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The Effect of Red Imported Fire Ants on *Gopherus polyphemus* at Camp Shelby, MS: Some Preliminary Results

Deborah M. Epperson¹, Craig R. Allen², and Daniel P. Wojcik³

¹ Mississippi Natural Heritage Program, Mississippi Department of Wildlife, Fisheries and Parks, Camp Shelby Training Site, Camp Shelby, MS 39407, USA.

² South Carolina Cooperative Fish and Wildlife Unit, Clemson University, Clemson, SC 29634, USA.

³ U.S. Department of Agriculture, Agricultural Research Service, Center for Medical, Agricultural, and Veterinary Entomology, Gainesville, FL 32605, USA.

Introduction

Camp Shelby Training Site (CSTS) in southern Mississippi contains the largest metapopulation of gopher tortoises (*Gopherus polyphemus*) in the western portion of their range (Jennings and Fritts, 1983; Lohoefer and Lohmeier, 1984). The gopher tortoise is listed as a Threatened species by the United States Fish and Wildlife Service in Mississippi, Louisiana, and Alabama west of the Mobile and Tombigbee rivers. In addition to a federal listing, the State of Mississippi has designated the gopher tortoise as an endangered species.

The gopher tortoise has been declining in numbers throughout much of its range (Auffenberg and Franz, 1982). Notable reasons for this decline include loss of habitat, lack of recruitment, and possibly disease. Earlier research suggests that mortality of young between egg laying and one year of age exceeds 94% (Alford, 1980). Landers et al. (1980) estimates that with such high mortality rates, the average adult female tortoise has a successful clutch once every 9-10 years. Depredation of both eggs and hatchlings results in a extremely low reproductive rate which may be a limiting factor to the recovery of the species. Predation on both eggs and hatchlings has been documented in other studies (Butler and Sowell, 1996; Casey and Cude, 1978; Fitzpatrick and Woolfenden, 1978; Landers et al., 1980; Smith, 1995; Wilson, 1991) and predators of tortoise eggs and hatchlings include mammals, birds, reptiles, and insects.

Throughout the southeastern U.S., red imported fire ants, *Solenopsis invicta*, have established themselves as aggressive exotics. Originally introduced in Mobile, Alabama around 1930 (Vinson and Sorenson, 1986), *S. invicta* are dominant throughout Mississippi, having replaced many other Formicidae (Mount, 1981). The potential negative impact of *S. invicta* on native wildlife populations in the southeast is documented in Allen et al. (1994). Many species of terrestrial oviparous

herpetofauna may be susceptible to fire ant impacts (Mount et al., 1981; Allen et al., 1996). Landers et al. (1980) observed that 10 gopher tortoise hatchlings in their reproductive study were killed by fire ants before emerging from the nest. In a study conducted by Smith (1995), 16 hatchlings from five different nests were destroyed by ants although the ant species responsible was not identified. Fire ant colonies can be found on burrow aprons throughout the range of the tortoise in Mississippi (Thomas Estes, pers. comm.). Jennings and Fritts (1983) found eight of 17 active burrows to contain fire ant colonies on the burrow apron (the authors do not mention whether these were native or non-native fire ants). During two years of life history and population structure research at Camp Shelby, Tuma (1996) recorded at least two tortoise hatchlings depredated by fire ants. Additionally, non-lethal exposure to fire ant venom may result in reduced weight gain and survivorship; as well as loss of digits and feet (Allen et al., 1996; Giuliano et al., 1996). In a laboratory setting approximating field conditions, Redbellied sliders (*Pseudemys nelsoni*) may experience greater than 70% mortality of hatching and pipping individuals when fire ants are present (Allen et al., unpub. manuscript). In addition, predation by *S. invicta* on adults of other species of turtles, (*Terrapene carolina triunguis*) has been documented (Montgomery, 1996).

