

## Population size of monodomous nests of *Formica* (*Serviformica*) *gagates* (Hymenoptera: Formicidae)

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**Abstract.** The consideration of population sizes of ant nests is essential for many ecological studies, such as biomass calculations. However, population sizes of many ant species have not been studied. For *Formica gagates* no data is available yet. In this study, six monodomous nests of *F. gagates* were monitored on four different investigation sites in the southeast of Styria. Of those six nests, two were completely dug out and the whole population was counted. The worker numbers of these two nests, as well as observations of the other four nests, were then used to estimate the mean worker number of monodomous *F. gagates* nests. In the first nest 3664 workers and four queens were counted, in the second 3304 workers and no queen. We estimate the mean worker number of monodomous nests of *F. gagates* to be 3179. No other European species of the subgenus *Serviformica* is known to have similarly high mean worker-numbers.

**Zusammenfassung.** Die Berücksichtigung von Volksstärken von Ameisennestern ist für viele ökologische Studien, wie Berechnungen der Biomassen, essenziell. Trotzdem sind die Volksstärken vieler Ameisenarten noch unerforscht. Für *Formica gagates* gibt es hierzu keine bisherigen Daten. In dieser Studie wurden sechs monodome Nester von *F. gagates* auf vier unterschiedlichen Untersuchungsflächen in der Südoststeiermark beobachtet. Von diesen sechs Nestern wurden zwei ganz ausgegraben und die gesamte Population wurde gezählt. Durch die Anzahl der Arbeiterinnen dieser zwei Nester, sowie Beobachtungen der vier anderen Nester, wurde die mittlere Anzahl von Arbeiterinnen eines monodomen *F. gagates*-Nestes geschätzt. Das erste Nest enthielt 3664 Arbeiterinnen und 4 Königinnen, das zweite 3304 Arbeiterinnen und keine Königin. Wir schätzen die mittlere Zahl der Arbeiterinnen eines monodomen *F. gagates*-Nestes auf 3179. Keine andere europäische Art der Untergattung *Serviformica* hat eine so hohe mittlere Anzahl an Arbeiterinnen.

**Key words.** colony demography, worker numbers, ant ecology, Südliche Sklavenameise, Austria, Styria.

## Introduction

Nest density and biomass investigations are most important for the understanding of ant ecology. Species-specific mean nest-population data are necessary to calculate the biomass per unit of area. In detail:  $\text{fresh mass}/100 \text{ m}^2 = \text{nests}/100 \text{ m}^2 * \text{mean worker number of one nest} * \text{mean fresh mass of one worker}$ . Knowledge about nest populations of Central European ants is apparently insufficient. For example, SEIFERT (2017) gives 5000 workers for all Central European species of *Lasius* s. str. and 10000 workers for all species of *Cauto-*, *Chthono-*, and *Austrolasius*. Such values are obviously rough estimates. The situation is much better for species with small mean – and thus easy to count – nest populations like *Myrmica* spp., *Temnothorax* spp., and *Leptothorax* spp. (ELMES 1975, HEINZE & ORTIUS 1991, WARDLAW & ELMES 1996, PARTRIDGE et al. 1997, FELKE & BUSCHINGER 1999, FOITZIK et al. 2003, BENGSTON & DORNHAUS 2013, MITRUS 2013, SEIFERT 2017).

In the monograph of the ecology of Central European non-arboreal ants (SEIFERT 2017), the thermophilic species *F. gagates* is not even mentioned a single time. *Formica gagates*, although often confused in the past (WAGNER 2012, SEIFERT 2018, WAGNER 2020) a non-cryptic species (cf. LEBAS et al. 2016, cf. SEIFERT 2018, cf. WAGNER 2019), is in several aspects distinctly different from all other European *Serviformica* species. For example, recent studies suggest that *F. gagates* is phylogenetically closer related to species of the New than to those of the Old World (ROMIGUIER et al. 2018, BOROWIEC et al. 2021). It is the largest of all black European *Serviformica* species (SEIFERT 2018). Furthermore, it is known to have polydomous colonies with very aggressive workers and to be rather rarely used as slave for *Polyergus rufescens* (D'ETTORRE et al. 2002, SEIFERT 2018). Taking these circumstances into account, population-size extrapolations being based on data of other European *Serviformica* species (e.g., *F. fusca*) seem risky.

In the investigation area *F. gagates* is a rather rare species, restricted to xerothermous grasslands and warm, often south-facing, deciduous woodlands. For the whole state of Styria, only 20 sites in the south and east of the state are known so far (WAGNER 2020) although the species is rather conspicuous. Polydomous nests are not known from Styria. The mean fresh weight of one worker was already calculated (WAGNER & WIESER 2021) following SEIFERT's (2017) method. This study aims to provide data of mean worker-numbers of nests to enable, for example, biomass calculations.

## Material & Methods

The four investigated sites are in Styria, Austria.

1. Einfaltwiese-Hang, 46°48'49" N, 15°52'24" E, 288 m, south-west exposed semi-arid grassland at the edge of deciduous woodland (see also WAGNER & WIESER 2021).

2. Scheucher-Hangwiese, 46°50'09" N, 15°53'01" E, 265 m, south-east exposed semi-arid grassland at the edge of deciduous woodland (see also WAGNER & WIESER 2021).
3. Colombolowiese-Marktl, 46°48'12" N, 15°52'48" E, 275 m, east-exposed semi-arid grassland, on postglacial deposits (see also WAGNER & WIESER 2021).
4. Hofstätten Pfarrwiese, 46°53'14" N, 15°52'50" E, 370 m, south-west exposed grassland at the edge to a pine forest, on silicate (see also FRIEß et al. 2010).



