# Survival of subordinate in extremes –Story of Cataglyphs

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Animals that live in deserts appear to be special as they are adapted in one or the other way to survive in the extremes of temperature and scarcity of water. The most universal behavioral adaptation used by small mammals, reptiles and insects to deal with high temperatures is to avoid heat by staying out of it as much as possible. However, ants in the genus, *Cataglyphis* do not avoid heat and come out during the hottest times of the day to forage. Since they forage at midday in hot deserts, they are also known as furnace ants or mad Englishmen.

### *Cataglyphis*

Genus *Cataglyphis* includes around hundred species of ants and are found in arid deserts of Palearctic region. Cataglyphs lives in small colonies that are widely dispersed in desert sand, comprising only few hundred to thousand individuals. They are solitary foragers and strictly diurnal thermophilic scavengers as they forage for insects and other arthropods died due to the environmental stress of their desert habitats. By restricting their foraging times to the hottest times of day and year, which are avoided by the majority of other species, they get two advantages (i) they can escape predation by lizards which are less thermotolerant and hence won't be active when cataglyphs comes out for foraging and (ii) being subordinate species, they will be forced to abandon prey when dominant species are competing for the same resource. Hence foraging during the hottest hours allows them to exploit food resources with reduced competition.

### Adaptations to survive in arid environment

(a) Long legs: Most cataglyphs have relatively long legs (Fig.A) that carry their body away from hot sand (Sommer and Wehner, 2012).

(b) Thermal shield: The Saharan silver ant, *Cataglyphis bombycina* Roger has triangular shaped hairs (silver hairs-Fig. B) covering the body that act as thermal shield. Willot et al. (2016) measured the reflectance and temperature on abdomen of both hairy and shaved workers of *C. bomycina* and observed that the reflectance was tenfold higher in the presence of hairs which in turn, resulted in the reduction of the internal temperature by $2^0$C.

(c) Thermal refuge: When the temperature increases above $40^0$C, ants show a particular kind of respite behaviour in which, they retreat to cooler thermal refuges by climbing up stones or small sticks (Fig.C) of dry vegetation to radiate off excess heat from body (Wehner, 2020).

(d) Improve mobility by raising gaster: While running, Cataglyphs particularly, *Cataglyphis bicolor* Fabricus (Fig.A) and *Cataglyphis fortis* Forel raise their gaster vertically above the body to reduce their moment of inertia so that they can take tighter turns with increased speed without losing balance (McMeeking et al., 2012).

(e) Ultra runners: The most conspicuous behavioural trait of thermophilic desert ants is their extraordinary running speed. At temperatures (50°C–55°C) during which peak foraging activities occur, the ants' running speeds reach 855 mm/s or nearly one meter per second (Pfeffer et al., 2019).

(f) Heat shock proteins: Heat shock genes play a protective role by refolding denatured cellular proteins that have been damaged under heat stress. The more thermophilic ant species were found to have higher constitutive expression and lower induced expression of heat shock protein genes in response to heat stress than the more mesophilic ant species (Willot et al., 2017).

(g) Social hybridogenesis: In addition to the classical reproduction seen in ants, cataglyphs exhibit a special kind of reproduction called social hybridogenesis wherein, males and queens are produced as a result of parthenogenesis, while workers are hybrids and produced as a result of mating with another lineage. This benefits the colony by providing a genetically diverse workforce. This may be particularly relevant for scavengers such as *Cataglyphis* who are at risk from pathogens from dead arthropods (Wehner, 2020).

(h) Colony division: Two different modes of colony foundation *viz*., independent colony foundation (ICF) and dependent colony foundation (DCF) exist in cataglyphs. In ICF, a mature colony produces numerous queens that disperse individually by flight and start new colonies alone. In DCF, a mature colony splits to produce one (or a few) new colonies and is more predominant among cataglyphs. Deserts are patchy environments and it has very limited viable habitats where ants can establish a nest. So, in ICF, there is more chance that they may fail to find a favourable habitat in a desert environment and colony foundation is by queen alone. In contrast, DCF queens disperse on foot and they remain close to mother colony. And here, workers also help in excavating nest and taking care of young ones and hence, mortality will be less and thus, DCF maximize the competitiveness and tolerance of their offspring colony (Wehner, 2020).

