

PREDATION ON FOUNDING QUEENS  
OF *SOLENOPSIS INVICTA* BY  
WORKERS OF *CONOMYRMA INSANA*<sup>1,2,3</sup>

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ABSTRACT

*Solenopsis invicta* Buren founding queens are especially vulnerable to predation during and following the nuptial flight. *Conomyrma insana* (Buckley) workers are effective predators of the queens in some areas of northern Florida. The respective behaviors that occurred during the confrontation of the 2 species were studied in the field in Jefferson, Leon, Madison, and Gadsden counties of northern Florida from 1968 to 1973. Detection of a founding queen alighting within a *C. insana* enclave by workers varied from a few seconds to several minutes. The pressure of attack by the workers increased with time. The founding queen's reactions to attack by *C. insana* consisted of 5 basic responses: (1) escape, (2) concealment, (3) cessation of movement, (4) mandibular defense, and (5) rapid flexing or shaking. Less than 3% of the queens observed alighting within a *C. insana* enclave were successful in escaping predation. No *S. invicta* queens were found that survived predation by *C. insana* workers long enough to construct a brood chamber and begin a new colony within an area occupied by *C. insana*.

The founding queens of the red imported fire ant, *Solenopsis invicta* Buren, are especially exposed to predation during the period following the nuptial flight and before entering the soil (Whitcomb et al. 1973). The major predators at this point appear to be its own workers and those of other ant species. Hung (1974), Markin et al. (1971), Whitcomb et al. (1972), and Whitcomb et al. (1973) have reported the dolichoderine ant *Conomyrma insana* (Buckley) as one of the more effective ant predators of the *S. invicta* founding queens. Our observations indicate that these queens have a great deal of difficulty in establishing where *C. insana* occur in north Florida. Although *C. insana* is sporadic in distribution in this region, it may be an important factor in limiting local populations of the red imported fire ant.

Competition for preferred nesting sites and foraging territories appears to be the major factor determining the distribution of many formicine species (Bhatkar et al. 1972, Leston 1973, Van Pelt 1966). Nowhere is this more true than in the aggression of the formicine species toward founding queens. Predation on founding queens alighting in a territory dominated by a given ant species would reduce or eliminate future competition for available resources in favor of the dominant species. Carroll and Janzen (1973) stated that founding queens were usually killed by worker ants of the same or other species. This strong statement is supported by research of several workers

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(Janzen 1967, Levieux 1971, Marikowsky 1961, Pontin 1960). Janzen (1973) presented research on *Pseudomyrmex ferruginia* F. Smith and described in detail how workers destroyed new queens of their own species. Hung (1974) analyzed the refuse pile of a *Conomyrma insana* colony and reported the recovery of discarded heads of the queens of 5 species of myrmecines, including those of *Solenopsis invicta* queens.

The predator-prey relationship of the founding queens of *Solenopsis invicta* and *Conomyrma insana* workers is of special interest due to the apparent complexity of the encounters leading to the death of the founding queens or the rare successful escape from predation by the latter. The first objective of the present research was to gain information on the general behavior pattern of a dolichoderine ant worker attacking a myrmecine founding queen. Furthermore, such data is needed on the predator-prey relationship of these 2 species, in particular, to evaluate the effectiveness of *C. insana* as a predator and its potential in limiting the local increase of *S. invicta*. Conversely, this information was collected to determine the ability of *S. invicta* to survive within an area under these high stress conditions.

#### METHODS

This research consisted of field observations of the behavior(s) of the predator (*C. insana* workers) and prey (*S. invicta* founding queens) under natural conditions. These events were observed in detail in Jefferson, Leon, Madison, and Gadsden counties in northern Florida in areas where *Conomyrma insana* nests were present. Of approximately 2,800 *Solenopsis invicta* founding queens observed while under attack, 240 were watched from the time they alighted until they were either destroyed by predators or escaped. When possible, the action was verbally described and recorded on tape as it occurred. Most observations were made on bare ground, either on dirt roadways or in fallow fields. Additional observations were made in mowed fields with sparse vegetation cover. All observations were made during 6 successive years from 1968 to 1973. This report is based on observations of queens which alighted naturally; information on queens which had been captured and handled was discarded.

In 1972 we attempted to determine the effectiveness of predation by *C. insana*. Nests of *C. insana* were examined and excavated to determine the numbers of *S. invicta* queens taken as prey. In addition, five 3 × 8m plots were randomly located in an open field. These plots were examined at 1/2 hr intervals from 1400 to 1830 on the dates of heavy *S. invicta* nuptial flights. Predation of *S. invicta* queens within these plots was noted and recorded. For 3 consecutive days following nuptial flight this field was searched for additional *S. invicta* females on the surface and for signs of brood chamber construction.

