOCC and nGU may occasionally achieve 1.5 and 3.0 in *F. anatolica* sp. n.), mesosoma with zero to numerous setae; petiole scale rather wide (nest means of PEW / CS$_{1.4}$ 0.364 - 0.523), with a convex or bluntly angulate dorsal crest; gaster tergites with a dense, usually silvery pubescence (sqPDG$_{1.4}$ 2.7 - 3.9) and with more or less dense transverse microripples (RipD$_{1.4}$ 3.8 - 9.2), thus appearing more matt at low magnifications. Range West Europe to East China. Moderately to strongly thermophilic; avoiding the boreal zone; in the temperate climate zone only in open, sun-exposed habitats; in warmer climate zones some species also occurring in woodland. Primary habitats are open grassland, and most species invade rural or suburban areas. Monodomous colonies with single to few queens. Simple, sometimes extended soil nests, frequently under stones, rarely with a flat mound of mineral soil particles or even some organic material. Predacious and trophobiotic.

Treatment by species

Formica rufibarbis Fabricius, 1793

Formica rufibarbis Fabricius, 1793; France.
Formica fusca var. *cinereorufibarbis* Forel, 1874; Switzerland: Zürich.

Type material examined: *F. rufibarbis*: Neotype worker labelled "FRA: 44.073°N, 7.295°E, St. Martin Vesubie, Cime de la Palu, 2058 m R. Schultz 2002.05.14 -108" and "Neotype Formica rufibarbis Fabricius 1793, des. Seifert & Schultz 2009"; SMN Görlitz. In case of destruction or loss of the neotype specimen, a replacement neotype can be designated from a series of 6 mounted workers and 14 workers in ethanol from the same nest sample, having identical sample number, kept in SMN Görlitz and coll. RS.

Justification of the neotype fixation: *Formica rufibarbis* has been described from France ("Habitat in Gallia"). There is no specimen from Fabricius available that could be interpreted as a primary type. During a thorough search in the Fabricius collection in ZMU Copenhagen in 2006, a *Formica* worker labelled "rufibarbis" was found. It is without head, has a damaged mesosoma, carries no locality label but the registration label "Formica rufibarbis 402.26 Kiel" (a permanent loan from the museum in Kiel). This specimen definitely belongs to *Formica truncorum* Fabricius, 1804. It cannot be considered as type of *F. rufibarbis* because its characters clearly disagree with the original description: It has reddish legs including tarsi instead of "pedes nigri" and a reddish brown gaster instead of "Abdomen atrum". The missing parts of this *F. truncorum* specimen would also not have a "Caput nigrum ore late rufo".

***F. fusca* var. *cinereorufibarbis*:** Two worker types (the specimen with CL = 1663 was labelled as lectotype by B. Seifert in 1999) and 1 gyne paratype, all labelled "F. cinereo-rufibarbis Forel", "Z. hôpital" and "Type", MNH Geneve.

Material examined: 74 samples with 232 workers were subject to a numeric analysis of 18 characters (Figs. 18, 19): Austria (1 sample), Bosnia & Herzegovina (3), Bulgaria (1), Finland (4), France (3), Germany (27), Hungary (1), Kazakhstan (20), Lebanon (1), Russia (1), Sweden (4), Switzerland (6), Turkey (2). For details, see Appendix, as digital supplementary material to this article, at the journal's web pages.

Description of worker (Tab. 2, Fig. 3): Large *Serviformica* species (mean CS 1.455 mm), head more elongated (CL / CW$_{1.4}$ 1.141), Scape moderately long SL / CS$_{1.4}$ 1.068; distance of lateral ocelli moderate (OceD / CS$_{1.4}$ 0.169), petiole rather wide (PEW / CS$_{1.4}$ 0.471). Clypeus with sharp median keel and fine longitudinal microcarinulae. Frontal triangle finely transversely rippled and with 35 - 55 short pubescence hairs. Eyes with microsetae of 11 - 15 µm maximum length. Total mean of unilateral setae numbers on different body parts predicted for a specimen with CS = 1.4 mm: pronotum 11.1, mesonotum 6.5, propodeum plus dorsolateral metapleuron 0.8, petiole scale dorsal of spiracle 3.2, flexor profile of hind tibia 2.8. Posterior margin of head normally without setae. Ventral coxae and gaster tergites with long setae. Dorsal mesonotum in lateral aspect broadly rounded. Metanotal groove relatively deep. Propodeal dome in profile rounded, its basal profile sometimes flat or slightly concave. Dorsal crest of petiole in frontal view convex, sometimes (especially in larger specimens) with straight or weekly excavate median portion, in smaller ants sometimes bluntly angled. Petiole scale in lateral aspect rather thin, with convex anterior and more straight posterior profile. Gaster with transverse microripples of small average distance (RipD 4.4 µm) and covered by dense silvery pubescence (sqPDG 3.2). Pubescence on head, mesosoma and petiole dense. Posterior vertex, sometimes dorsal promesonotum, coxae and all appendages normally brown or dark brown, gaster always dark brown. Other body parts reddish.

Comments on taxonomy: *Formica rufibarbis* is safely separable by discriminant analysis from any other species of the group throughout its whole geographic range. Sometimes, less hairy specimens of *F. rufibarbis* could be confused with more hairy *F. clara*. Considering the characters CS, CL / $CW_{1.4}$, SL / $CS_{1.4}$, OceD / $CS_{1.4}$, EYE / $CS_{1.4}$, PEW / $CS_{1.4}$, GHL / $CS_{1.4}$, $nPN_{1.4}$, $nMN_{1.4}$, $nPRME_{1.4}$, $nPE_{1.4}$, and $nHFFL_{1.4}$, a two-class DA separates 97.8% of 274 nest samples from Eurasia with $p > 0.95$ and the LOOCV-DA gives an error indication of 0.4%:

D(12) *F. clara* -2.810 ± 0.861 [-6.33, -0.16] n = 200
D(12) *F. rufibarbis* 2.818 ± 1.297 [0.16, 6.15] n = 74

The type samples of *F. rufibarbis* and *F. fusca* var. *cinereorufibarbis* are allocated to the *F. rufibarbis* cluster with p = 1.000 and 0.999 and the type samples of *F. clara* Forel, 1886, *F. lusatica* Seifert, 1997 and *F. rufibarbis sinae* Emery, 1925 to the *F. clara* cluster with p = 1.000, 1.000 and 0.929, respectively. The case of *F. rufibarbis sinae* is discussed in the *F. clara* section and the separation of *F. rufibarbis* from the similarly setose Asian species *F. anatolica* sp.n. and *F. tarimica* sp.n. is shown in the section of the latter species.

Distribution and biology: Inhabiting the temperate, Ponto-south-Siberian and Submediterranean zones of the West Palaearctic from the Pyrenees to West Siberia (76° E) and the Southwest Siberian Saur Mountains (85° E). In Fennoscandia going to 61° N, both in Sweden (Collingwood 1979) and Finland, in the Alps and the Caucasus climbing up to 2100 m. In habitat selection intermediate between the moderately thermophilic *F. cunicularia* and the strongly thermophilic *F. clara*. Compared to the former more frequent on sandy and open ground with higher soil temperature, lower moisture and less developed herb layer and penetrating deeper into the urban zone. Presence, mean and maximum nest density on 81 potentially suitable, 150-m^2-test-plots on open land in Germany was 44%, 1.0 and 6.0 nests / 100 m^2 respectively. Diet, activity pattern and nest construction similar to *F. cunicularia* but often with larger nest populations, more aggressive, more readily attacking other ants and more effectively defending against social parasites than *F. cunicularia*. Cooperative transport of large prey items may occur. Alates occur in Central Europe 14 July ± 15 d [16 June, 3 August], n = 13 (Seifert 2007).

Formica cunicularia Latreille, 1798

Formica cunicularia Latreille, 1798; France.
Formica fusca var. *rubescens* Forel, 1904; Switzerland: Vaux.
Formica cunicularia fuscoides Dlussky, 1967; Armenia: Byurakan.

Type material examined: *F. cunicularia*: Neotype worker labelled "FRA: 44.4947°N, 0.9597°E, Fumel, 120 m, in a garden, leg. Galkowski 2008.07.25" and "Neotype Formica cunicularia Latreille 1798, des. Seifert & Schultz 2009"; SMN Görlitz. In case of destruction or loss of the neotype specimen, a replacement neotype can be designated from a series of five mounted workers from the same nest series in SMN Görlitz and further five workers in MNHN Paris.

Justification of the neotype fixation: A current search in the Latreille collection of MNHN Paris failed to detect a specimen interpretable as a primary type (J. Casevitz-Weulersse, pers. comm. 2008) and the literature gives no indication that a revisor ever has seen one. In order to establish an unambiguous standard for differentiation from similar species, we fixed a neotype in a sample from the terra typica which is in agreement with the traditional morphological conception of *F. cunicularia*.

***F. fusca* var. *rubescens*:** 4 syntype workers labelled by Forel himself "Vaux", "Cotypus" and "F. fusca r. glebaria v. rubescens For", MZ Lausanne.

***F. cunicularia fuscoides*:** Five workers from the holotype nest, labelled "1103", "Byurakan 1800 m Armen. Dlusskij 13.VI. 960" [in cyrillic letters], "Formica cunicularia kajastanica Dlussky paratypes". Serial No. 1103 definitely designates the holotype nest (Dlussky 1967, p. 74) but a holotype cannot be identified within these five specimens. They are paratypes at least. A "*F. c. kajastanica*" has never been validly published. One gyne and two workers labelled "1091" and "Alagez nad Byurakanom Armeniya G. Dlusskij 13. 6.60" were also explicitly mentioned by Dlussky and have paratype status.

Material examined: 85 samples with 307 workers were subject to a numeric analysis of 18 characters (Figs. 20, 21): Armenia (2 samples), France (12), Georgia (5), Germany (24), Great Britain (1), Greece (3), Hungary (3), Italy (10), Kazakhstan (7), Portugal (1), Russia (1), Spain (1), Switzerland (2), Turkey (11), Ukraine (2). For details, see Appendix, as digital supplementary material to this article, at the journal's web pages.