Gopher tortoises may be vulnerable to fire ants at several life-history stages (Montgomery, 1996). Limited evidence indicates adults may be vulnerable. Pipping eggs are vulnerable to predation and newly hatched young may be stung which can lead to reduced survival by reducing weight gain and causing secondary infection through the necrotic action of the venom leading to death (Allen et al., 1996). Finally, small tortoises may also be vulnerable to both direct and indirect impacts. Because of the invertebrate fauna associated with gopher tortoise burrows, and a micro-climate attractive to fire ants, fire ants may forage heavily into burrows, increasing the possibility of contact. In addition to the potential impacts on gopher tortoises, the use of the burrow chamber by fire ants may have negative impacts on the fauna of the entire burrow system.

Methods

1) Study sites: 5 pairs, 20-40 hectares in size each, containing resident tortoise colonies. 5 sites will be used for controls for treatment with LOGIC®. Pairing of sites to reduce heterogeneity will be on the basis of gopher tortoise populations, *S. invicta* densities and overall habitat similarities.

2) *S. invicta* densities will be determined at each site by placing multi-species ant baits along two 200-meter transects (20' transect) through each study site. Baits will be collected after one hour and the number of *S. invicta* recruiting to the bait will be quantified. While quantifying *S. invicta* levels, sampling to determine *S. invicta* use of

burrow systems and the impact of *S. invicta* on burrow commensals will be done using baits placed in burrows, D-vac suction apparatus, and light traps.

3) Adult female tortoises will be trapped annually within the study sites prior to the nesting season. They will be manually palpated to evaluate gravidity and standard measurements taken. Measurements include carapace length (CL), plastron length (PL), mass, anal notch (AN), anal width (AW), gular projection (GP), total thickness (TH), and maximum body width (BW).

4) Gopher tortoise nests will be located at each site. For each nest located, date of deposition (if known), incubation period and clutch size will be recorded. Number of eggs, depth from the soil surface to the uppermost egg, distance from the burrow entrance to the center of the nest, placement of eggs and approximate nest dimensions will be recorded.

5) Nests will be protected from all other predators with a wire mesh enclosure as described in Smith (1992) and checked daily to monitor disturbance. Unprotected nests will also be monitored for predator disturbance. Tracks and characteristics of burrow excavations will be used to identify the type of predator. Once the hatchlings emerge, straight-line carapace length (CL), plastron length (PL), and wet body mass of hatchlings will be recorded and AVM hatchling transmitters will be attached. The hatchlings will be tracked for the duration of the study or until mortality occurs.

6) The LOGIC® applications will occur in the spring and fall of 1998 and the spring of 1999. If ant densities are reduced significantly, the fall 1998 treatment may not be necessary. As stated above, only one member of each pair will be treated with the pesticide at a rate of 1.67 kilograms per hectare. This is the recommended application rate for broadcast treatment. The treatment will be conducted under the supervision of Homer Collins, entomologist with the USDA Plant Protection Station in Gulfport, MS. Broadcast application will be completed by either manual spreading or with the use of mechanized ground equipment. There will be no aerial application. The total are proposed for treatment of the 5 sites will not exceed 200 hectares.

Preliminary Results

Mound counts were performed on four unforested sites. There was no significant difference ($P > 0.05$) between sites in the total number of ants or the total number of RIFA present before the LOGIC application, however, significant differences ($P < 0.05$) were noted between sites after the application. Using a T-test, significant differences were observed in the both the % colony kill and the population indices between treated and untreated sites.

Ant bait transects were sampled at 10 sites immediately prior to treatment. A total of 400 baits were collected and no significant differences were observed in either the number of ants ($P=.342$), or the number of RIFA ($P=.242$) present between treated and untreated sites. After the treatment, significant differences were observed in the number of RIFA present between treated and untreated sites ($P=.002$), however, no significant difference ($P=.082$) was observed in the number of ants present.

The insignificant differences noted in the number of ants present between treated and untreated sites after treatment could be explained in a number of ways. In the treated sites, a number of species appeared to have increased their numbers after the treatment. A species that responded well to decreased *S. invicta* numbers was *Dorymyrmex bureni*. *D. bureni* numbers were significantly ($P=.022$) larger in treated areas than in untreated areas after treatment. While this may appear to reflect an increased population size, it may be a sampling artifact. When RIFA dominate a bait, *D. bureni* may not be represented on the bait while they may be present on the site. The reduction of RIFA densities may allow them better representation on the bait while not necessarily increasing their overall population size. Real population level changes will be easier to discern in the next two years of this study as a second treatment (Spring 1999) continues to reduce *S. invicta* numbers on the treated sites.

