Records of bilateral gynandromorphism in three species of ants (Hymenoptera, Formicidae) in Norway

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This paper describes and illustrates three new cases of gynandromorphism in three ant species, *Leptothorax kutteri* Buschinger, 1965, *Polyergus rufescens* (Latreille, 1798) and *Formica lugubris* Zetterstedt, 1838. All specimens described have bilateral asymmetry, in which one side is male and one is female. Gynandromorphism is in general a very rare phenomenon. The specimens of *P. rufescens* and *F. lugubris* were collected from exceptionally warm microhabitats, a fact that might affect the probability for gynandromorphism to appear.

Key words: gynandromorphism, ants, *Leptothorax kutteri*, *Polyergus rufescens*, *Formica lugubris*.

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Introduction

Gynandromorphism occurs when an individual has both male and female characters at the same time (Wheeler 1919, Donisthorpe 1929). In some forms a specimen can show bilateral asymmetry, in which one side is male and one is female. A mosaic gynandromorphism occurs when male and female tissues are spread in patches across the body (Campos *et al.* 2011). The phenomenon is known from both vertebrates and invertebrates (Bear & Monterio 2013). Gynandromorphism has been reported from 69 families of insects, across 13 orders (Cui & Cui 2003). In ants, it has been documented from 30 species and 17 genera (Skvarla & Dowling 2014). The probability of finding a gynandromorph individual is very low, probably around one in ten thousand in both invertebrates and vertebrates (Williams 2010, Sample 2011, Skvarla & Dowling 2014).

Numerous mechanisms have been proposed to explain the occurrence of gynandromorphs in animals. Useful reviews and discussions on the various mechanisms implicated in formation of insect gynandromorphs are provided by Morgan & Bridges (1919), Wheeler (1937), Rothenbuhler *et al.* (1952), Brust (1966) and Wigglesworth (1972). Most mechanisms invoke either fertilizationrelated phenomena or cytogenetic complications during early embryogenesis. It has been proposed to be caused by events during mitosis in early development, due to improper migration of chromosomes (Seal 1966). Other possible genetic mechanisms include fertilization of binucleate eggs by male gametes (Ahmad *et al.* 1985), or the fusion of two sperms with products of female meiosis in a single egg (Clements 1992). A developmental network theory of how gynandromorphism develops from a single cell is presented by Werner (2012). Social insect biologists have speculated on what gynandromorphs could reveal about the evolutionary and developmental origins of caste determination in social insects (Yang & Abouheif 2011). Gynandromorphism should not be confused with intersexes (intercastes). Some intersexes are genetically intermediate between the typical male genotype and the typical female genotype. Other intersexes are genetically purely male or female, but some parts of their bodies having a sexual phenotype that is opposite to their genetic sex (Wigglesworth 1972, Narita *et al.* 2010, Yang & Abouheif 2011).

In this paper, we describe and illustrate three new cases of bilateral gynandromorphism within the three ant species *Leptothorax kutteri* Buschinger, 1965, *Polyergus rufescens* (Latreille, 1798) and *Formica lugubris* Zetterstedt, 1838.

Material and Methods

Abbreviations and codes: AS= Arnstein Staverløkk; FØ=Frode Ødegaard; JOG=Jan Ove Gjershaug; KMO = Kjell Magne Olsen.

Material collected by AS, JOG and FØ is preserved in the dry insect collections at NINA. Material collected by KMO is preserved in 70 % ethanol in the private collection of KMO. All records are available at the interoperable biodiversity database services Species Map Service (run by the Norwegian Biodiversity Information Centre) (Artsdatabanken 2016), and at the Global Biodiversity Information Facility (GBIF 2016).

Abbreviations of the biogeographical regions and reporting of localities follow the revised Strand-system (Økland 1981), and the coordinates are given in decimal degrees (Grid: Lat/lon; datum WGS84).

The records

The inquiline species *L. kutteri* was collected from a nest of *Leptothorax acervorum* (Fabricius, 1793) in a rotten birch on a bog at Rønningen (SØR-TRØNDELAGinterior [**STI**], Midtre Gauldal: Soknedal, Rønningen, N62.95845˚E10.25121˚, leg. JOG, AS and FØ, 25 August 2015). This is near the locality where the first record of the species in Norway was made in 2014 (Ødegaard *et al.* 2015).

The specimen shows male characteristics on the left side of the body, where the head has a larger eye, much longer antenna and reduced mandible (Figure 1). The right side of the specimen shows characteristics of a queen, with a smaller eye, shorter antenna and larger mandible. Both sides of the metasoma have wings. This is as far as we know the first report of gynandromorphism in *Leptothorax* (Skvarla *et al.* 2014).

The amazon ant *P. rufescens* was collected on the Norwegian island of Skåtøy (TELEMARK coastal [**TEY**], Kragerø: Skåtøy, Burøyheia, N58.85569˚ E9.51644˚, leg. KMO, 16 August 2014 (*cf*. Ødegaard *et al.* 2015)).

The specimen shows male characteristics on the left side of the body. On the male side the head is darker with a larger eye and a reduced mandible, and the mesosoma has a pair of wings (Figure 3). The right side of the specimen shows the characteristics of a worker, with a smaller eye and a characteristic large dagger-like mandible. The mesosoma of the right side lacks wings and is very slender, like a worker and not a queen. Gynandromorphism in *P. rufescens* has earlier been reported by Forel (1874).

The specimen of *F. lugubris* was collected at Faksfall (OPPLAND north [**ON**], Dovre: Faksfall, N62.03607˚ E9.17017˚, leg. FØ, 29 June 2014). The specimen shows male characteristics on the left side of the body, with a larger eye and a reduced mandible. The right side has the characteristics of a queen, with a smaller eye and larger mandible (Figure 4).

FIGURE 1. A gynandromorphous specimen of *Leptothorax kutteri* Buschinger, 1965, showing male characters on the left side and characters of a queen on the right side. Photo: A. Staverløkk.

FIGURE 2. Head of a gynandromorphous specimen of *Polyergus rufescens* (Latreille, 1798) with male characters on its left side and worker characters on its right side. Photo: A. Staverløkk (from Ødegaard *et al.* 2015).

FIGURE 3. Dorsal view of a gynandromorphous specimen of *Polyergus rufescens* (Latreille, 1798). Photo: A. Staverløkk (from Ødegaard *et al.* 2015).

FIGURE 4. A gynandromorphous specimen of *Formica lugubris* Zetterstedt, 1838, with characters from male (left side) and queen (right side). Photo: A. Staverløkk.

Discussion

Gynandromorphism has been regarded as a rare phenomenon (Williams 2010, Sample 2011, Skvaria & Dowling 2014). We are not able to give any estimates of the number of individuals we have investigated of these three ant species before we found a gynandromorphous individual. We suppose that gynandromorphs stay in the nest for a much longer time than normal alate (with wings) individuals, and that this might increase the probability of detecting such individuals. The particular specimens of *P. rufescens* and *F. lugubris* were collected from exceptionally warm microhabitats, a fact that might affect the probability for gynandromorphism to appear. Gynandromorphs have been experimentally generated through temperature shock in ants and bees (Drescher & Rothenbuhler 1963, Berndt & Kremer 1982, 1983).

The gynandromorphous individuals of *L. kutteri* and *F. lugubris* can easily be distinguished by the longer antenna on the male side of the ant, but this was not observed when the specimens were collected. The gynandromorphous individual of *P. rufescens* was very different from normal alate individuals, as it has wings only on the male side. The female side had the characteristics of a worker without wings. Campos et al. (2011) have proposed the name "ergatandromorphous" for such individuals.

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