Sociobiology 67(2): 330-334 (June, 2020) DOI: 10.13102/sociobiology.v67i2.5084

Sociobiology
An international journal on social insects

SHORT NOTE

Ergatandromorphism in the Ant *Myrmica lobulicornis* Nylander, 1857 (Formicidae: Myrmicinae)

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Article History

Edited by
Evandro Nascimento Silva, UEFS, Brazil
Received 11 March 2020
Initial acceptance 08 April 2020
Final acceptance 09 April 2020
Publication date 30 June 2020

Keywords
Bilateral mosaic, gynandromorph, developmental defects, Italian Alps, Stelvio National Park.

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Abstract
Ergatandromorphism is the result of an aberrant development in which part of the body of a social insect shows the traits of the worker caste, while the other resembles a male. It is considered a specific case of gynandromorphism. Specimens with these characteristics have rarely been collected in different ant lineages across the world. Here, we provide the first description of ergatandromorphism in the ant *Myrmica lobulicornis* Nylander, 1857: an ergatandromorphous specimen was recovered during an arthropod sampling campaign across altitudinal and ecological gradients on the Italian Alps (Stelvio National Park), together with 480 workers and 4 queens of the same species, which expressed the normal phenotype.

Arthropods are typically sexually dimorphic, and hermaphroditism is very rare among them (Narita et al., 2010). However, developmental defects, which occur at low frequencies under natural conditions, may lead to morphologically anomalous individuals with both female and male traits (Narita et al., 2010). A distinction can be made between cases in which male and female traits are uniformly combined (intersexes) and those in which chimeric mosaics occur (gynandromorphs *sensu lato*), and this distinction can either be made on a phenotypic or genetic basis (Narita et al., 2010). Narita et al. (2010) reviewed several mechanisms that may lead to the development of these forms in arthropods, most of the existing knowledge being based on *Drosophila* Fallén, 1823 (Diptera: Drosophilidae).

In ants (Hymenoptera: Formicidae), different kinds of morphologically intermediate forms between castes or sexes (sex mosaics) have been described. Among them, ergatoids, which represent a subcategory of ergatogynes (worker-queen), are the only ones who possess a functional role within ant colonies and their occurrence may be frequent in some species (Peeters, 1991; Molet et al., 2012). On the other hand, other ergatogynes (intercastes), as well as the chimeric mosaics (queen-male: gynandromorphs *sensu stricto*, worker-male: ergatandromorphs or androergatomorphs, soldier-male: dinergatandromorphs), are typically very rare hybrid phenotypes with no functional role (Donisthorpe, 1929; Berndt & Kremer, 1983; Peeters, 1991; Silva & Feitosa, 2019). All these aberrant forms have been seen as an opportunity to understand the development and evolution of castes and the mechanisms for sex determination in social insects (e.g. Donisthorpe, 1929; Yang & Abouheif, 2011).

Ergatandromorphism has been reported as a phylogenetically widespread phenomenon occurring in tens of ant species (Creighton, 1928; Donisthorpe, 1929; 1938; 1939;

Wheeler, 1914; 1937; Parapura, 1972; Torossian, 1974; Berndt & Kremer, 1982; Crosland et al., 1988; Kremer & Berndt, 1986; Kinomura & Yamauchi, 1994; Heinze & Trenkle, 1997; Yosuke, 2008; Yoshizawa et al., 2009; de Campos et al., 2011; Yang & Abouheif, 2011; Skvarla & Dowling, 2014). Normally, they occur unfrequently, but in a few cases, they were discovered in large numbers (Donisthorpe, 1946; Kinomura & Yamauchi, 1994; Yoshizawa et al., 2009). Under laboratory conditions, they may be obtained by causing heat shocks during egg development (Berndt & Kremer, 1982). Phenotypically, ergatandromorphs are usually characterized by a bilateral mosaic development which affects at least the head, and often parts of the mesosoma, while one of the sexes is overall prevalent. Usually, the reproductive system of gynandromorphs or ergatandromorphs is only that of one of the two sexes (Cokendolpher & Francke, 1983; Heinze & Trenkle, 1997; Yoshizawa et al., 2009). However, their reproductive capabilities remain unclear and there are very few reports on the behavior of these forms (e.g. Torossian, 1974; Yoshizawa et al., 2009).

