**Discussions of worker ants' rule-based CHC dealing with changing environments**

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Contrary to popular belief, biologists discovered that worker ants are really not all hardworking. It has been found that in three separate 30-strong colonies of black Japanese ants (Myrmecina nipponica), about 20% of worker ants are diligent, 60% are ordinary, and 20% are lazy. That is called 20:60:20 rule. Though they are lazy, biologists suggested that lazy worker ants could be contributing something to the colony that is yet to be determined. In our last research, we used CHC (cross generational elitist selection, heterogeneous recombination, and cataclysmic mutation) with the worker ants' rule (WACHC) aiming at solving optimization problems in changing environments. CHC is a nontraditional genetic algorithm (GA) which combines a conservative selection strategy that always preserves the best individuals found so far with a radical (highly disruptive) recombination operator. In our last research, we verified that WACHC performs better than CHC in only one case of fully changing environment. In this paper, we further discuss our proposed WACHC dealing with changing environment problems with varying degree of difficulty, compare our proposal with hypermutation GA which is also proposed for dealing with changing environment problems, and discuss the difference between our proposal and ant colony optimization algorithms.

**Synergy between pheromone trails and quorum thresholds underlies consensus decisions in the ant Myrmecina nipponica**

[Cronin, Adam L.](https://bib.cnrs.fr/)Behavioral Ecology and Sociobiology. Oct 2013, Vol. 67 Issue 10, p1643, 9 p.

Coordination of group actions in social organisms is often a self-organised process lacking central control. These collective behaviours are driven by mechanisms of positive feedback generated through information exchange. Understanding how different methods of communication generate positive feedback is an essential step in comprehending the functional mechanisms underlying complex systems. The Japanese small-colony ant, Myrmecina nipponica uses both pheromone trails and an apparent quorum response during consensus decisions over a new home. Both of these mechanisms have been shown to generate positive feedback and are effective means of selecting among mutually exclusive courses of action. In this study, I investigate how pheromone trails and quorum thresholds contribute to consensus decisions during house-hunting in this species through experimental manipulations of pheromone trails, colony size and environmental context. Results demonstrate that (1) providing colonies with pre-established pheromone trails increased the number of ants finding the new site and led to higher quorum thresholds and more rapid relocations, (2) experimentally halving colony size resulted in a proportional decrease in quorum thresholds and (3) colonies relocating long distances had higher quorums than those relocating short distances. Taken together, these data indicate that pheromone trails are important for recruitment and navigation during nest site selection, but that decision making is contingent on a quorum response. Such synergy between mechanisms of positive feedback may be a common means of optimising collective behaviours.

**Larval stenocephaly related to specialized feeding in the ant genera Amblyopone, Leptanilla and Myrmecina (Hymenoptera: Formicidae) [Academic Journal]**

[Masuko, Keiichi](https://bib.cnrs.fr/)

[Arthropod Structure and Development](https://bib.cnrs.fr/) 2008 37(2):109-117

Larvae of the ant genera Amblyopone, Leptanilla and Myrmecina have unusually minute crania. This characteristic is here termed stenocephaly. To study it in detail larvae of the three genera were examined morphometrically and histologically in comparison with other non-stenocephalous larvae of the genera Cryptopone and Manica. The stenocephalous larvae are very specialized, in that their supra- and sub-esophageal ganglia are entirely displaced into the anterior thoracic segments, apparently as a consequence of the small cranial capacity. In Amblyopone and Leptanilla the small cranium appears to facilitate group feeding by a large number of larvae on the whole, intact bodies of the specialized centipede prey characteristic of these genera. In Myrmecina, the small, elongate head adapts the larva to consume the contents of the partly opened bodies of oribatid mites, which are the specialized prey of this genus. Therefore, stenocephaly seems to be a larval morphological adaptation facilitating specialized predation in these ants. These morphological specializations by ant larvae, and active larval involvement in prey dissection are possible because ants rear the larvae without confining them in cells. Acellular nests, a universal feature in Formicidae, may thus facilitate larval adaptations of benefit both to the larvae themselves and to the functionality of parental colonies, allowing them more efficiently to exploit accessible prey through well-integrated cooperation between adult and immature individuals.