#### RESULTS AND DISCUSSION

A summary of the responses of *S. invicta* queens to attack(s) by *C. insana* workers is shown in the flow diagram in Fig. 1. While the responses of the queen to attack are varied, they can be separated into artificial categories which recur frequently.

An abridged summary of a single attack sequence by *C. insana* workers on 1 *S. invicta* queen is presented in Table 1. This was taken from observations

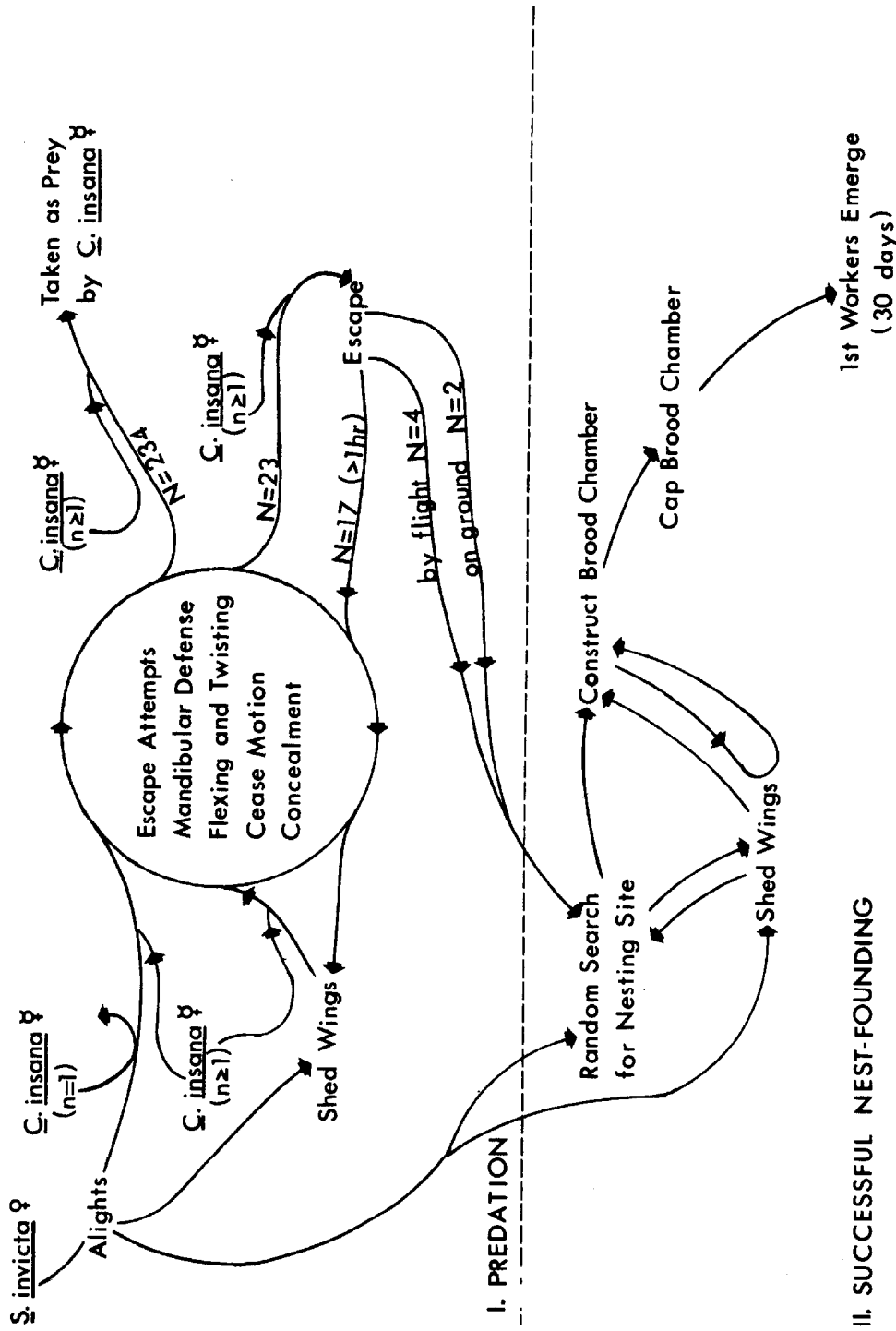


Fig. 1. Flow diagram of responses of 240 *Solenopsis invicta* founding queens to initial contact, pursuit, and attack by *Conomyrma insana* workers. The contrasting behavior leading to nest founding is included.

made 21 June 1972 of a queen that had alighted at 1625. The nuptial flight began after 2 days of intermittent storms resulting in 18 cm rainfall. The temperature at 1414 was 35°C and the wind velocity varied from 8 to 24 kmh. The alates of *S. invicta* emerged from the mounds at 1331. The first queen observed returning from the nuptial flight alighted at 1450.