Fig. 1: The main entrance of nest 4 on site 2. Photo: F. Kraker.

During the visit on the sampling sites on the 8<sup>th</sup> of September 2020, a 100 m<sup>2</sup> area was marked. The warm temperature of the date guaranteed worker activity and thus facilitated nest detection. This area was intensively observed with the claim to find every *Serviformica* nest, like a quick-search area sensu SEIFERT (2017). This methodology should minimize the risk of overlooking small nests, an error source which would lead to an overestimation of the mean nest-population size. Detected nests were marked for later investigation. Nest 1 was dug out on the 7<sup>th</sup> and 8<sup>th</sup> of November 2020 to collect the full population. On the 22<sup>nd</sup> of March 2022, nest 2 was dug out. The low temperature on these days guaranteed a lack of foraging activity and thus all workers were inside the nest. All ants were collected in ethanol and are stored in the first author's collection. A total of 9 fieldwork days were needed, as the marked nests were hard to be found again because of frequent nest relocations.

To counter the small sample-size of only 2 fully excavated nests, all found nests in the quick-search area have been assigned a relative subjective nest-size value (RSNSV). For nest 1,  $RSNSV_1 = 1$ . To estimate the RSNSVs, worker size, aggressiveness, foraging distance, foraging activity, and the general nest size as seen from above – in relation to

nest 1 – have been considered. RSNSVs and worker numbers of nest 1 and 2 allowed extrapolating the numbers of workers of all observed nests.

For the worker estimate 1, nest 1 was used as reference by using the formular  $worker\ number\ 1 * RSNSV_n = worker\ estimate\ 1_n$

For the worker estimate 2, nest 2 was used as reference by using the formular  $worker\ number\ 2 * RSNSV_n / RSNSV_2 = worker\ estimate\ 2_n$

A final estimate was made by taking the mean of the two estimates.

## Results

The nest volume of nests 1 and 2 was 0.28125 and 0.16200 m<sup>3</sup>, the maximal depth 0.5 and 0.45 m, respectively. Nest 1 contained 3664 workers and 4 queens, nest 2 contained 3304 workers and no queen. No brood was found in either of the nests. Nest 1 also was inhabited by 4 individuals of the myrmecophil isopod *Platyarthrus hoffmanseggii*, in nest 2 the rove beetle *Drusilla canaliculata* was found. The mean monodomous nest of *Formica gagates* in Styria is estimated to contain  $3179 \pm 792$  (min = 2201, max = 4401) workers.



Fig. 2: A worker of *Formica gagates*. Photo: G. Kunz.

Nest	1	2	3	4	5	6	Mean
Site	1	2	2	3	3	4	
Nest volume	0.28125 m3	0.16200 m3					
Maximal nest depth	0.50 m	0.45 m					
Worker numbers	3664	3304					
Queen numbers	4	0					
Ant guests	<i>Platyarthrus-hoffmanseggii</i> , 4 ind.	<i>Drusilla canaliculata</i> , 2 ind.					
RSNSV	1	0.9	1.2	0.6	0.7	0.8	
Worker estimate 1	3664	3298	4397	2198	2565	2931	
Worker estimate 2	3671	3304	4405	2203	2570	2937	
Final estimate	3668	3301	4401	2201	2567	2934	3179

Tab. 1: Overview about nest and population size of six *Formica gagates* nests in Styria. Nests 1 and 2 were completely excavated, other nest population sizes were extrapolated using the formulas described in Material & Methods. Two ant guests have been found.



Fig. 3: *Platyarthrus hoffmanseggii*. Photo: G. Kunz.



Fig. 4: *Drusilla canaliculate*. Photo: G. Kunz.

## Discussion

Currently, the average worker numbers of species of the subgenus *Serviformica* are estimated to be 520 (*F. gagatoides*) to 2000 (*F. cinerea* group and *F. clara*) (BERMAN et al. 2010, SEIFERT 2017, SEIFERT 2018). Interestingly, *Formica gagates* has with 3179 a distinctly higher mean number of workers than all other European *Serviformica* species. Even though the goal was to find each nest in the area, very small nests such as a founding queen with only a few workers and brood could have been overlooked, as there is little foraging activity. This could lead to an overrepresentation of large nests and, consequently, an overestimation of the mean worker-number. Even though in nest 2 no queen was found, the authors are certain no chamber were overseen or left out.

In other areas, *Formica gagates* is also known to form polydomous nests (SEIFERT 2018). Hence, the result of this study must be applied carefully. It is possible that forming only monodomous colonies in the investigated area is due to non-ideal climatic conditions in Styria which represents a margin of the species' distribution area. This suggests higher population sizes in areas of ecological optimum, where polydomous colonies can be found (e.g., in the Pannonian zone). Also worth mentioning, all detected nests were earth nests, while literature suggests *F. gagates* nests are frequently found under logs or rocks (BERNARD 1968, SEIFERT 2018).

As previously mentioned in Materials & Methods, the nests of *F. gagates* were frequently relocated. It seemed like relocation would occur at least once per year, either shortly before or after hibernation. Also in *F. fusca*, nests stay rarely at the same spot for longer than one year (ZORMANN 2007).

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