Description of worker, continental population (Tab. 1, Figs. 1, 4): medium-sized *Serviformica* species (CS 1.365 mm); head slightly elongated (CL / $CW_{1.4}$ 1.131); Scape moderately long SL / $CS_{1.4}$ 1.073; distance of lateral ocelli moderate (OceD / $CS_{1.4}$ 0.164); eyes rather large (EYE / $CS_{1.4}$ 0.301), petiole rather wide (PEW / $CS_{1.4}$ 0.468). Clypeus with sharp median keel and fine longitudinal microcarinulae. Frontal triangle finely transversely rippled and with 30 - 60 short pubescence hairs. Eyes with microsetae of 7 - 13 µm maximum length. Total mean of unilateral setae numbers on different body parts predicted for a specimen with CS = 1.4 mm: pronotum 1.1, mesonotum 0.8, petiole scale dorsal of spiracle 0.25, flexor profile of hind tibia 0.3. Posterior margin and underside of head and dorsolateral metapleuron as a rule without setae. Ventral coxae with long setae, dorsum of gaster with scattered, moderately long setae. Dorsal mesonotum in lateral aspect broadly rounded. Metanotal depression in larger individuals relatively deep. Propodeal dome rounded in lateral view, basal profile sometimes concave and in smaller specimens often straight. Dorsal crest of petiole in frontal view bluntly angled in smaller specimens to broadly convex in larger specimens, in some of the large individuals with straight or weekly excavate median portion. Petiole scale in lateral aspect rather thin, with convex anterior and more straight posterior profile. Gaster with transverse microripples of small average distance (RipD 4.6 µm) and covered by dense silvery pubescence (sqPDG 3.1). Pubescence on head, mesosoma and petiole dense. Typical colour pattern: Head with exception of round reddish-yellowish spots on anterior genae, dorsal promesonotum, coxae and all appendages dark brown, gaster blackish brown. Other body parts more or less reddish-yellowish. Nests with much lighter specimens having whole mesosoma, coxae and petiole uniformly reddish and such with very dark specimens having the reddish pigmentation reduced to a very small spot on frontal margin of ventrolateral mesonotum; exceptionally completely dark specimens occur.

Description of worker, West Mediterranean isolated populations: We do not at this time propose these deviating and isolated populations from Corsica, Sardinia and the Sierra Nevada as heterospecific from *F. cunicularia*. Differences to the continental population are a significantly narrower petiole (PEW / $CS_{1.4}$ 0.433) and slightly longer 1st tergite setae (GHL / $CS_{1.4}$ 7.24%). It seems to be the only species of the group from Corsica where *F. clara* and *F. rufibarbis* have not been reported so far.

Comments on taxonomy: The separation of *F. cunicularia* and *F. clara* represents the most difficult discrimination problem within the *F. rufibarbis* group because there is a deficiency of strongly discriminating structural characters. We ran a DA for the whole Palaearctic range of *F. clara* excluding material from the West Himalayas (Pakistan and India) where no ant species similar to *F. cunicularia* is present. Considering the characters CS, CL / $CW_{1.4}$, SL / $CS_{1.4}$, OceD / $CS_{1.4}$, EYE / $CS_{1.4}$, PEW / $CS_{1.4}$, $nPN_{1.4}$, $nMN_{1.4}$, $nPRME_{1.4}$, $nPE_{1.4}$, $nHFFL_{1.4}$, $RipD_{1.4}$, $sqPDG_{1.4}$, $PIGM_{1.4}$, and $CONT_{1.4}$, a two-class DA separates 97.4% of 268 nest samples with $p > 0.95$ and the LOOCV-DA gives an error prediction of 0.4% (Fig. 14):

D(15) *F. clara* -2.781 ± 0.864 [-4.40, -0.17] n = 183
D(15) *F. cunicularia* 2.642 ± 1.245 [0.17, 5.22] n = 85

The neotype sample of *F. cunicularia*, the syntype sample of *F. fusca* var. *rubescens* and the holotype sample of *F. cunicularia fuscoides* are safely allocated to the *F. cunicularia* cluster (each with p = 1.000) while syntype sample of *F. clara* FOREL, 1886, the holotype sample of *Formica lusatica* SEIFERT, 1997 and the syntype sample of *F. rufibarbis* var. *sinae* EMERY, 1925 are safely assigned to the *F. clara* cluster (each with p = 1.000).

While these type allocations allow clear nomenclatural decisions at least within this species pair, we do not fully trust any determination within the complete data set. The weak point is that intraspecific colour polymorphism and loss of pigmentation by light or storage media could possibly affect the reliability of the pigmentation characters PIGM and CONT, but just these two characters have the largest loadings (canonical correlations) in the DA. These loadings are 0.788 in $PIGM_{1.4}$ and 0.391 in $CONT_{1.4}$ but only 0.336 in $EYE_{1.4}$ and 0.170 in $nPN_{1.4}$, the two best structural discriminators. Another problem are the isolated West Mediterranean populations of *F. cunicularia* from Corsica, Sardinia and the Sierra Nevada which were all allocated in the DA to the *F. cunicularia* cluster but possibly represent a third species. We have currently no NUMOBAT method to show this. Integrative approaches including DNA analysis could bring more clarity into this issue.

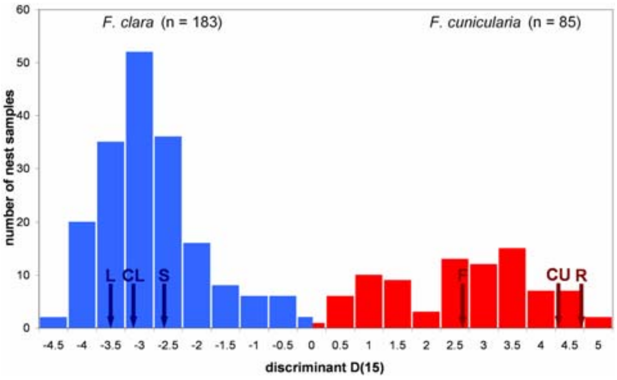


Fig. 14: Discriminant analysis of worker nest samples considering 15 characters of the Palaearctic population of *F. clara* and *F. cunicularia*. Position of type samples shown by arrows: CL – *F. clara*, L – *F. lusatica*, CU – *F. cunicularia*, R – *F. fusca* var. *rubescens*, F – *F. cunicularia fuscoides*, S – *F. rufibarbis var. sinae*.

Distribution and biology: Temperate, Ponto-south-Siberian and Submediterranean species of the West Palaearctic, occurring from southernmost England and Iberia to West Siberia (85° E). In northwestern Europe, it goes north to southern Sweden (58° N) but has not reached southern Finland so far. Having a planar to colline distribution in the northern parts of its range, it climbs up to 1800 m in the Alps, up to 2400 m in the Caucasus and up to 2000 m in the South Siberian Tarbagatay Mountains.

Moderately thermophilic. Preferred habitats are meagre and semidry grasslands on differing geological outcrop, more rarely extremely xerothermic grasslands and also open ruderal, rural or disturbed habitats, including road or railway verges. In contrast to *F. rufibarbis* more frequently occurring on loamy soils with more developed herb layer and less often invading the urban zone. Presence, mean and maximum nest density on 81 potentially suitable, 150-m^2-test-plots on open land in Germany 5%, 1.6 and 23.2 nests / 100 m^2 respectively. Colony foundation usually by single gynes but also pleometrotic. Nests moderately populous, usually containing 1000 - 1800 workers, sometimes weakly polygynous, but polydomous colonies unknown (as in all members of the group). Usually inhabits simple soil nests, construction of high mounds of mineral soil in meagre grassland with higher herb layer regularly observed. Usually timid and fugitive, but populous nests with large workers may be very aggressive during nest defence. Not territorial. Foraging at surface temperatures of up to 50°C, mainly on open surfaces and in the herb layer, but not avoiding bushes and trees. Zoophagous, trophobiotic and nectarivorous. Low position in dominance hierarchies of ant communities, usually inferior to even *Lasius niger* (LINNAEUS, 1758), whom it carefully evades thanks to superior walking speed and well-developed visual sense, thus enabling coexistence at long-term food sources. May snatch large prey items from *L. niger* by swift surprise attack. Favoured host species for several socially parasitic ant species. Alates occur 7 July ± 12 d [16 June, 1 August], n = 17 (SEIFERT 2007).

Formica clara clara **Forel, 1886**

Formica rufibarbis var. *clara* Forel, 1886; Syria: Damascus.
Formica rufibarbis var. *caucasica* Wheeler, 1913; Caucasus. [first available use of *Formica rufibarbis* ssp. *clara* var. *caucasica* Ruzsky, 1905]
Formica lusatica Seifert, 1997; Germany: Förstgen.

Type material examined: ***F. clara*****:** 9 syntype workers labelled "F. rufibarbis v. clara Forel, Damas (Lortet)"; MHN Genéve.

F. rufibarbis **var.** ***caucasica*****:** One worker lectotype labelled "Form. rufib. clara, var. caucasica, Kavkaz Ruzsky" and "Lectotype des.", ZMLSU Moskva. The specimen is badly damaged: pilosity and pubescence of dorsal body surfaces is almost completely torn off and both scapes are lacking. By subjective guess, based upon the ventral pilosity situation and overall impression, the specimen belongs to *Formica clara*.

F. lusatica**:** Holotype plus 5 paratype workers labelled "Kr.Niesky Förstgen-1.5W 1994.06.19-88" and "Formica lusatica Seifert Holotyp" / "Formica lusatica Seifert Paratyp", SMN Görlitz.

Material examined: 199 samples with 734 workers were subject to a numeric analysis of 18 characters (Figs. 22, 23): Azerbaijan (1 sample), Bulgaria (1), China (18), Cyprus (1), Czech Republic (1), Finland (8), France (1), Georgia (2), Germany (40), Greece (3), Hungary (1), India (14), Iran (26), Kazakhstan (22), Kyrgyzstan (27), Pakistan (3), Russia (2), Slovakia (1), Switzerland (1), Syria (3), The Netherlands (1), Turkey (22). For details, see Appendix, as digital supplementary material to this article, at the journal's web pages.