#### CONSISTENCIES AND VARIATIONS IN BEHAVIOR

*Detection.* When a *S. invicta* queen alighted in an area heavily populated by *C. insana*, a period, varying from a few seconds to several minutes, elapsed prior to initial contact by *C. insana*. During this period, if sufficient, the queen shed her wings and commenced searching for a suitable site to construct the brood chamber. Detection of the *S. invicta* queen by *C. insana* workers occurred any time after the queen alighted, depending upon the immediate proximity of the workers. The first contact with the queen was made by a single worker approaching from the front or side with mandibles spread and maintaining only momentary contact with the queen. It is probable that the queen was marked with an identifying compound by the *C. insana* worker. Following

TABLE 1. ABRIDGED SUMMARY OF OBSERVATION OF ATTACK BY *Conomyrma insana* (*Ci*) ON A FOUNDING QUEEN OF *Solenopsis invicta* (*Si*) BEGINNING AT 1625 ON 21 JUNE 1972. LEON CO., FLA.

Elapsed time (min)	Observations
0	<i>Si</i> alights, immediately moves under debris and into soil crevices.
4	Met by 1st <i>Ci</i> ; duration of contact momentary. <i>Si</i> movement rapid and erratic.
9	<i>Si</i> reverted to normal rate of movement.
13	<i>Ci</i> attacked (n=2) and pursued (n=1). <i>Si</i> hid under leaf.
20	<i>Si</i> left leaf. <i>Ci</i> attacked <i>Si</i> at base of wing (n=1), head (n=1), and thorax (n=1). <i>Si</i> fled.
21	<i>Si</i> has traveled 8.5 m from alighting point, wings intact.
30	<i>Ci</i> attacked (n=1) <i>Si</i> at head. <i>Si</i> fled.
33	<i>Ci</i> attacked (n=9), <i>Si</i> shook <i>Ci</i> loose by rapidly flexing body.
34	<i>Ci</i> attacked (n=4), <i>Ci</i> clinging to wing, <i>Si</i> shook <i>Ci</i> loose. <i>Si</i> climbed blade of grass, attempted to fly, failed.
35	<i>Ci</i> pursuing (n=7), <i>Ci</i> attached (n=3) to <i>Si</i> . All <i>Ci</i> dislodged from <i>Si</i> .
36	<i>Ci</i> clinging to thorax and wing (n=2). <i>Si</i> dislodged <i>Ci</i> .
38	<i>Ci</i> attacked (n=4), <i>Si</i> motionless (6 sec), fled. <i>Ci</i> pursued and attacked (n=2).
39	<i>Ci</i> pursuing (n=7) and clinging to <i>Si</i> head (n=1).
40	<i>Si</i> moving rapidly, attempting to break off wings. <i>Ci</i> (n=3) pursuing and biting at legs and wings. <i>Si</i> flexed abdomen rapidly, curled into "C" position and bit at <i>Ci</i> . <i>Si</i> has traveled 16.8 m since alighting.