**Thelytokous Parthenogenesis in the Ant Myrmecina nipponica (Hymenoptera: Formicidae). [Academic Journal]**

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[Zoological Society of Japan](https://bib.cnrs.fr/) 1984 (2014 ..)

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Myrmecina nipponica Wheeler is a terrestrial ant nesting chiefly in the soil in forest. It is a specialized predator of oribatid mites, but also scavenges on a broad spectrum of other arthropods. In the studied population at Cape Manazuru in central Japan, M. nipponica colonies are typically monogynous, and previous dissections of queens suggested that these individuals were not inseminated, thus suggesting these ants can reproduce via thelytokous parthenogenesis. To test for thelytokous parthenogenesis in M. nipponica the spermathecae of queens (dealate gynes) from worker-containing colonies were histologically examined in detail. All specimens examined (n=5) had no spermatozoa in the spermatheca. In addition, a total of four colony-founding queens were reared in isolation in the laboratory to test whether non-inseminated females were capable of egg laying and to test whether female offspring emerged from this brood. In all of four culture replicates, only new workers were produced from the eggs those queens had laid and male offspring was absent. After the breeding experiment, the queens' spermathecae were histologically examined and no sperm were detected in their spermathecae. These results reveal that M. nipponica queens of the Manazuru population are capable of producing female offspring thelytokously. Sexual reproduction by typical gynes and also by intermorphs has been known from other local populations of M. nipponica; therefore, this species shows geographical polymorphism in sexuality.

Buschinger, A. (2003). "Mating behavior in the ant, Myrmecina graminicola (Myrmicinae)." Insectes Sociaux **50**(3): 295-296.

Sexual behavior of Myrmecina graminicola in laboratory conditions is described. Virgin females, both gynomorphs and intermorphs, exhibit an inconspicuous "sexual calling", apparently depositing a sex pheromone on the substrate close by. The sexual pheromone is produced in the poison gland. Copulation needs between 40 and 60 seconds, dealation of gynomorphs follows soon after. Some observations are in marked contrast to former reports, e. g. on duration of copulation in M. graminicola (Donisthorpe, 1927: several hours) and on the source of a sex pheromone in the closely related M. nipponica (Murakami et al., 2002: pygidial gland).

Buschinger, A. (2005). "Experimental evidence for genetically mediated queen polymorphism in the ant species Myrmecina graminicola (Hymenoptera: Formicidae)." Entomologia Generalis **27**(3-4): 185-200.

Controlled mating of gynomorphic (gyn/gyn) and intermorphic (gyn/int or int/int) females of Myrmecina graminicola (Latreille 1802) with gyn- or int-males, respectively, and rearing of their sexual offspring revealed that the genotypes of the parents are decisive of the phenotypes of female progeny. Female sexuals, both gynomorphs and intermorphs, exhibit a kind of sexual calling behavior, the gynomorphs flying only little. Males are attracted by poison gland secretion of the females. Colony foundation success of mated queens was enhanced by adding a few workers from the parental colony, and worker pupae and larvae from other colonies. The first sexual offspring was reared in the colonies in the 2(nd) to 6(th) artificial summer season. In up to four "summers" always the same phenotype(s) of young queens were produced in a given colony. Gynomorphs (gyn/gyn) mated with a son of a gynomorph (gyn-&MALE) always produced gynomorphs (workers and a few males in addition). Intermorphs mated with a gyn-&MALE; either produced both gynomorphs and intermorphs (gyn/gyn and gyn/int, if the queen was a gyn/int heterozygote), or only intermorphs. Since gyn/int-&FEMALES; and int/int-&FEMALES; are morphologically indistinguishable, as well as gyn-&MALES; and int-&MALES, the putative genotype of intermorphs and int-&MALES; had to be identified according to the phenotypes of their mothers and later produced sisters in the laboratory-reared parental colonies. The effects of the hypothesised alleles gyn and int are similar to e and E in Harpago-xenus sublaevis and Leptothorax sp-A in that int is dominant in preventing the development of gynornorphs from gyn/int-larvae. This is the third example of a genetically mediated queen polymorphism in an ant species confirmed by crossbreeding experiments, and the first instance in a tribe (Myrmecinini) outside the Formicoxenini. The principle may be involved in other instances of queen polymorphism among ants.