While no significant differences were noted in the total number of ant species present between sites either before or after the treatment, a negative correlation ($r=-0.463$, $df=39$, $P<0.01$) was observed between the number of ant species on site and the density of RIFA on site.

A total of 19 gopher tortoise nests was located in the 1997 field season. This represented a total of 51 intact eggs, which resulted in 7 hatchlings. Of these seven hatchlings, none are alive. They were all dead prior to the nesting season of 1998. The 1998 nesting season yielded a total of 26 nests, representing 99 intact eggs. Forty eight of these eggs hatched successfully and 21 hatchlings had transmitters attached. Of these 21 originally transmitted, only six remain alive to date.

Initial results seem to indicate increased survivorship at treated sites. While mortalities did occur at treated sites, none of these can be attributed to RIFA. In contrast, hatchlings on untreated sites were often found covered with fire ants. It is possible that these tortoises were killed by another predator, however, no visible damage to either the shell or the body parts was ever noted.

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SUMMARY

Experiments were conducted to estimate the flight capabilities of fire ant (*Solenopsis invicta* Buren) alates. These experiments were designed to (1) quantify energetic expenditure during fixed flight, (2) characterize metabolic substrate of male and female alates, (3) estimate flight speed of male and female alates, and (4) quantify wingbeat frequency and water loss during flight. Flying males (in closed-system respirometry) increased metabolic rate approximately 38.4-fold over resting rate. Females increased metabolic rate approximately 51-fold (closed-system respirometry) and 48-fold (flow-through respirometry) over resting rate (Table 1). Female alates had mean respiratory quotient (RQ) of 0.999, indicating carbohydrate flight fuel. Mean RQ of males was significantly lower (0.867). Female flight speed on a circular flight mill averaged approximately 0.7 m sec^{-1} , and increased with temperature (Fig. 1) but decreased with increasing body mass (Fig. 2). Male flight speed was 43% greater (approximately 1.0 m sec^{-1}) and increased linearly with temperature and increasing body mass. Female alates lost an average of $1.8 \text{ mg water h}^{-1}$ during flight. A simple energetics model, combined with previous work on nutrient content of *S. invicta* and patterns of CO_2 release observed in this study (Fig. 3), indicate that flight capability of *S. invicta* alates is probably limited to $<5 \text{ km}$ in the absence of wind.

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Table 1. Flight performance of male and female *S. invicta* during closed-system and open-system respirometry.

Sex	n	Temp. (°C) ($\bar{x} \pm \text{SD}$)	Mass (g) ($\bar{x} \pm \text{SD}$)	Flight time (min) ($\bar{x} \pm \text{SD}$)	\dot{V}_{O_2} (ml g ⁻¹ h ⁻¹) ($\bar{x} \pm \text{SD}$)	\dot{V}_{CO_2} (ml g ⁻¹ h ⁻¹) ($\bar{x} \pm \text{SD}$)	RQ ($\bar{x} \pm \text{SD}$)	Increase over resting \dot{V}_{O_2}
Male (closed system)	10	32.6 ± 0.6	0.0073 ± 0.0006	12.0 ± 6.6	47.6 ± 18.4	31.2 ± 12.8	0.867 ± 0.052*	~35.5X
Female (closed- system)	12	27.9 ± 0.7	0.0155 ± 0.0006	15.4 ± 13.2	19.8 ± 3.6	15.4 ± 3.1	0.999 ± 0.189	~47.5X
Female (open- system)	10	33.6 ± 1.0	0.0152 ± 0.0010	51.7 ± 19.9	33.8 ± 4.7 ^a	29.3 ± 4.1	N/A	~48.0X

* RQs of male and female alates differ significantly (t-test, P=0.036).

^a Estimated using \dot{V}_{CO_2} in flight and RQ estimated in closed-system respirometry.