- 41 *Si* knocked left forewing off. *Ci* cling to *Si* leg. *Si* bit and killed *Ci* (n=1). *Si* now moving rapidly, *Ci* pursuing (n=9). *Ci* clinging (n=3), *Si* shook all off, still moving rapidly. *Ci* clinging (n=3) and pursuing (n=11). *Si* curled into "C" position and bit at *Ci*, then moved away with *Ci* in pursuit (n=14).
- 48 *Si* still moving with no pursuit.
- 50 *Ci* attack (n=2) *Si*. *Si* shook off attack.
- 51 *Si* under leaf momentarily, then emerged.
- 52 *Si* attacked by *Ci* (n=1). *Si* curled into "C" position and bit *Ci*. *Ci* (n=17) pursuing *Si*. *Si* shook off pursuit and attack, moved under clod of soil.
- 53 *Si* emerged, immediately attacked by *Ci* (n=1). *Ci* attacked (n=3). *Si* dislodged attackers. *Ci* clinging to wing. *Si* climbed blade of grass, immediately descended with *Ci* (n=1) still clinging to wing.
- 54 *Ci* (n=1) attacked *Si* at right metathoracic leg. *Si* curled into "C" position and bit *Ci*, forcing it to release. *Ci* (n=2) attacked, forced away by *Si*.
- 55 *Ci* attacked (n=2). *Si* curled into "C" position and bit at *Ci*. *Si* moved with *Ci* still clinging to leg. *Ci* (n=7) biting and pursuing, *Si* flexing abdomen and thorax, intermixed with assuming "C" position and biting.
- 58 *Ci* (n=3) attacking *Si*. *Si* shook loose *Ci*. Additional *Ci* (n=8) attacked. *Si* dislodged all *Ci* by shaking and biting. *Si* moved forward and went under a leaf.
- 60 *Si* emerged from under the leaf and was immediately attacked by *Ci* (n=1). *Si* curled into "C" position and bit *Ci* until it left. *Ci* (n=3) in pursuit of *Si*. *Ci* (n=3) caught *Si*. *Si* bit at *Ci* on leg. Additional *Ci* attacked (n=9). *Si* assumed "C" position and bit *Ci* clinging to leg but did not dislodge.
- 63 *Si* moving with *Ci* clinging. Additional *Ci* in pursuit (n=7) and attacking (n=15+) *Si* moving rapidly while shaking and flexing body. Stopped, assumed "C" position, bit and killed *Ci* (n=1). *Ci* attacking (n=4).
- 66 *Ci* (n=3) clinging to *Si*. *Si* dislodged *Ci* and moved forward rapidly. *Ci* (n=4) pursuing, *Ci* (n=1) clinging to leg. *Si* curled into "C" position and bit *Ci*.
- 68 *Ci* (n=12) attacking. *Si* halted assumed "C" position, bit *Ci* (n=1), now moving with *Ci* continuing attack. *Si* biting at *Ci* killed 1.
- 72 *Si* nearly subdued (= taken as prey by *Ci*). Little response to *Ci* and only feeble attempts to escape.
- 75 *Ci* have severed left prothoracic and both metathoracic legs.
- 76 *Ci* have severed left mesothoracic leg.
- 77 All legs severed.
- 80 *Ci* moving appendageless *Si* to nest. *Si* alive and trying to bite *Ci*. Distance from alighting point = 53 m.
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attacks were not comparable to the initial attack in that subsequent attacks were progressively more frequent and prolonged. In later attacks, the workers remained attached to the queen until dislodged. In the first approach penetration by the mandibles was never observed. The contact was made at any portion of the body, although 1 observer reported that the first contact involved the queen's head or propodeum in 82 of 97 observations.

During a short span of time following the initial contact the queen was unmolested by *C. insana* workers. Again, the queen may attempt to remove the wings (if not previously shed), but the usual reaction of the queen was to flee from the point of attack. In most observed cases this was followed by a halcyon period as evidenced by the less erratic and hurried rate of movement. Subsequently, the queen would renew the search for a suitable location in which to excavate the brood chamber.

*Secondary Contacts.* The time between first contact and subsequent attacks varied from 15 sec to 35 min depending on the local population densities and the degree of surface activity of *C. insana*. These secondary contacts differed from the first encounter in several respects. The *C. insana* attacks were progressively more frequent and prolonged; the workers tended to cling to the queen until dislodged. Pursuit of the queen by workers also occurred, although individual workers did not take part continuously. The intensity of pursuit was again dependent upon the local density of *C. insana*. As the attack progressed, the number of individuals of *C. insana* workers taking part increased up to the time the queen was taken as prey.

*Queen response to attack.* The responses of the *S. invicta* founding queens to the attack by the *C. insana* workers can be divided into 5 basic reactions: (1) escape, (2) concealment, (3) cessation of all movement, (4) mandibular defense, and (5) rapid flexing or shaking of the body. All or several of these responses were utilized by the queens in attempting to avoid or fight off the attack of *C. insana* worker(s).

Escape attempts from the attack of *C. insana* workers occurred in 2 forms: (1) flight and (2) surface movement. If a queen was attacked prior to shedding of the wings, she could avoid predation by further flight. This was accomplished by less than 2% of the queens under observation. The queens, when under attack, crawled up vegetation or any other available elevation in an attempt to gain the height necessary to become airborne. Queens not under attack were seldom observed by us to attempt flight after landing. The response most often elicited by the attack of *C. insana* was attempted escape on the ground surface. The distance covered varied with the topography, presence of vegetation, or other natural barriers. The escaping queen usually covered distances of 20 to 80 cm per min; some covered distances of 3 m or more. This response was often temporarily successful in avoiding immediate predation by *C. insana* workers.