Buschinger, A. and M. Schreiber (2002). "Queen polymorphism and queen-morph related facultative polygyny in the ant, Myrmecina graminicola (Hymenoptera, Formicidae)." Insectes Sociaux **49**(4): 344-353.

Polymorphism of the functional queens in Myrmecina graminicola is analyzed. Both gynomorphs (G-females; G) and a wide range of intermorphs (I-females; I) occur, which all are usually mated and egg-laying. Colonies having a gynomorphic queen are always monogynous, whereas about 57% of all colonies with intermorphic queens are polygynous, having two or more coexisting functional queens. The female sexual offspring of individual gynomorphic queens either consists of gynomorphs only, or exclusively of intermorphs. Intermorphic queens may have exclusively intermorphic female sexual progeny, or simultaneously both gynomorphs and intermorphs. Single colonies in laboratory culture produce the same kind of female progeny over several subsequent breeding cycles (artificially compressed "years" of 9-10 months). No environmental influence on queen morph determination could be detected. A genetically mediated queen polymorphism, as in Harpagoxenus sublaevis and Leptothorax sp. A, is suggested. Colony sizes vary considerably, with polygynous I-queen colonies being largest (57.2 +/- 34.3 s.d. workers), followed by G-queen colonies (44.6 +/- 22.7 s.d.) and monogynous I-queen colonies (34.4 +/- 23.7 s.d.), suggesting occasional budding of polygynous colonies.

Heinze, J. (1998). "Intercastes, intermorphs, and ergatoid queens: who is who in ant reproduction?" Insectes Sociaux **45**(2): 113-124.

The terminology for ant females which are morphologically intermediate between "normal" originally winged queens and workers teems with ill-defined terms, such as "ergatogyne", "apterogyne", or "gynaecoid worker". The terminology proposed by Peeters (1991a) gets rid of most of these terms but fails to distinguish between sporadically occurring "intercastes", reared due to "mistakes" in caste differentiation, and "intermorphic queens", which are the ordinary female reproductives in many colonies of formicoxenine ants. A detailed examination of development, morphology, and occurrence of the latter suggests that intermorphic queens are more similar to ergatoid queens (sensu Peeters, 1991a) than to "intercastes", and should not be comprised under the latter term.

Heinze, J. and L. Keller (2000). "Alternative reproductive strategies: a queen perspective in ants." Trends In Ecology & Evolution **15**(12): 508-512.

Ant colonies are commonly thought to have a stable and simple family structure, with one or a few egg-laying queens and their worker daughters. However, recent genetic studies reveal that the identity of breeding queens can vary over time within colonies. In several species, some queens are apparently specialized to enter established colonies instead of initiating a new colony on their own. The previously overlooked occurrence of queen turnover within colonies has important consequences not only on the genetic structure and nature of kin conflict within colonies, but also on the evolution of social parasitism.

Ito, F. (1996). "Colony characteristics of the Indonesian myrmicine ant Myrmecina sp (Hymenoptera, Formicidae, Myrmicinae): Polygynous reproduction by ergatoid queens." Annals Of The Entomological Society Of America **89**(4): 550-554.

Colony composition of Myrmecina sp. A, which has a specialized myrmecophilous oribatid mite Aribates javensis Aoki, Takaku, & Ito, was studied in Bogor, West Java, Indonesia. The colonies had no alate or dealate queens. Alternatively, an average of 8 ergatoid queens, who were easily distinguished from workers in width and length of the 4th abdominal tergaite, mated and laid eggs. Males were frequently produced in many colonies, but, production of ergatoid queens was observed in only 2 of 24 colonies in the field. Expulsion of some old ergatoid queens by workers was observed after emergence of new ergatoid queens in one colony. Experimental evidence confirmed the presence of queens had the negative effect on production of new ergatoid queens.