Description of worker (Tab. 1, Figs. 2, 5, 12, 13): larger than *F. cunicularia* (CS 1.441 mm), head slightly longer (CL / $CW_{1.4}$ 1.138), distance of lateral ocelli moderate (OceD / $CS_{1.4}$ 0.162); eye smaller than in *F. cunicularia* (EYE / $CS_{1.4}$ 0.290), petiole wide (PEW / $CS_{1.4}$ 0.467). Scape rather long (SL / $CS_{1.4}$ 1.080). Clypeus with sharp median keel and fine longitudinal microcarinulae. Frontal triangle finely transversely rippled and with 35 - 55 short pubescence hairs. Eyes with microsetae of 10 - 15 µm maximum length. Total mean of unilateral setae numbers on different body parts predicted for a specimen with CS = 1.4 mm: pronotum 3.2 (W-population: 3.6, E-population: 2.2), mesonotum 1.4 (W: 1.7, E: 0.8), petiole dorsal of spiracle 0.8 (W: 0.9, E: 0.6), flexor profile of hind tibia 0.6. Posterior margin and underside of head and dorsolateral metapleuron as a rule without setae. Ventral coxae with long setae. Dorsum of gaster normally with rather long setae, rarely these are missing. Dorsal mesonotal profile broadly rounded. Metanotal depression in larger individuals relatively deep. Propodeal dome in profile rectangular to round, the basal part sometimes rather linear to concave, whole propodeum flatter in smaller specimens. Dorsal crest of petiole in frontal view normally broadly convex, in smaller specimens sometimes bluntly angled, in larger specimens occasionally with weakly excavate median portion. Petiole scale in lateral aspect rather thin, with convex anterior and more straight posterior profile. Gaster with transverse microripples of small average distance (RipD 4.4 µm) and covered by dense silvery pubescence (sqPDG 3.1). Pubescence on head, mesosoma and petiole dense. Typical size-dependent variation of colour pattern in the northern population (*F. lusatica*): smaller specimens: area between frontal carinae, posterior vertex, dorsal promesonotum, coxae, and all appendages dark brown, all other body parts light reddish; large specimens: whole dorsal head more or less reddish, whole mesosoma and petiole light reddish, but coxae remaining dark brown; gaster in all size-classes dark brown. Colouration in the southern population (*F. clara*) on average significantly lighter, with predominance of yellowish reddish pigmentation, though specimens with the whole body being more or less dark brown may occur. The type series of *F. clara* represents a colour extreme: all body parts pale yellowish red with exception of antennal funiculus and a patch on dorsocaudal head where brown colour components are added and the gaster which is light brown with a yellowish tinge or even yellowish red (reminiscent of *Formica truncorum*).

Comments on taxonomy: The distinction from the similar species *F. cunicularia* and the unambiguous position of the type samples of *F. cunicularia*, *F. fusca* var. *rubescens*, *F. cunicularia fuscoides*, *F. clara*, *F. rufibarbis var. sinae* and *F. lusatica* within a DA has already been shown above (see also Fig. 14). We only comment here on the synonymisation of *F. lusatica* with *F. clara*.

The extreme colour differences and some morphometric deviation between the Syrian type series of *F. clara* and the northern *F. lusatica* population has suggested heterospecificity in a time when the geographic variation of both taxa over their whole Palaearctic range has been poorly known (Seifert 1997). This situation has changed now – 200 nest samples from Eurasia with recording of the complete character set and 62 samples with incomplete character set became available during the last years. Considering all sixteen structural characters and two pigmentation characters, a principal component analysis gave no suggestion on a possible grouping according to geography. We also could not demonstrate two entities by starting with the hypothesis that only material from Syria, Lebanon and Iran represented *F. clara*, then iteratively running discriminant analyses and forming new hypotheses after each run. The circuit system stabilised at insufficient parameters: only 83.1% of determinations achieved $p > 0.95$, the error indication by LOOCV was 2.6% and 21% of the samples from Germany and Finland were determined as *F. clara* which should not be true if the latter one is a separate southern species. The assumed differences between northern and southern populations most probably represent intraspecific clinal variation. Indeed there are detectable some highly significant geographic trends: CS and CL / $CW_{1.4}$ increase with growing geographical latitude while GHL / $CS_{1.4}$ falls (all regressions with $p < 0.0001$).

Distribution and biology: Shows the widest geographical range among all species of the *F. rufibarbis* group. Inhabits the temperate, submeridional and meridional zones of the Palaearctic, occurs between 2° and 88° E (as opposed to 120° E in *F. clara sinae* stat.n.) and 31° and 61°N (in Finland). Having a planar to colline distribution in the northern parts of its European range, but climbing up to 3500 m at 31° N in the Himalayas. Primarily a species of the dry steppes. Most thermophilic of the European species of the *F. rufibarbis* group (Seifert 1997, 2007) and in Central Europe the rarest of these species, with only regional occurrence in warm regions below 700 m, occurring here mainly on very xerothermic sandy and limestone grasslands, also

Tab. 1: Nest sample means of RAV-corrected morphometric data of six weakly setose species of the *F. rufibarbis* group; *F. clara* includes *F. clara sinae*. All data indexed with "1.4" are corrected for the assumption that all specimens have an equal head size of CS = 1.4 mm. Arrangement of data: mean ± standard deviation [minimum, maximum]. n = number of nest samples; CS in mm, RipD and sqPDG in µm.

	F. clara (n = 200)	***F. cunicularia*** (n = 85)	***F. persica* sp.n.** (n = 20)	***F. tianshanica* sp.n.** (n = 32)	***F. glabridorsis*** (n = 6)	***F. orangea* sp.n.** (n = 32)
CS	1.427 ± 0.144 [1.128, 1.731]	1.362 ± 0.109 [1.160, 1.642]	1.332 ± 0.110 [1.162, 1.540]	1.220 ± 0.074 [1.075, 1.378]	1.425 ± 0.083 [1.274, 1.517]	1.349 ± 0.107 [1.121, 1.524]
CL / CW$_{1.4}$	1.136 ± 0.020 [1.077, 1.216]	1.135 ± 0.020 [1.090, 1.179]	1.162 ± 0.014 [1.141, 1.196]	1.143 ± 0.013 [1.110, 1.171]	1.164 ± 0.015 [1.145, 1.187]	1.111 ± 0.014 [1.085, 1.138]
SL / CS$_{1.4}$	1.081 ± 0.024 [1.006, 1.146]	1.074 ± 0.028 [1.012, 1.138]	1.152 ± 0.023 [1.119, 1.197]	1.057 ± 0.017 [1.033, 1.094]	1.184 ± 0.025 [1.166, 1.233]	1.021 ± 0.025 [0.964, 1.079]
PEW / CL$_{1.4}$	0.466 ± 0.022 [0.392, 0.523]	0.466 ± 0.022 [0.412, 0.516]	0.450 ± 0.017 [0.423, 0.479]	0.434 ± 0.014 [0.413, 0.476]	0.430 ± 0.030 [0.373, 0.457]	0.421 ± 0.018 [0.382, 0.452]
EYE / CS$_{1.4}$	0.290 ± 0.005 [0.278, 0.309]	0.300 ± 0.006 [0.286, 0.311]	0.297 ± 0.006 [0.289, 0.311]	0.299 ± 0.004 [0.288, 0.306]	0.301 ± 0.006 [0.294, 0.309]	0.288 ± 0.006 [0.274, 0.296]
OceD / CS$_{1.4}$	0.161 ± 0.008 [0.143, 0.186]	0.164 ± 0.008 [0.145, 0.180]	0.162 ± 0.008 [0.147, 0.175]	0.165 ± 0.006 [0.154, 0.178]	0.151 ± 0.012 [0.137, 0.168]	0.172 ± 0.009 [0.156, 0.192]
GHL / CS$_{1.4}$ [%]	7.25 ± 0.77 [3.48, 8.96]	6.75 ± 0.74 [5.21, 8.56]	4.28 ± 2.04 [0.00, 7.66]	7.15 ± 0.59 [5.88, 8.29]	6.00 ± 0.32 [5.64, 6.51]	8.16 ± 0.91 [6.75, 10.30]
nOCC$_{1.4}$	0.01 ± 0.05 [0.0, 0.47]	0.00 ± 0.00 [0.0, 0.00]	0.00 ± 0.00 [0.0, 0.00]	0.00 ± 0.00 [0.0, 0.00]	0.00 ± 0.00 [0.0, 0.00]	0.01 ± 0.02 [0.0, 0.13]
nGU$_{1.4}$	0.01 ± 0.06 [0.00, 0.33]	0.03 ± 0.11 [0.0, 0.75]	0.02 ± 0.07 [0.0, 0.25]	0.01 ± 0.06 [0.0, 0.33]	0.00 ± 0.00 [0.0, 0.00]	0.01 ± 0.05 [0.0, 0.17]
nPN$_{1.4}$	2.77 ± 1.95 [0.0, 9.2]	1.29 ± 1.54 [0.0, 7.7]	0.03 ± 0.09 [0.00, 0.35]	1.73 ± 0.97 [0.40, 4.90]	0.04 ± 0.09 [0.0, 0.23]	1.53 ± 1.78 [0.0, 7.2]
nMN$_{1.4}$	1.19 ± 1.20 [0.0, 5.2]	0.76 ± 0.96 [0.0, 5.2]	0.02 ± 0.06 [0.0, 0.2]	0.50 ± 0.49 [0.0, 1.9]	0.02 ± 0.05 [0.0, 0.13]	0.78 ± 0.46 [0.0, 1.6]
nPRME$_{1.4}$	0.03 ± 0.09 [0.0, 0.6]	0.02 ± 0.05 [0.0, 0.3]	0.00 ± 0.00 [0.0, 0.0]	0.00 ± 0.00 [0.0, 0.0]	0.02 ± 0.06 [0.0, 0.15]	0.05 ± 0.18 [0.0, 0.8]
nPE$_{1.4}$	0.70 ± 0.55 [0.0, 2.8]	0.31 ± 0.38 [0.0, 1.5]	0.58 ± 0.06 [0.5, 0.6]	0.01 ± 0.04 [0.0, 0.2]	0.09 ± 0.16 [0.0, 0.40]	0.22 ± 0.38 [0.0, 1.8]
nHFFL$_{1.4}$	0.51 ± 0.49 [0.0, 2.1]	0.31 ± 0.36 [0.0, 1.7]	0.06 ± 0.11 [0.0, 0.3]	0.60 ± 0.53 [0.0, 2.3]	0.12 ± 0.31 [0.0, 0.8]	0.34 ± 0.43 [0.0, 1.6]
RipD$_{1.4}$	4.42 ± 0.20 [3.8, 5.1]	4.56 ± 0.28 [3.9, 5.4]	5.80 ± 0.41 [5.2, 6.4]	6.19 ± 0.43 [5.3, 7.1]	4.24 ± 0.32 [3.80, 4.72]	6.74 ± 0.54 [5.3, 7.9]
sqPDG$_{1.4}$	3.14 ± 0.13 [2.75, 3.47]	3.06 ± 0.17 [2.67, 3.43]	3.26 ± 0.15 [3.01, 3.53]	3.28 ± 0.17 [3.00, 3.89]	2.92 ± 0.09 [2.83, 3.06]	3.15 ± 0.10 [2.90, 3.42]
PIGM$_{1.4}$	11.1 ± 12.1 [0.0, 65.5]	68.7 ± 18.7 [22.5, 105.3]	64.5 ± 14.5 [29.0, 85.7]	70.7 ± 7.9 [45.4, 86.3]	69.5 ± 35.4 [11.5, 100.5]	3.0 ± 4.1 [0.0, 13.3]
CONT$_{1.4}$	0.16 ± 0.21 [0.00, 1.1]	0.67 ± 0.30 [0.0, 1.1]	0.69 ± 0.22 [0.1, 1.0]	0.40 ± 0.21 [0.0, 0.8]	0.18 ± 0.10 [0.00, 0.30]	0.02 ± 0.03 [0.0, 0.1]