Here, we report the discovery of the first case of ergatandromorphism in the myrmicine ant *Myrmica lobulicornis* Nylander, 1857 (Formicidae: Myrmicinae), a species whose taxonomic identity was recognized recently (Seifert, 2005; see also Radchenko & Elmes, 2010; Jansen et al., 2010; Guillem et al., 2016). Its lineage is estimated to have differentiated from its closest relatives quite recently (Jansen et al., 2010). Today, *M. lobulicornis* is associated with montane and alpine environments across Europe, in the Alps occurring between 1,000 and 2,700 m asl in sunny grasslands and pastures (Seifert, 2018). In Italy, relatively few data on its distribution were published so far (Radchenko & Elmes, 2010; Sielezniew et al., 2010; Glaser et al., 2011; Schifani & Alicata, 2018). Standardized surveys covering the Italian ant fauna remain very rare (e.g. Castracani et al., 2010; Spotti et al. 2010; 2015; Gibb et al. 2017). During 2017 and 2018, the second step of a mid-term extensive survey of Alpine arthropod and bird faunas was carried out in the protected area of the Stelvio National Park (Lombardy Sector), Italian Alps, in co-ordination and with the same survey design of the other three Italian Alpine national parks and in cooperation with MUSE-Science Museum of Trento. Terrestrial arthropods were sampled using pitfall traps, baited with a standard mixture of wine-vinegar and salt (Latella et al., 2019), across an altitudinal and ecological gradient. As a result, a total of 480 workers, 4 queens and 1 ergatandromorph of *M. lobulicornis* were collected from approximately 1,400 to 2,400 m asl. The ergatandromorph is stored in the Myrmecology Lab collection at the University of Parma (Italy), and has the following collection data: Valle Messi, Sondrio, 46°17’55.1”N, 10°31’09.4”E, 2045 m asl, south-exposed, *Festucetum variae* grassland with shrubs and scree, 29.V-14.VI.2018, trap code 6.2.4. A total of 26 workers were also collected from the same plot. The ergatandromorphous specimen was photographed using a CANON 6D reflex and MP-E 65mm f/2.8 1–5× Macro Photo lens. Helicon Focus was then used to fuse images taken at different focal planes into single images with greater depth of field.

Most of the body of the ergatandromorph is notably worker-like (Fig 1, 2), while only the right side of the head is clearly that of a male. In comparison with the left side, the right one is characterized by a blackish color, a smaller mandible, a male-like antenna (unfortunately partly broken), a much larger eye, two ocelli, a different surface sculpture and a different development of the frons (Fig 2). Morphometric characteristics respectively of the male-like and worker-like

Fig 1. *Myrmica lobulicornis* ergatandromorph specimen (whole body). Up to down: dorsal view; profile (left) view, profile (right) view. Scale bar: 0.5 mm.

Fig 2. *Myrmica lobulicornis* ergatandromorph specimen (head). Left to right: frontal view and dorsal view. Scale bar: 0.5 mm.

parts of the head follow the standard proportions of the two castes (Seifert, 2005; 2018; Radchenko & Elmes, 2010). However, the mesosoma is abnormal, although still mostly worker-like (Fig 1, most evident in profile view). As the worker-like phenotype is prevalent, it is unsurprising that the specimen does not possess the male genitalia, which are particularly large and evident in *Myrmica* males. In conclusion, the specimen morphology follows the common aspect of ergatandromorph ants: a bilateral mosaic in the head, while one sexual phenotype prevails in the rest of the body.

While gynandromorphs or ergatandromorphs have already been reported in few other *Myrmica* species (e.g. Donisthorpe, 1929), most of the old records appear unreliable due to the huge amount of taxonomic changes that the genus went through, and the occurrence of these forms in *M. lobulicornis* has never been reported before (see Radchenko & Elmes, 2010). However, it is worth noting that Meinert (1861) reported a case of grynandromorphism in *M. lobicornis* Nylander, 1846, which is morphologically very close to *M. lobulicornis* and was not considered a separate taxon at that time (Seifert, 2005; Radchenko & Elmes, 2010; Seifert, 2018).

Acknowledgements

This work was supported by Stelvio National Park as part of the mid-term monitoring of Alpine faunistic biodiversity in relation to climate change. The work was granted by the Italian Ministry for Environment, Land and Sea Protection and co-financed by Autonomous Province of Trento.

Alessandro Gugiatti and Paolo Belotti supervised and managed field work for survey of epigean arthropod fauna, Teresa Boscolo and Michael Bernasconi (MUSE-Science Museum of Trento, Italy) sorted the Formicidae collected by pitfall traps.

This work was also supported by grants from the University of Parma (FIL-2019) assigned to D.A. Grasso and A. Mori and benefited from the equipment and framework of the COMP-HUB Initiative, funded by the "Departments of Excellence" program of the Italian Ministry for Education, University and Research (MIUR, 2018–2022).

Authors contribution

E. Schifani performed the taxonomic part and drafted the first version of the manuscript. D. Giannetti provided high quality pictures of the ergatandromorph. C. Castracani, F.A. Spotti and M. Ghizzoni directed and coordinated the processing of the ant specimens. M. Gobbi and L. Pedrotti conceived and organized the sampling campaign. L. Pedrotti, D.A. Grasso and A. Mori were responsible of funding acquisition. All authors contributed to draft the final version of the manuscript.

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