Kikuchi, T., R. Yoshioka, et al. (2002). "Effects of worker manipulation on the sex ratio of a Japanese ant species, Myrmecina nipponica." Ecological Research **17**(6): 717-720.

In order to test the effects of colony size and nutritional condition on the survivorship and sex ratio of ants, Myrmecina nipponica colonies were housed in a laboratory in colony sizes of 10 or 30 individuals and fed either daily or weekly. Under all conditions, most of the larvae successfully grew into adults, which suggests that survivorship was not significantly affected by either colony size or nutritional condition. However, the number of new queens was significantly higher in colonies that were fed daily. These results indicate that workers do not control the proportion of diploid and haploid broods by eliminating some larvae and that nutritional condition exerts a significant effect on sex ratio.

Miyazaki, S., T. Murakami, et al. (2005). "Morphological differences among three female castes: Worker, queen and intermorphic queen in the ant Myrmecina nipponica (Formicidae: Myrmicinae)." Sociobiology **46**(2): 363-374.

In social insects, caste morphologies are different depending on their tasks allocated in their colonies. Although many ant species generally possess two female castes: winged queen and wingless worker, in some Myrmecina species, some colonies produce a wingless reproductive caste instead of alate queens. This wingless reproductive caste is termed 'intermorphic' queen, and its morphological features are intermediate between winged queen and worker. In the present study, we analyzed the morphological features of the three female castes to explore the adaptive meaning of the intermorphics in terms of reproductive strategy, in addition to the developmental and evolutionary origin in Myrmecina nipponica. We first performed the principal component analysis based on the morphometric data of the three female castes of adults (alate queen, intermorphic queen and worker). The results of analysis showed that allometry of the intermorphic queen differ from those of alate queen and worker. In intermorphics, compound eyes and gasters were more developed in comparison with heads and thoraxes. We also examined several body parts in detail by scanning electron microscopy in the three female castes. The morphological features of intermorphics varied widely compared with the other two castes. Intriguingly, some parts of intermorphics were queen-like, while others were worker-like. Our findings suggest that the morphological features of intermorphic queens have specialized reproductive strategy involving budding.

Murakami, T., K. Ohkawara, et al. (2002). "Morphology and developmental plasticity of reproductive females in Myrmecina nipponica (Hymenoptera: Formicidae)." Annals Of The Entomological Society Of America **95**(5): 577-582.

We examined the morphology and developmental plasticity of alate/dealate queens and permanently wingless reproductive females (hereafter referred to as "intermorphic queens") in Myrmecina nipponica Wheeler. Alate/dealate queens and intermorphic queens had nearly equal reproductive capacities. The number of ovarioles was almost identical between virgin and inseminated alate/dealate queens, but inseminated intermorphic queens had significantly more ovarioles than virgin females. To determine if intermorphic queens in M. nipponica are 'ergatoid queens' or 'intercaste,' we compared seven external traits of each female caste. The external traits of intermorphic queens, in particular pronotal width and Weber's length of the mesosoma, were more similar to workers than to alate/dealate queens. Data on ovarioles suggest that the intermorphic queens have a reproductive ability similar to alate/dealate queens. The absence of a reproductive female in a colony and low temperature stimulated the production of new intermorphic queens but not new alate queens. The plasticity afforded by the production of intermorphic queens is likely an adaptation to low food resources and patchy nest sites.

Murakami, T., L. Wang, et al. (2000). "Mating frequency, genetic structure, and sex ratio in the intermorphic female producing ant species Myrmecina nipponica." Ecological Entomology **25**(3): 341-347.