Tab. 2: Nest sample means of RAV-corrected morphometric data of the three more strongly setose species of the *F. rufibarbis* group. For further information see Table 1 on the left page.

	***F. tarimica* sp.n.** (n = 34)	***F. rufibarbis*** (n = 74)	***F. anatolica* sp.n.** (n = 13)
CS	1.242 ± 0.095 [0.996, 1.485]	1.455 ± 0.142 [1.147, 1.725]	1.401 ± 131 [1.205, 1.612]
CL / CW$_{1.4}$	1.158 ± 0.015 [1.135, 1.202]	1.141 ± 0.014 [1.099, 1.171]	1.110 ± 0.012 [1.092, 1.138]
SL / CS$_{1.4}$	1.070 ± 0.019 [1.024, 1.112]	1.068 ± 0.019 [1.028, 1.117]	1.031 ± 0.014 [1.009, 1.053]
PEW / CL$_{1.4}$	0.395 ± 0.016 [0.364, 0.426]	0.471 ± 0.019 [0.432, 0.521]	0.484 ± 0.026 [0.442, 0.520]
EYE / CS$_{1.4}$	0.281 ± 0.003 [0.274, 0.287]	0.291 ± 0.004 [0.279, 0.299]	0.303 ± 0.006 [0.295, 0.312]
OceD / CS$_{1.4}$	0.163 ± 0.005 [0.149, 0.174]	0.167 ± 0.007 [0.148, 0.185]	0.169 ± 0.007 [0.160, 0.186]
GHL / CS$_{1.4}$ [%]	9.40 ± 0.52 [8.28, 10.40]	8.46 ± 0.70 [7.02, 10.06]	8.10 ± 0.50 [7.15, 8.84]
nOCC$_{1.4}$	0.28 ± 0.22 [0.00, 0.70]	0.09 ± 0.15 [0.0, 0.67]	0.06 ± 0.08 [0.0, 0.2]
nGU$_{1.4}$	0.04 ± 0.07 [0.0, 0.25]	0.02 ± 0.08 [0.0, 0.50]	1.59 ± 0.71 [0.6, 3.0]
nPN$_{1.4}$	12.77 ± 2.70 [8.6, 19.7]	11.12 ± 2.70 [4.8, 17.2]	8.92 ± 5.56 [2.3, 18.0]
nMN$_{1.4}$	3.21 ± 1.92 [0.5, 11.6]	6.49 ± 2.48 [2.7, 14.2]	4.22 ± 4.18 [0.4, 13.6]
nPRME$_{1.4}$	0.43 ± 0.51 [0.0, 2.3]	0.78 ± 0.84 [0.0, 3.5]	0.13 ± 0.29 [0.0, 1.0]
nPE$_{1.4}$	1.15 ± 0.76 [0.0, 2.7]	3.23 ± 0.99 [0.6, 5.8]	0.79 ± 0.80 [0.0, 2.2]
nHFFL$_{1.4}$	0.83 ± 0.68 [0.0, 3.0]	2.78 ± 1.17 [0.3, 6.0]	1.42 ± 1.26 [0.0, 4.4]
RipD$_{1.4}$	7.88 ± 0.53 [7.2, 9.2]	4.35 ± 0.21 [3.9, 4.8]	4.56 ± 0.15 [4.4, 4.9]
sqPDG$_{1.4}$	3.16 ± 0.18 [2.75, 3.43]	3.15 ± 0.15 [2.73, 3.49]	3.39 ± 0.11 [3.2, 3.6]
PIGM$_{1.4}$	2.65 ± 3.6 [0.0, 15.4]	14.7 ± 12.9 [0.0, 48.0]	84.0 ± 40.1 [38.5, 155.8]
CONT$_{1.4}$	0.03 ± 0.02 [0.0, 0.1]	0.36 ± 0.24 [0.0, 0.9]	0.36 ± 0.22 [0.0, 1.0]

on ruderal grassland, generally preferring open land with patchy herb layer. In sandy areas of the Lausitz (Germany) outcompeting *F. rufibarbis*. In the southern parts of the range also in more moist places, city parks and semi-shaded woodland. Presence, mean and maximum nest density on 81 potentially suitable, 150-m^2-test-plots on open land in Germany 15%, 0.21 and 3.7 nests / 100 m^2 respectively. Nests often rather populous, monogynous to weakly polygynous, with aggressive workers which are, at least in the northern range, notably larger than those of *F. cunicularia* and *F. rufibarbis*. Big nests defend territories. Resistance against social parasites certainly stronger than in *F. cunicularia* (SEIFERT 1997, 2007; CZECHOWSKI & RADCHENKO 2006). However, main host of *Polyergus rufescens* (LATREILLE, 1798) in Central Asia where *F. cunicularia* and *F. rufibarbis* are rare or absent. Alates occur in Central Europe 14 July ± 16 d [29 June, 20 July], n = 14.

Formica clara sinae **EMERY, 1925 stat.n.**

Formica rufibarbis var. *sinae* EMERY, 1925; China: Shantung, Tsingtao. [replacement name for *Formica rufibarbis* var. *orientalis* WHEELER, 1923, a junior primary homonym of *Formica fusca* ssp. *orientalis* RUZSKY, 1915]

Type material examined: Three workers labelled "ShanTung', China Aug.24 1922 A.P.-Jacot" [integrated interpretation from both handwritten labels of Jacot], "A.P. Jacot No. 2287", "Gift of W.M. Wheeler", "M.C.Z. Type 1-3 21733", "var. orientalis Wheeler"; three further workers labelled "ShanTung', China Aug.24 1922 A.P.-Jacot" [integrated interpretation from both badly handwritten labels of Jacot], "Gift of W.M. Wheeler", "M.C.Z. Type 4-6 21733"; all MCZ Cambridge.

Material examined: 1 sample with 6 workers from China was subject to a numeric analysis of 18 characters (Fig. 23).

Description of worker (based on the type sample): medium-sized *Serviformica*, CS 1.327 mm; pronotum more hairy than in *F. clara* s.str., nPN$_{1.4}$ 9.2. Propodeum plus dorsolateral metapleuron normally with one seta. Petiole narrower than in average *F. clara* s.str.: PEW / CS$_{1.4}$ 0.428. All other body dimensions near the average of the nominal form: CL / CW$_{1.4}$ 1.142, OceD / CS$_{1.4}$ 0.168, EYE / CS$_{1.4}$ 0.283, SL / CS$_{1.4}$ 1.060, nMN$_{1.4}$ 1.6, nPE$_{1.4}$ 2.5, nHFFL$_{1.4}$ 0.2, RipD$_{1.4}$ 4.2, sqPDG$_{1.4}$ 2.9. Clypeus with sharp median keel and longitudinal microcarinulae. Frontal triangle finely transversally rippled and with 40 - 60 pubescence hairs. Eyes with microsetae of 5 - 7 µm maximum length. Ventral coxae and gaster tergites with long setae. Dorsal crest of petiole in frontal view convex, sometimes with straight median portion. In lateral aspect wedge-shaped, relatively small with more convex anterior and more straight posterior profile. Colouration as in the typical northern population of *F. clara* s.str.: light yellowish brown with darker vertex, dorsal pronotum and mesonotum, coxae only slightly more dark.

Comments on taxonomy: Though being most similar to *F. clara* s.str. in the majority of characters, the much more developed pronotal pilosity (nPN$_{1.4}$ 9.2) and some 2850 km distance from the next known population of *F. clara* s.str. makes it advisable to establish an East Chinese subspecies *F. clara sinae*. We cannot exclude that *F. c. sinae* could have species rank but testing this is prevented by lack of further sympatric material.

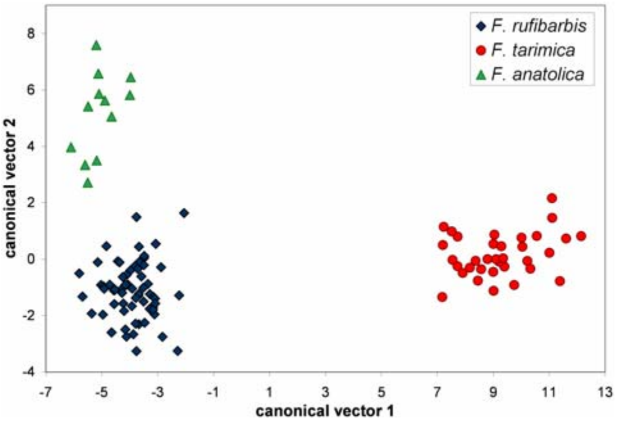


Fig. 15: Discriminant analysis of worker nest samples considering 14 characters of *F. rufibarbis, F. tarimica* sp.n. and *F. anatolica* sp.n.

