Biological control as potential means to protect honey bee colonies from driver ant (*Dorylus quadratus*) attack (Hymenoptera: Formicidae) in Tropical Africa

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In the tropics, honey bee pests are more serious and economically important than honeybee diseases and among which ants are the most damaging pests. Many species of ants are known to attack honey bees (Hepburn & Radloff, 1998. Among which Driver ants species, *Dorylus quadratus*, have been described as the greatest natural enemy of honeybees in tropics (Robinson, 1982; Adjare, 1990).

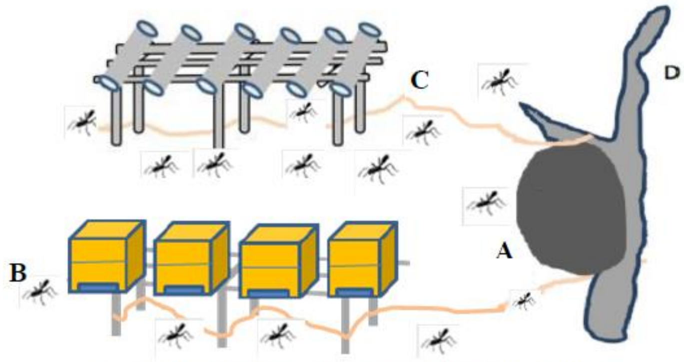
Driver ants can destroy all honey bee colonies in an apiary, carrying off all brood and stores in a matter of hours (Dubois & Collart, 1950; Robinson, 1982). In areas where driver ants are common, commercial bee farms, backyard beekeeping and use of box hives, have been deterred by fear of the ants, and beekeepers are forced to hang their hives on the branches of tall trees which makes it difficult to manage the colonies properly. Various cultural practices and mechanical ant-barrier methods have been used to minimize the driver ant invasions. However, virtually impossible to find a foolproof way of protecting honey bees from ants invasion.

Behavior of ants like, defense of foraging territories and intra- and interspecific disputes among different ants suggested to be used some ants species for biological control of undesirable ants (Philpott & Armbrecht, 2006). Among different ant species the arboreal *Crematogaster* ants are well known for their rapid hunting, aggressive and territorial behaviours (Longino, 2003), attributes that can be utilized well as potential biological control agents against undesirable pests. The Sheka forest beekeepers community of South West Ethiopia, have used the *C. chiarinii* to protect honeybee colonies from *D. quadratus* attacks by hanging their bee hives selectively on forest trees where these ant nests are found (Fig. 1).

In this study, the potential of *C. chiarinii* as a biological control agent against *D. quadratus*: the mode of the aggressive reactions between the species; how many hives can be protected by a single *C. chiarinii* colony and possible ways of its artificial propagation were studied and reported.

Fig. 1 Carton nests of *Crematogaster chiarinii* on trees (height about 5 m above the ground.

To describe and quantify the aggressive behaviour in inter-specific encounters between *C. chiarinii* and *D. quadratus* we used three different bioassays: dyadic encounters and interaction between groups and colonies following the procedures of Human & Gordon (1999) and Zee & Holway (2006). To assess the possibility of rapid multiplication and large-scale utilization of the *C. chiarinii*, we symmetrically split four *C. chiarinii*, colonies into smaller units, and the success of establishment of the split colonies was assessed for a period of one year. The effective foraging (defending) area of a *C. chiarinii* colony was assessed through artificially introducing its nest in to honey bee apiary and counting the density of workers and distance covered from their nest (Fig. 2). These data have been used to estimate the size of apiary and optimum number of hives that could be protected against *D. quadratus* predation.



A = *C. Chiarnii* ant nest, B =Forager ants around apiary, C = extension rope to guide the movements of forager ants, D = stem branch used by ants to establish the nest

Fig. 2 Showing artificially introduced *C. chiarinii* colony nest placed in apiary to protect honey bee colonies

In all types: dyadic, between group and colony fighting, *C. chiarinii* initiated the fighting and gained the upper hand and the first response of the *D. quadratus* was avoidance. Of the 40 times one-on-one fighting instances, 18 (45%) resulted in death of the *D. quadratus* while in 12 (30 %) cases the *C. chiarinii* died. In the remaining 10 trials (25%), both ants died. In group fighting from the total of 320 *D. quadratus* individuals, 230 of them or an average of (72%) died while from the 320 *C. chiarinii* a total of 150 or an average of (47%) died. The numbers of dead *D. quadratus* were significantly higher than *C. chiarinii* ($F = 93.18$, $df = 1,17$, $p < 0.0001$).

In the interaction between the two ant species colonies; in six out of the eight confrontations, *D. quadratus* immediately panicked, retreated and lost the battle. In two cases only the *C. chiarinii* lost. In each fight, an average of 217.5±74.2 (range 125 to 320) *D. quadratus* were observed to die or be physically injured, while an average of only 36.8 ±15.9 (range15 to 61) *C. chiarinii* were recorded as dead or injured and the variation was significant ($N = 16$, $F = 39.17$, $df = 1,12$, $p < 0.0001$).

In *D. quadratus*, the assistance of a fellow worker was rare. The most obvious reasons for the success of *C. chiarinii* were their speed of attack and the strength of their cooperation in group attack, spread-eagling the opponents and their small body size appears to be very effective against larger ants (Fig. 3).

Fig. 3. The co-operation among *C. chiarinii* workers in group fighting with *D. quadratus* (the larger *Dorylus* (media morph)).

In all fighting, most of the *C. chiarinii* were observed fighting and moving with strong abdominal curling, suggesting the use of some sort of chemical repellent. The immediate disintegration and the retreat of the whole mass of the *D. quadratus*, may indicate the complemented of the physical fighting with chemical release by *C. chiarinii*. The strong conflict between the two ant species may arises from a great capacity of *C. chiarinii* to defend its nest territory and its brood from the nomadic carnivorous *Dorylus* that raids other ants and honeybee nests in search of its food. Raiding, defense of foraging territories and intra- and inter-specific disputes among various ant species have been well documented (Tschinkel *et al*., 1995; Adams, 1998; Zee & Holway, 2006). The defence capacity underlines the potential, of *C. chiarinii* as biological control against *D. quadratus* swarms that attack honeybee apiaries.

From the twelve colonies that were obtained by artificial splitting of four mother *C. chiarinii* colonies, nine (75%) of them adapted and became established as an independent and successful colonies in the new location. Thus the study indicated symmetrical splitting of a *C. chiarinii* nest could be potential for artificial propagation and utilization of the species. *C. chiarinii* colonies were observed to forage up to an average distance of 28 m radius from their nest with an overall average density of 25 individuals per 10 cm^2. This may indicate that one *C. chiarinii* colony could protect honeybee hives from *D. quadratus* swarms within an average of 2500 m^2 area which could accommodate 100–200 beehives/apiary.

The observed ability of *C. chiarinii* easily to defeat *D. quadratus*, or at least to cause a mass retreat, suggests the significant potential use of this ant as a biological control agent against the latter. Unlike many other ant species, *C. chiarinii* has no tendency to enter honeybee nests and predate the brood which favours its use to guard honey bee apiaries. The use of *C. chiarinii* to protect an apiary from *D. quadratus* attack will reduce fears of keeping hives at ground level, encouraging commercial bee farm and backyard beekeeping in many tropical African countries. As *C. chiarinii* is not found in areas of intensive cultivation, nor in areas devoid of tree cover, its distribution is expected to decline with deforestation indicate the importance of maintaining biodiversity and ecosystem conservation.

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