**Foraging in desert**

Cataglyphs are zoonecrophages as they feed on dead bodies of arthropods that succumbed to death because of high temperature in desert. They forage individually and do not use chemical trails or trail pheromones that are used by most of the ants in other genera since at high temperature pheromones will evaporate and degrade. During hottest hours of the day, cataglyphs come out of the nest and take tortuous path in search of sparsely dispersed food. But, after collecting food they take the shortest path towards the nest. This kind of navigation is termed as path integration (PI) or vector navigation. Path integration is a method of determining current position based on knowledge from the previous position, heading, and velocity. Distance and directional information needed for PI are acquired by the ants *via* several methods. For knowing direction, cataglyphs use pattern of polarised light to know the position of sun whereas distance is measured by a combination of methods. Ants estimate distance using ant pedometer, wherein, ants employ a stride meter (pedometer) that counts numbers and measure lengths of the strides to know the distance travelled. Though the actual mechanism remains unclear, it is assumed that the ant might have used proprioceptors on the leg and body to achieve this (Wittlinger et al., 2006). Another technique used to measure distance is self-induced optic flow. If we are moving continuously in one direction looking on an object located far, as we are moving towards it, image of the same object changes constantly with regards to the area of retina it stimulates. This flow of information is known as optic flow. Measuring this rate of optic flow gives ants the distance covered (Ronacher and Wehner, 1995). Cataglyphs are known to memorise landmarks as well to locate their nest (Akesson and Wehner, 2002).

**Ecological role**

Cataglyphs can be found even in deserts with barely any vegetation. They are known to play a role in nutrient recycling as they feed on heat-stricken arthropods. They are also fed upon by robber flies and spiders during early morning or late evening hours when these ants are sluggish (Wehner, 2020). Few cataglyphs are known to contribute to seed dispersal and help in establishment of pioneer species through seed dispersal (Sharafatmandrad and Mashizi, 2021).

## Conclusion

Harsh environments drive unique ecological adaptations, allowing organisms to take advantage of extreme conditions to reduce competition and predation pressure. *Cataglyphis* ants possess several adaptations to increase thermotolerance and overcome the limitations of chemical communication in hot environments. Though these adaptations are not novel or exclusive to *Cataglyphis*, these heat loving ants have succeeded by enhancing a number of individual features and traits that are generally normal to ants.

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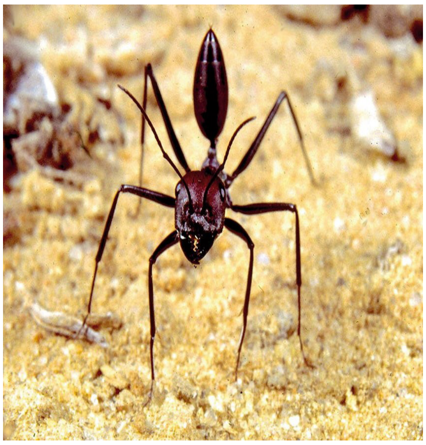

Fig. A. *Cataglyphis bicolor* with raised gaster. (Wehner, 2019 https://link.springer.com/article/10.1007/s00359-019-01333-5)


Fig. B. Thermal shield in *Cataglyphis bombycina* Willot et al, 2016, http://dx.doi.org/10.1371/journal.pone.0152325

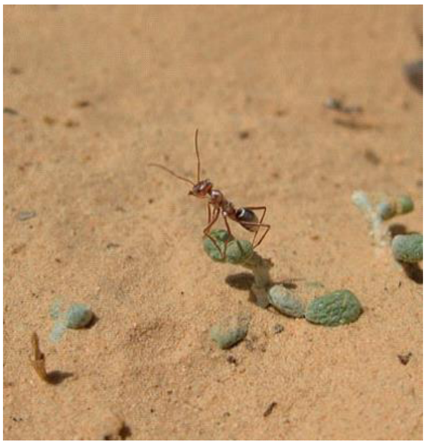

Fig. C. Respite behaviour in *Cataglyphis bombycina* (Pfeffer et al. 2019 https://jeb.biologists.org/content/jexbio/222/20/jeb198705.)

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