Distribution and biology: This subspecies is only known by the type series which was collected on the sandflats west of Nu Ku Kow, Kiachou Bay, Quingdao (= Tsingtao), Shandong Province (WHEELER 1923).

Formica orangea sp.n.

Derivatio nominis: from the mainly orange body colour.

Type material examined: Holotype worker plus 4 worker paratypes labelled "KIR:41.8327°N,71.1948°E Tshatkal valley, 1830 m R.Schultz 1998.07.28-115" and "Holotype Formica orangea Seifert & Schultz" / "Paratype Formica orangea Seifert & Schultz", 5 paratype workers in ethanol, SMN Görlitz; from the same nest series: 3 mounted paratype workers and 19 paratype workers in ethanol, coll. RS.

Material examined: 32 samples with 100 workers were subject to a numeric analysis of 18 characters (Figs. 18, 19): Afghanistan (2), Iran (1), Kazakhstan (4), Kyrgyzstan (10), Mongolia (14), Uzbekistan (1). For details, see Appendix, as digital supplementary material to this article, at the journal's web pages.

Description of worker (Tab. 1, Fig. 6): medium-sized *Serviformica* species (CS 1.349 mm), head short (CL / $CW_{1.4}$ 1.111), scape shortest and distance of lateral ocelli largest within the *F. rufibarbis* group (SL / $CS_{1.4}$ 1.021, OceD / $CS_{1.4}$ 0.172), eye relatively small (EYE / $CS_{1.4}$ 0.288), petiole relatively narrow (PEW / $CS_{1.4}$ 0.421). Clypeus with sharp median keel and fine longitudinal microcarinulae. Frontal triangle finely transversely rippled and with 35 - 60 short pubescence hairs. Eyes with microsetae of 10 - 13 µm maximum length. Total mean of unilateral setae numbers on different body parts predicted for a specimen with CS = 1.4 mm: pronotum 1.5, mesonotum 0.8, petiole scale dorsal of spiracle 0.2, flexor profile of hind tibia 0.3. Posterior margin of head and propodeum plus dorsolateral metapleuron normally without setae. Ventral coxae and gaster tergites with long setae. Dorsal mesonotal profile broadly rounded. Metanotal depression moderately deep. Propodeal dome in profile flatly rounded to angled, the basal profile sometimes slightly concave. Dorsal crest of petiole in frontal view broadly convex. Petiole scale in lateral aspect relatively low and thicker than in other species of the *F. rufibarbis* group, except *F. tarimica* sp.n., with convex anterior and straight to slightly convex posterior profile. Gaster with transverse microripples of rather large distance (RipD 6.7 µm, second largest within the *F. rufibarbis* group) and covered by dense silvery pubescence (sqPDG 3.15). Pubescence on head, mesosoma and petiole less dense. Whole head, mesosoma, coxae, all appendages, and petiole in typical cases reddish yellow; sometimes in smaller specimens brown spots may occur on posterior vertex and dorsal promesonotum, but always with low contrast between the pigmented and the light parts, gaster always brown.

Comments on taxonomy: *Formica orangea* sp.n. shows an unmistakable combination of orange colour, short head, short scape, high interocellar distance, low pronotal setae numbers and large microripple distance on gaster tergites (Tab. 1).

Distribution and biology: Occurring in the Oriental-Turanian and Central Asian floristic region of the south submeridional and meridional zones. Ranging from 58° (Iran) to 104° E (Mongolia) and 34° (Afghanistan) to 48° N (Kazakhstan) at elevations between 400 and 2200 m. Prefers dry steppe and semi-desert habitats, in the vicinity of rivers or lakes. Invades rural areas and gardens. Nests found in moderately dry sand, often with characteristic slant gateways leading to the underground. Foraging on available trees, probably tending trophobionts.

Formica tarimica sp.n.

Derivatio nominis: from the distribution in the Tarim Basin.

Type material examined: Holotype worker plus 4 worker paratypes labelled "CHI:42.1251°N,84.4323°E Yengisar, 1515 m R.Schultz 2004.09.03-086" and "Holotype Formica tarimica Seifert & Schultz" / "Paratype Formica tarimica Seifert & Schultz", SMN Görlitz; from the same nest series: 3 mounted paratype workers and 48 paratype workers in ethanol, coll. RS.

Material examined: 34 samples with 126 workers from Tarim Basin (China) were subject to a numeric character analysis (Fig. 15). For details, see Appendix, as digital supplementary material to this article, at the journal's web pages.

Description of worker (Tab. 2, Fig. 7): small *Serviformica* species (CS 1.242 mm), head elongated (CL / $CW_{1.4}$ 1.158), scape moderately long (SL / $CS_{1.4}$ 1.070), has the smallest eyes and the narrowest petiole within the *F. rufibarbis* group (EYE / $CS_{1.4}$ 0.281, PEW / $CS_{1.4}$ 0.395). Clypeus with sharp median keel and fine longitudinal microcarinulae. Frontal triangle finely transversely rippled and with 30 - 50 short pubescence hairs. Eyes with microsetae of 7 - 10 µm maximum length. Total mean of unilateral setae numbers on different body parts predicted for a specimen with CS = 1.4 mm: pronotum 12.8, mesonotum 3.2, propodeum plus dorsolateral metapleuron 0.4, petiole dorsal of the spiracle 1.2, flexor profile of hind tibia 0.8, underside of head 0.0. Dorsal mesonotum in lateral aspect broadly convex. Metanotal depression relatively deep. Propodeal dome in profile rounded or angulate-convex. Dorsal crest of petiole in frontal view convex or bluntly angled. Petiole scale in lateral aspect thicker than in other species of the *F. rufibarbis* group, except *F. orangea* sp.n., with convex anterior and straight to slightly convex posterior profile. Gaster with transverse microripples of the largest average distance found in the *F. rufibarbis* (RipD 7.9 µm) and covered by dense silvery pubescence (sqPDG 3.2). Pubescence on head, mesosoma and petiole less dense. Whole head, mesosoma, coxae, all appendages, and petiole in typical cases reddish yellow, gaster always brown.

Comments on taxonomy: Seeing this orange species walking on the ground of dry steppe or semidesert habitats, *F. tarimica* sp.n. could be mistaken on the first glance for *F. orangea* sp.n. but the former is easily distinguished by the much more numerous pronotal setae and longer head. The separation of *F. tarimica* sp.n. from the other species with similarly large pronotal setae numbers, *F. rufibarbis* and *F. anatolica* sp.n., is shown in Figure 15: a three-class DA considering the characters CS, $CL / CW_{1.4}$, $SL / CS_{1.4}$, $OceD / CS_{1.4}$, $EYE / CS_{1.4}$, $PEW / CS_{1.4}$, $nPN_{1.4}$, $nMN_{1.4}$, $nPRME_{1.4}$, $nPE_{1.4}$, $nHFFL_{1.4}$, $RipD_{1.4}$, $sqPDG_{1.4}$, and $PIGM_{1.4}$, separated any of the 111 nest samples of these three species with $p > 0.975$ and 0% error indication in a LOOCV-DA.

Distribution and biology: A Central Asian species, apparently restricted to the Tarim Basin and adjacent foothills of the Tian Shan Mountains at elevations between 850 and 1550 m. Perhaps due to rarity of competing *Formica* species it occupies a diversity of habitats including semidesert, pastures, irrigated crop plantations, gardens, open alluvial sand banks, and poplar or tamarisk stands. As a rule, the habitats are found on water-influenced ground, frequently near the Tarim River. Nests in moderately dry sand, often with characteristic slant gateways leading to the underground. Change of nest sites after inundation once observed. Foraging on poplars, probably tending trophobionts.

Formica anatolica sp.n.

Derivatio nominis: from the distribution in Anatolia.

Type material examined: Holotype worker plus 4 worker paratypes labelled "TUR: 37.348°N, 34.360°E Halkapinar-32 rkm SE, Aydos Dagi 1600-1800 m, A.Schulz 1997.05.08-214" and "Holotype Formica anatolica Seifert & Schultz" / "Paratype Formica anatolica Seifert & Schultz"; SMN Görlitz.

Material examined: 13 samples with 54 workers from Anatolia (Turkey) were subject to a numeric analysis of 18 characters (Fig. 18). For details, see Appendix, as digital supplementary material to this article, at the journal's web pages.

Description of worker (Tab. 2, Fig. 8): large *Serviformica* species (CS 1.401 mm), head and scape significantly shorter than in *F. rufibarbis* ($CL / CW_{1.4}$ 1.110, $SL / CS_{1.4}$ 1.031) and eye distinctly larger ($EYE / CS_{1.4}$ 0.303). Petiole very wide ($PEW / CS_{1.4}$ 0.484). Clypeus with sharp median keel and fine longitudinal microcarinulae. Frontal triangle finely transversely rippled and with 55 - 80 short pubescence hairs. Eyes with microsetae of 8 - 10 µm maximum length. Total mean of unilateral setae numbers on different body parts predicted for a specimen with CS = 1.4 mm: pronotum 8.9, mesonotum 4.2, propodeum plus dorsolateral metapleuron 0.1, petiole dorsal of spiracle 0.8, flexor profile of hind tibia 1.4, underside of head 1.6 (only species of the *F. rufibarbis* group usually having gular setae). Posterior margin of head normally without setae. Ventral coxae and gaster tergites with long setae. Dorsal mesonotum in profile broadly convex. Metanotal depression rather deep. Propodeal dome in profile obtuse-angled or rounded, the basal profile sometimes linear or slightly concave. Dorsal crest of petiole in frontal view rounded, sometimes (especially in larger specimens) with a straight or slightly excavated median portion. Petiole scale in lateral aspect thin, with convex anterior and more straight posterior profile. Gaster with transverse microripples of small distance (RipD 4.6 µm) and covered by dense silvery pubescence (sqPDG 3.4). Pubescence on head, mesosoma and petiole dense. Posterior vertex, often dorsal promesonotum, coxae and all appendages dark brown, gaster always dark brown. Other body parts reddish. In overall impression, this species appears relatively dark with remarkable contrasts between brown and reddish parts, especially on genae.