1. Myrmecina nipponica has two types of colonies: a queen colony type, in which the reproductive females are queens and new colonies are made by independent founding, and an intermorphic female colony type, in which reproductive females belong to a wingless intermediate morphology between queen and worker, and where colonies multiply through colonial budding. 2. The mating frequencies of reproductive females in both types indicate monoandry. The relatedness among nestmates in both types was almost 0.75, however relatedness between mother and daughter in intermorphic female colonies was slightly higher than that of queen colonies. 3. The sex ratio (corrected investment female ratio) was 0.70 at the population level, suggesting that the sex ratio is controlled by workers in this species, however the ratio differed greatly between the two types of colonies. Queen colonies (n = 37) had a female-biased sex ratio of 0.77 while intermorphic female colonies (n=33) had a ratio of 0.56. 4. Each reproductive intermorphic female was accompanied by an average of 2.9 workers (including virgin intermorphic females) in the colonial budding, and when the investment to those workers was added to the female investment, the sex ratio reached 0.81. 5. The frequency distribution of sex ratio was bimodal, with many colonies producing exclusively males or females, however mean estimated relatedness within colonies was almost 0.75. These data are inconsistent with the genetic variation hypothesis, which is one of the predominant hypotheses accounting for the between-colony variation in sex ratio.

Ohkawara, K., F. Ito, et al. (1993). "Production And Reproductive Function Of Intercastes In Myrmecina-Graminicola-Nipponica Colonies (Hymenoptera, Formicidae)." Insectes Sociaux **40**(1): 1-10.

Many females morphologically intermediate between queens and workers were found in a northernmost population of Myrmecina graminicola nipponica Wheeler. Dissection and morphological observation revealed that there were three categories of intercastes. Major intercastes were as large as queens in body size, with seven or more ovarioles, but had only one ocellus, unlike queens, which had three ocelli. Medium intercasts had an enlarged mesonotum, one or no ocellus and 2 to 12 ovarioles. Minor intercaste was very simlar to workers in external morphology, but had a spermatheca, unlike workers. Inseminated females constituted 75 %, 40 % and 28.6 % in the major, medium and minor intercastes respectively. Many of the virgin medium and minor intercastes had a small disfunctional spermatheca. In queenright colonies, a single queen was inseminated and had an active ovary. In queenless colonies where the intercastes reproduced, however, some colonies were functionally monogynous, but the others polygynous. The ratio of polygynous colonies to monogynous colonies was lowest in July and highest in September, suggesting that polygyny results from newly inseminated intercastes remaining in their natal nests, although they leave those nests in the season of colonial budding. Queenless colonies containing inseminated intercastes exclusively produced intercastes, while queenright colonies almost exclusively produced queens.

Steiner, F. M., B. C. Schlick-Steiner, et al. (2006). "Phylogeny and evolutionary history of queen polymorphic Myrmecina ants (Hymenoptera: Formicidae)." European Journal Of Entomology **103**(3): 619-626.

The phylogenetic relationships in the myrmicine ant genus Myrmecina were analyzed using 1,281 bp of the mitochondrial cytochrome c oxidase I gene. Intermorphic queens observed in M. graminicola (Europe), M nipponica (Japan), M americana (North America; reported for the first time) and M sp. A (Java) were reconstructed as an ancestral trait in this genus. Molecular-clock-based age estimates suggest that queen polymorphism evolved in Myrmecina at the latest during the Miocene. In terms of bio-geographical regions, the inferred chronological order of divergence is: (oriental, (nearctic, (western palearctic, eastern paleartic))).

**Domination et monogynie fonctionnelle dans une société digynique de myrmecina graminicola Latr.**

[Baroni-Urbani, Cesare](https://bib.cnrs.fr/)

Insectes Sociaux; Dec1968, Vol. 15 Issue 4, p407-411, 5p

* L'autore, mediante osservazioni regolari in una colonia diginica sperimentale di Myrmecina graminicola, dimostra la presenza di un rapporto di dominazione trale due femmine. Il comportamento aggressivo della femmina α nei confronti della β è determinato dalla presenza delle larve e delle operaie, ma quest'ultime non partecipano minimamente alla scelta od all'eliminazione della regina soprannumeraria come era stato osservato in altre specie.