While under attack or when unmolested by *C. insana* workers, the *S. invicta* queens were continuously moving under twigs, leaves, or into soil cracks. This appeared to be a concealment response, even though it may be difficult to distinguish from the normal instinct of the queen to commence construction of the brood chamber as soon as possible after landing. Hiding was usually effective in momentarily avoiding predation. If the queen abandoned the protection of the leaf or twig, *C. insana* workers immediately resumed their attack.

In further attempts to avoid predation, the queen often remained mo-

tionless briefly (6-10 sec) when attacked or investigated by a *C. insana* worker; afterwards, attempted escape or defense methods were used. In a number of observed cases, the cessation of motion was temporarily successful as the *C. insana* worker either did not commence further attack or broke off the attack and left the vicinity of the female.

The queens also attempted to take a defensive stand against the attack of the *C. insana* workers by aggressively biting. This was most often seen when the *S. invicta* queen had failed to dislodge attacking workers and 1 or more had seized an appendage. To effectively use the mandibles, the queen would lie on either side and assume a "C" position with the tip of the abdomen curled ventrally toward the mandibles. In this position, the *S. invicta* queen could effectively use the mandibles for defense. On a number of occasions, a queen severed an abdomen from a *C. insana* worker's thorax at the pedicel or decapitated a worker hanging onto 1 of her legs. The worker's decapitated head often remained attached to the seized appendage. This method of defense was effective against an individual worker, although the queen could not remain in the position long as it was vulnerable to further attack by other *C. insana* workers.

The *S. invicta* queens frequently attempted to dislodge clinging *C. insana* workers by rapid shaking or flexing of the abdomen. This was used by all queens under attack by *C. insana* workers. The queen was always successful in dislodging attacking workers by this means until she became exhausted or was overcome by the mass attack of the *C. insana*. The founding queens of *Solenopsis invicta* did not use or attempt to use the stinger as a defensive means against the *C. insana* workers in any confrontation observed.

*Predation and Disposal of Queens.* When the queens were successfully preyed upon by *C. insana* workers, the appendages were removed by a combination of tugging and biting at the joints. Appendageless queens were dragged, while still alive, to nests by the workers.

On the day following predation, bits of discarded body parts and heads of *S. invicta* queens were found on the periphery of the *C. insana* nests. After a major nuptial flight of 21 June 1972, a series of 24 nests were excavated on each of 2 successive days. On the 1st day, live appendageless queens were found in all nests. The fewest found in a single colony was 7 and the most was 18. A total of 329 *S. invicta* queens was recovered from the *C. insana* nests. An additional 83 queen heads were counted from the discarded debris and around the colonies that were excavated. On the 2nd day, only 1 *C. insana* nest had live appendageless *S. invicta* queens (n = 2).

#### EFFECTIVENESS OF *C. insana* AS A PREDATOR

Nests of *C. insana* tend to be concentrated in localized areas. The greater the number of *C. insana* nests within the area, the more intense the attack on fire ant queens. Mortality to the *S. invicta* queens did not depend on the effectiveness of the bite or toxin of the individual workers, but rather on the ability of *C. insana* to continue the attack until the *S. invicta* queens were taken as prey. When the process was interrupted prior to removal of appendages, the queen survived and laid eggs. However, where the process was followed by us from beginning to end, only 6 queens out of 240 contacted by *C. insana* workers managed to escape destruction by any means; 4 by flying away from the *C. insana* area and 2 by escaping on the ground surface to outside of the foraging range of *C. insana*.

In 1972, an effort to quantify predation by *C. insana* was made using five 3

× 8 m plots. On 9 May, a total of 613 postnuptial *S. invicta* queens was counted in these plots; 60% of these were completely subdued by the *C. insana* workers, 36.4% were under continuous attack, and 3.6% were momentarily unmolested. The results of an additional survey on 21 June were nearly identical. A total of 556 queens was noted; 61.3% completely subdued, 35.4% under continuous attack, and 3.3% momentarily unmolested.

A field at the Tall Timbers Research Station was searched for *S. invicta* queens for 3 successive days following a nuptial flight. On 10 May, 19 *S. invicta* queens were being dragged to the *C. insana* colony by coordinated effort of workers. Only 4 *S. invicta* queens were still under attack by *C. insana*. On 11 and 12 May, no live queens were found even though the area was extensively searched. An identical search was conducted following the nuptial flight on 21 June. On 22 June, 24 *S. invicta* queens were found that had been subdued by *C. insana* workers and were being taken into the colony. No queens were found on 23 and 24 June within the *C. insana* enclave.

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