Comments on taxonomy: Well separable from any other Palaearctic species. The very clear distinction from the other two setose species, *F. rufibarbis* and *F. tarimica* sp.n., has already been presented above (Fig. 15). The short head, short scape, large eye and pilosity on underside of head suggest certain affinities to the *F. cinerea* group but the very wide petiole scale and overall pilosity pattern indicate an allocation to the *F. rufibarbis* group.

Distribution and biology: So far only known from south-central Anatolia in the region of the Taurus Mountains (Toros Daglari). Occurring there at elevations between 1300 and 1900 m. Most remarkable habitat selection: so far only found in woodland stands with *Abies*, *Juniperus*, *Quercus* and other deciduous tree species, occasionally interspersed with grassland patches.

Formica tianshanica sp.n.

Derivatio nominis: from Tian Shan, the region of the first finding.

Type material examined: Holotype worker plus 4 worker paratypes labelled "KIR: 42.4079°N, 73.7893°E Kap Tshigai valley, R.Schultz 1998.07.16-004" and "Holotype Formica tianshanica Seifert & Schultz" / "Paratype Formica tianshanica Seifert & Schultz", SMN Görlitz; 3 mounted paratype workers and 10 paratype workers in ethanol, coll. RS.

Material examined: 32 samples with 119 workers were subject to a numeric character analysis (Fig. 21): China (28), Kazakhstan (1), Kyrgyzstan (3). For details, see Appendix, as digital supplementary material to this article, at the journal's web pages.

Description of worker (Tab. 1, Figs. 9, 16): small *Serviformica* species (CS 1.220 mm). Compared to *F. cunicularia*, head more elongated ($CL / CW_{1.4}$ 1.143), scape slightly shorter ($SL / CL_{1.4}$ 1.057) and petiole narrower ($PEW / CS_{1.4}$ 0.434). Distance between lateral ocelli moderate ($OceD / CS_{1.4}$ 0.165), eyes rather large ($EYE / CS_{1.4}$ 0.299). Frontal triangle finely transversely rippled and with 25 - 40 short pubescence hairs. Eyes with microsetae of 7 - 12 µm maximum length. Total mean of unilateral setae numbers on different body parts predicted for a specimen with CS = 1.4 mm: pronotum 1.7, mesonotum 0.5, flexor profile of hind tibia 0.6. Petiole, posterior margin of head, propodeum, and dorsolateral metapleuron normally without setae. Ventral coxae and gaster tergites with long setae. Dorsal mesonotum in lateral aspect broadly convex. Metanotal depression of moderate depth. Propodeal dome in profile convex, the basal profile sometimes slightly concave, in smaller specimens more or less linear and horizontal. Dorsal crest of petiole in frontal view bluntly angled in smaller specimens to broadly convex in larger specimens in which the median portion is occasionally linear or weakly excavate. Petiole scale in lateral aspect slender, with convex anterior and more straight posterior profile. Gaster ter-

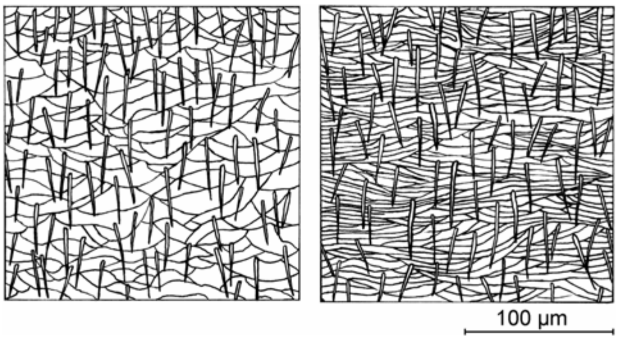


Fig. 16: Microsculpture and pubescence on dorsum of first gaster tergite in *F. tianshanica* sp.n. (left) and *F. cunicularia* (right).

gites with transverse microripples of a significantly larger distance than in *F. cunicularia* (RipD 6.2 µm, Fig. 16), increasing from West (W-Tianshan, E-Kazakhstan: 5.7 µm) to East (Bogda Shan: 6.5 µm). Dorsum of gaster covered by dense silvery pubescence (sqPDG 3.3). Pubescence on head, mesosoma and petiole less dense, ants appear mildly shining. Posterior vertex, sometimes dorsal promesonotum, coxae, and all appendages normally brown, gaster always dark brown. Other body parts more or less reddish, in the Bogda Shan population more yellowish-brown.

Comments on taxonomy: The character combination and overall phenotypic impression of *F. tianshanica* sp.n. is similar to that of *F. cunicularia* and *F. persica* sp.n., and we assume that these species are closely related allopatric and parapatric species. The discrimination, however, seems to be no problem. A three-class DA considering the characters CS, CL / $\mathrm{CW}_{1.4}$, SL / $\mathrm{CS}_{1.4}$, OceD / $\mathrm{CS}_{1.4}$, EYE / $\mathrm{CS}_{1.4}$, PEW / $\mathrm{CS}_{1.4}$, $\mathrm{nPN}_{1.4}$, $\mathrm{nMN}_{1.4}$, $\mathrm{nPRME}_{1.4}$, $\mathrm{nPE}_{1.4}$, $\mathrm{nHFFL}_{1.4}$, $\mathrm{RipD}_{1.4}$, $\mathrm{sqPDG}_{1.4}$, and $\mathrm{PIGM}_{1.4}$, separated each of the 138 nest samples of these three species with $p > 0.97$ and 0% error indication in a LOOCV-DA (Fig. 17). The type samples were allocated to the right clusters with the following probabilities: neotype sample of *F. cunicularia* ($p = 1.000$), the holotype sample of *F. cunicularia fuscoides* and syntype sample of *F. fusca* var. *rubescens* (both $p = 1.000$, to *F. cunicularia*), the holotype sample of *F. tianshanica* sp.n. ($p = 0.999$) and holotype sample of *F. persica* sp.n. ($p = 0.998$). *F. tianshanica* sp.n. is in no contact with *F. persica* sp.n. but is sympatric with *F. cunicularia* in the Tarbagatay-Saur Mountains in East Kazakhstan. There seems to exist no reduction of interspecific phenotypic contrast in this sympatric region but the small sample size available does not allow to really discuss possible interspecific hybridisation.

Considerable morphological variation within the *F. tianshanica* sp.n. population is apparently existing in the gynes: Two gynes from the Tian Shan and Tarbagatay differ from five gynes from the Bogda Shan by larger CS, smaller OceD / CS and EYE / CS, more voluminous mesosomas and lighter colour. The sparse information currently available does not allow to decide if these differences represent a gyne dimorphism (as for instance found in European *Formica fusca*) or indicate different allopatric species. Since there are no significant differences between the worker populations of Tian Shan and Bogda Shan, we provisionally assume a gyne polymorphism but the problem needs a detailed investigation by integrative taxonomy.

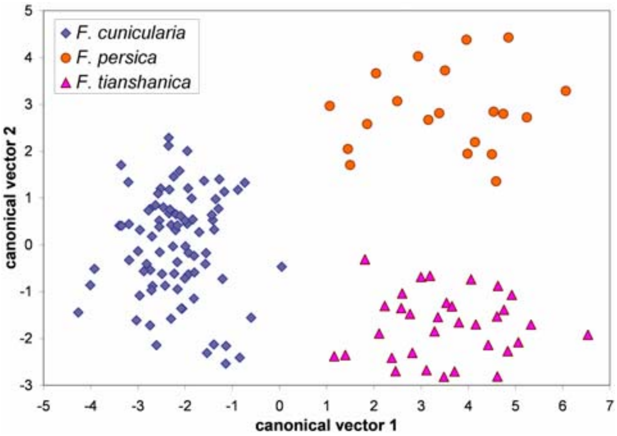


Fig. 17: Discriminant analysis of worker nest samples considering 14 characters of *F. cunicularia*, *F. persica* sp.n. and *F. tianshanica* sp.n.

Distribution and biology: Only known from mountain areas of the Turkestanian floristic subregion (Tian Shan, Tarbagatay-Saur, Bogda Shan). Range between 71° and 89° E and 42° and 47°N. Apparently rare in regions with competing montane and subalpine *Serviformica* species as observed in the Tian Shan, Tarbagatay and Quin Ling Shan. In contrast, very abundant in the Bogda Shan where these competitors are missing, occupying here a wide altitudinal range from 1380 to 3010 metres. This correlates with variable habitat selection in Bogda Shan: it was found here in pastures of any kind above and below the tree line, in open rural areas, in clear-cuttings of former *Picea* forest, in habitat mosaics of grassland, *Picea* and *Juniperus* and in light *Picea* forests.

Formica persica sp.n.

Derivatio nominis: from Persia – the terra typica of this species.

Type material examined: Holotype worker plus 6 worker paratypes (4 stored in ethanol) labelled "IRAN: 36.767°N, 54.567°E, Tuskestan forest, 900 m Juniperus forest O.Paknia 2005.09.23-517" and "Holotype Formica persica Seifert & Schultz" / "Paratype Formica persica Seifert & Schultz"; SMN Görlitz.

Material examined: 20 samples with 54 workers from Iran were subject to a numeric analysis of 18 characters (Fig. 20). For details. see Appendix, as digital supplementary material to this article, at the journal's web pages.

Description of worker (Tab. 1, Fig. 10): medium-sized *Serviformica* species (CS 1.332 mm), head and scape much longer than in *F. cunicularia* (CL / $\mathrm{CW}_{1.4}$ 1.162, SL / $\mathrm{CS}_{1.4}$ 1.152). Petiole rather wide (PEW / $\mathrm{CS}_{1.4}$ 0.450). Distance between lateral ocelli moderate (OceD / $\mathrm{CS}_{1.4}$ 0.162), eye medium-sized (EYE / $\mathrm{CS}_{1.4}$ 0.297). Clypeus with sharp median keel and fine longitudinal microcarinulae. Frontal triangle finely transversely rippled and with 45 - 85 short pubescence hairs. Eyes with microsetae of 9 µm maximum length. Pronotum, mesonotum, petiole, flexor profile of hind tibia, posterior margin of head, propodeum, and dorsolateral metapleuron normally without setae. Ventral coxae with long setae, setae on dorsum of first gaster tergite sometimes lacking. Dorsal mesonotum in lateral aspect broadly convex, but in small ants flatter. Metanotal depression in

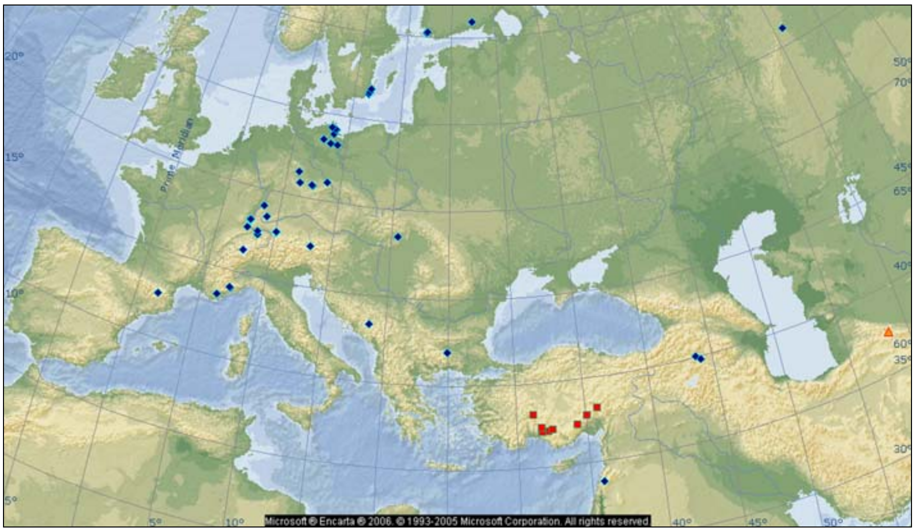


Fig. 18: Distribution of collecting sites of *F. rufibarbis* (blue rhombs), *F. anatolica* sp.n. (red squares) and *F. orangea* sp.n. (orange triangles) west of 65° E. Original map with permission of Microsoft®Encarta®2006©1993-2005 Microsoft Corporation. All rights reserved.

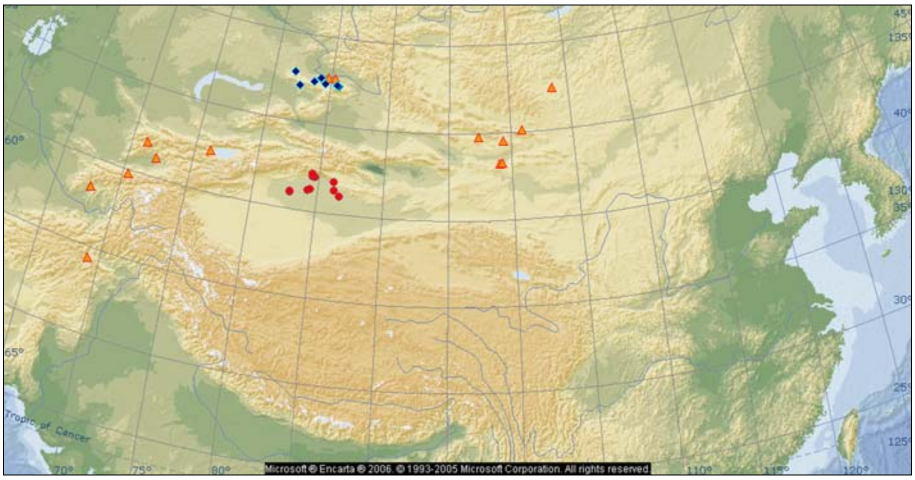


Fig. 19: Distribution of collecting sites of *F. rufibarbis* (blue rhombs), *F. tarimica* sp.n. (red discs) and *F. orangea* sp.n. (orange triangles) east of 65° E. Original map with permission of Microsoft®Encarta®2006©1993-2005 Microsoft Corporation. All rights reserved.

larger specimens deep, in small specimens shallow. Propodeal dome in profile obtuse-angled or rounded. Dorsal crest of petiole in frontal view convex, sometimes obtuse-angled. Petiole scale in lateral aspect slender, with convex anterior and more straight posterior profile. Mean distance of transverse microripples on dorsum of gaster larger than in *F. cunicularia* (RipD 5.8 µm). Gaster covered by a dense silvery pubescence (sqPDG 3.3). Pubescence on head, mesosoma and petiole less dense, ants appear somewhat shiny. Posterior vertex, often dorsal promesonotum, coxae, and all appendages brown, gaster always dark brown. Other body parts yellowish-reddish.

Comments on taxonomy: The clear separation of *F. tianshanica* sp.n. from *F. cunicularia* and *F. persica* sp.n. has already been stated above (Fig. 17). It is unknown if there are contact areas with the Anatolian and Caucasian population of *F. cunicularia*.

Distribution and biology: So far, only known from the North Iranian region of the Elburs Mountains between 48.5° to 56° E and 36.2° to 38.4° N, in a region with much precipitation (600 - 1500 mm per year). Altitudinal range from sea level up to 2300 metres. Occurs in highly diverse habitats from steppe, human settlements, rural areas, river sides, and frequently inside of forests. The forest sites are below 1000 metres and include deciduous and *Juniperus* forests.

Formica glabridorsis SANTSCHI, 1925

Formica rufibarbis var. *glabridorsis* SANTSCHI, 1925; China: Beijing.

Type material examined: One syntype worker labelled "Type", "Pechino S.Folchini 1905", "B.Finzi Coll purch. 1950", "Formia (Servif.) rufibarbis Nyl.glabribarbis Sah Santschi det. 1951", "M.C.Z. CoType 28817"; a second syntype worker without scapes labelled "Pechino S.Folchini 1905", "B.Finzi Coll purch.1950", "M.C.Z. CoType 28817", "Jan.-Jun. 2001 MCZ Image Database"; both syntypes MCZ Cambridge.

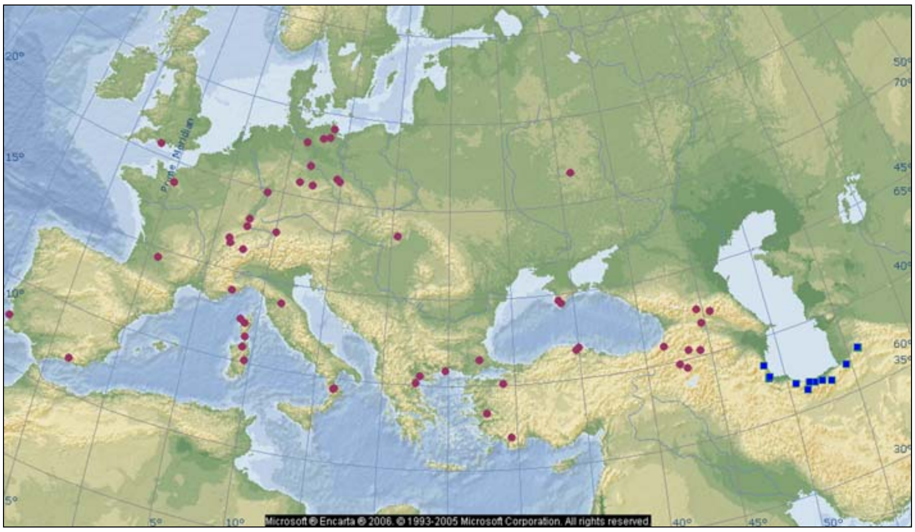


Fig. 20: Distribution of collecting sites of *F. cunicularia* (lilac discs) and *F. persica* sp.n. (blue squares) west of 65° E. Original map with permission of Microsoft®Encarta ®2006©1993-2005 Microsoft Corporation. All rights reserved.

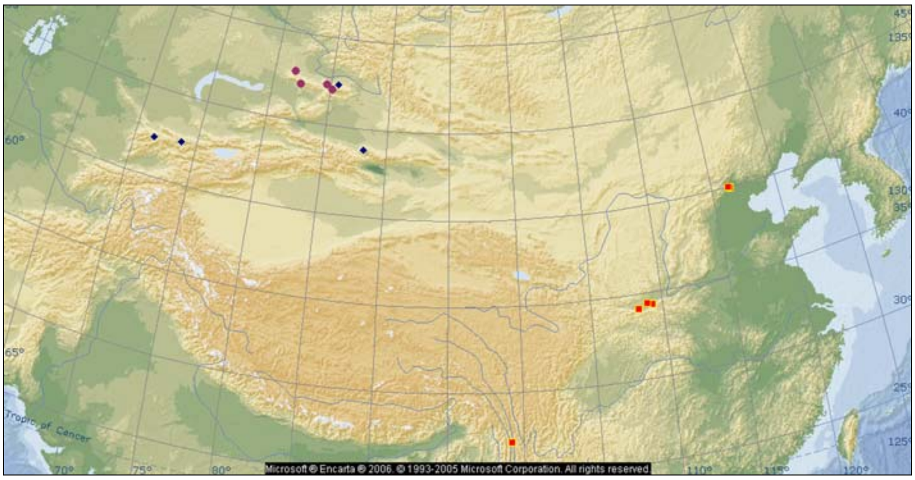


Fig. 21: Distribution of collecting sites of *F. cunicularia* (lilac discs), *F. tianshanica* sp. n. (blue rhombs) and *F. glabridorsis* (red squares) east of 65° E. Original map with permission of Microsoft®Encarta®2006©1993-2005 Microsoft Corporation. All rights reserved.

Material examined: 6 samples with 21 workers from China were subject to a numeric analysis of 18 characters (Fig. 21). For details, see Appendix, as digital supplementary material to this article, at the journal's web pages.

Description of worker (Tab. 1, Fig. 11): large *Serviformica* species (CS 1.425 mm), head very much elongated (CL / $CW_{1.4}$ 1.164), has the longest scape of the *F. rufibarbis* group (SL / $CS_{1.4}$ 1.184), distance between ocelli rather low (OceD / $CS_{1.4}$ 0.152), eye relatively large (EYE / $CS_{1.4}$ 0.301). Petiole relatively narrow (PEW / $CS_{1.4}$ 0.430). Clypeus with sharp median keel and fine longitudinal microcarinulae. Frontal triangle finely transversely rippled and with 55 - 75 short pubescence hairs. Eyes with microsetae of 6 - 9 µm maximum length. Pronotum, mesonotum, petiole, flexor profile of hind tibia, posterior margin of head, propodeum and dorsolateral metapleuron normally without setae. Ventral coxae and gaster tergites with long setae. Dorsal mesonotum in lateral aspect flatly convex. Metanotal depression moderately deep. Propodeal dome relatively flat. Dorsal crest of petiole in frontal view convex, sometimes (especially in larger specimens) trapezoidal. Petiole scale in lateral aspect slender, with convex anterior and more straight posterior profile. Gaster with transverse microripples of small distance (RipD 4.2 µm) and covered by very dense silvery pubescence (sqPDG 2.9). Pubescence on head, mesosoma and petiole dense, producing a rather matt surface appearance. Posterior vertex, often dorsal promesonotum, coxae and all appendages brown, gaster always dark brown. Other body parts reddish brown.

Comments on taxonomy: The character combination of *F. glabridorsis* is unmistakable at least within the East Asian ant fauna. A full separation from the next similar sympatric species *F. tianshanica* sp.n. is given alone by the non-overlapping SL / $CS_{1.4}$ and $RipD_{1.4}$ data (Tab. 1). The most similar Palaearctic species is the disjunct *F. persica* sp.n. which is separated by 4200 kilometres. A two-class DA considering the characters CS, CL / $CW_{1.4}$, SL / $CS_{1.4}$, OceD / $CS_{1.4}$, EYE / $CS_{1.4}$, PEW / $CS_{1.4}$, $RipD_{1.4}$, and $sqPDG_{1.4}$

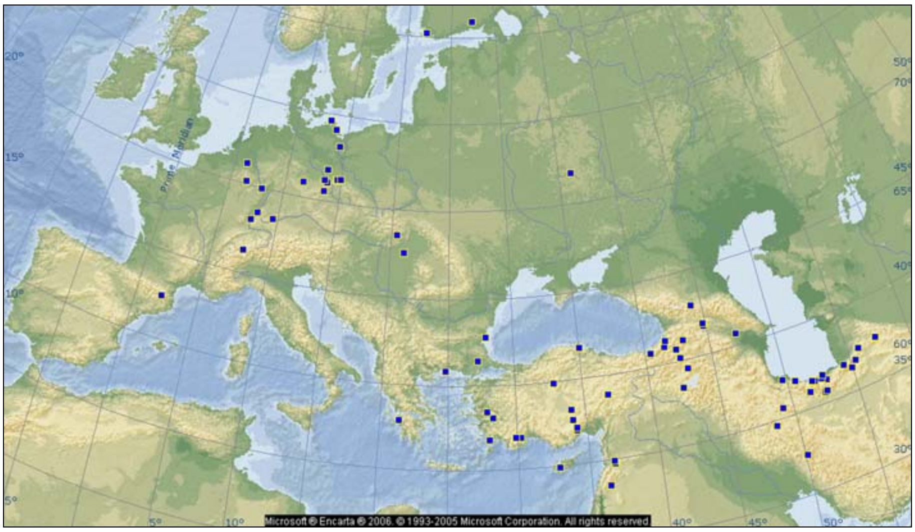


Fig. 22: Distribution of collecting sites of *F. clara* west of 65° E. Original map with permission of Microsoft®Encarta®2006©1993-2005 Microsoft Corporation. All rights reserved.

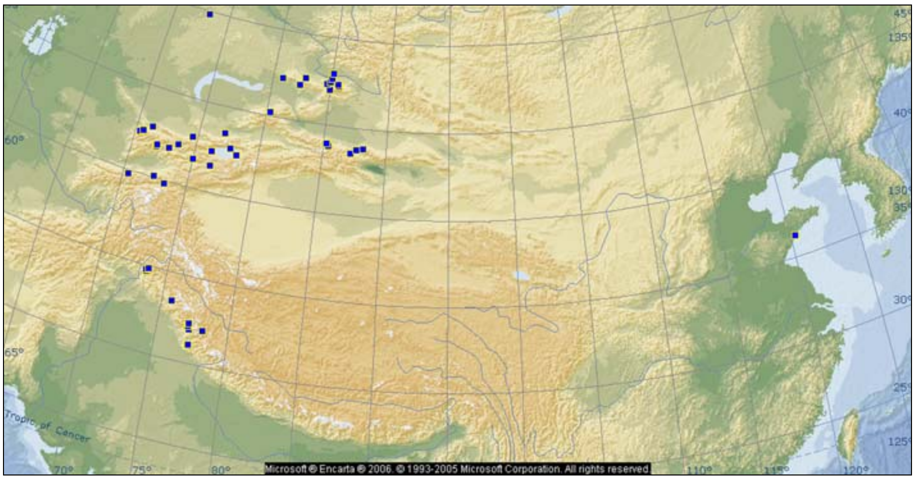


Fig. 23: Distribution of collecting sites of *F. clara* east of 65° E. The very isolated, most eastern site is the type locality of *Formica clara sinae* EMERY, 1925 stat.n. Original map with permission of Microsoft®Encarta®2006©1993-2005 Microsoft Corporation. All rights reserved.

separated each of the 26 nest samples of these two species with p = 1.000 and the error prediction by a LOOCV-DA was 0%. In addition, we ran a PCA (as an unsupervised method) using the same character set and found the first factor (explaining 28.7% of total variance) to offer a very strong separation of both species:

F. persica sp.n. factor 1: 0.503 ± 0.323 [0.02, 1.05] n = 20
F. glabridorsis factor 1: -1.675 ± 0.475 [-2.26, -0.97] n = 6

Distribution and biology: The known distribution is coincident with the southwest, central and northeast Chinese floristic provinces of MEUSEL & JÄGER (1992) and ranges from 27° to 40° N, 99° to 116° E and from 50 metres (in the north) to 1700 metres (in the south). Available habitat information: found in a city park in Beijing and on river banks of Wei Hei and Mekong River.

Nomina dubia

The species identity of the following taxa deemed to belong to the *F. rufibarbis* group cannot be concluded because of insufficient descriptions and missing type material. According to informations by the keepers of the entomological collections of St. Petersburg (letter of A. Zinovjev, May 1995, search by V. Krasilnikov in 2006), Moscow (letter of G. Dlussky, May 1996, letter of J. Antropov, September 2008), and Tucuman / Argentina (letter of E. Willink, February 1992) type material of these taxa is no longer available. According to our own search in German collections type material of Förster is completely destroyed (SEIFERT 1992).

Formica stenoptera FÖRSTER, 1850; Germany.

Formica fusca rufibarbis* var. *glauca RUZSKY, 1895; W Siberia.

Formica rufibarbis volgensis RUZSKY, 1914; Volga River.

Formica rufibarbis* ssp. *montana* var. *minor KUZNETZOV-UGAMSKY, 1926; Turkestan.

Formica rufibarbis* st. *montivaga SANTSCHI, 1928; [replacement name for *Formica rufibarbis* natio *montana* KUZNETZOV-UGAMSKY, 1923; Turkestan; junior primary

homonym of *F. subpolita* var. *montana* WHEELER, 1910]
Formica rufibarbis* var. *montaniformis KUZNETZOV-UGAMSKY, 1929; Daghestan.

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Zusammenfassung

Die paläarktischen Arten der *Formica rufibarbis*-Gruppe wurden mittels Numerischer Morphologie-Basierter Alpha-Taxonomie (NUMOBAT) untersucht. Es wurden 496 Nestproben mit insgesamt 1753 Arbeiterindividuen in achtzehn und weitere 330 Nestproben in zehn phänotypischen Merkmalen analysiert. Neun Morphospezies plus eine Subspezies wurden aufgestellt: *Formica rufibarbis* FABRICIUS, 1793, *F. cunicularia* LATREILLE, 1798, *F. clara* FOREL, 1886, *F. clara sinae* EMERY, 1925 stat.n., *F. glabridorsis* SANTSCHI, 1925, *F. orangea* sp.n., *F. tarimica* sp.n., *F. anatolica* sp.n., *F. tianshanica* sp.n. und *F. persica* sp.n. Alle neun Morphospezies waren mittels Diskriminanzanalyse (DA) und einer Fehlervorhersage durch Kreuzvalidierung von im ungünstigsten Fall 0.4 % unterscheidbar. Die Typenserien von 14 Taxa waren verfügbar und wurden nahe der Cluster-Zentren mit a-posteriori-Wahrscheinlichkeiten von p > 0.998 positioniert, mit Ausnahme von *F. clara sinae* EMERY, 1925 stat.n., die mit p = 0.929 *F. clara* zugeordnet wurde. Das führte zu folgenden Bewertungen: *F. fusca* var. *cinereorufibarbis* FOREL, 1874 als Synonym von *F. rufibarbis* (sensu BERNARD 1967), *F. fusca* var. *rubescens* FOREL, 1904 als Synonym von *F. cunicularia* (sensu YARROW 1954) und *F. cunicularia fuscoides* DLUSSKY, 1967 als Synonym von *F. cunicularia* (sensu ARAKELIAN 1994), *F. lusatica* SEIFERT, 1997 als Synonym und *F. rufibarbis* var. *sinae* EMERY, 1925 als Subspezies von *F. clara*. Es wurden Neotypen von *F. rufibarbis* und *F. cunicularia* festgelegt. Eine abweichende Population von *F. tianshanica* sp.n. im nordwestchinesischen Bogda Shan Gebirge wurde als intraspezifischer Gynen-Polymorphismus gedeutet, könnte sich aber als kryptische Art erweisen, wenn weiteres Material und eine genetische Analyse verfügbar werden. Alle Arten sind abgebildet und es wird ein vereinfachter Bestimmungsschlüssel präsentiert. Zwei Arten sind wahrscheinlich Endemiten: *F. anatolica* sp.n. und *F. persica* sp.n. sind auf die Gebiete des südanatolischen Taurus Gebirges bzw. des nordpersischen Elburs Gebirges beschränkt und weichen durch ihr regelmäßiges Vorkommen in Waldland von den sonstigen Arten der *F. rufibarbis*-Gruppe ab, welche überwiegend in Offenlandhabitaten von Magerrasen bis zur Halbwüste leben.

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