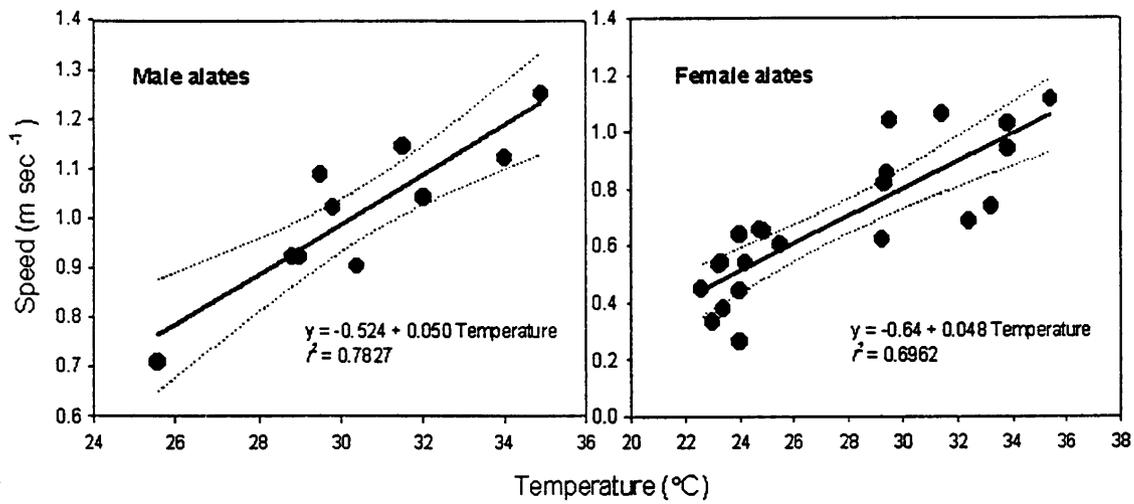


FIGURE 1. Relationship between temperature and flight speed in *S. invicta* alates. The dotted lines enclose the 95% confidence intervals for the regressions. Data have been adjusted for mean mass.

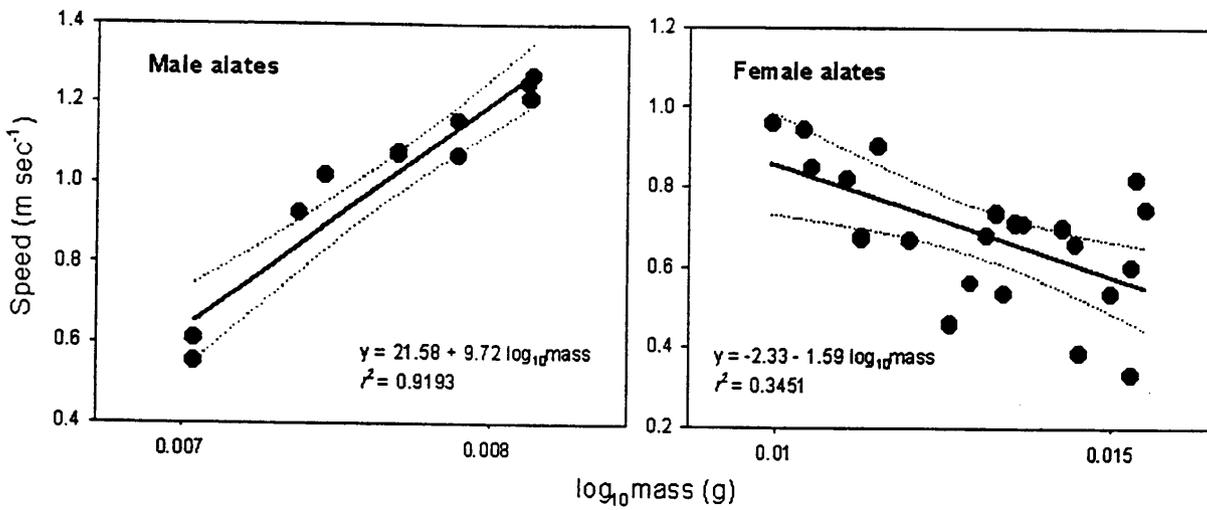


FIGURE 2. Relationship between log₁₀-transformed mass and flight speed in *S. invicta* alates. The dotted lines enclose the 95% confidence intervals for the regressions. Data have been adjusted for mean temperature.

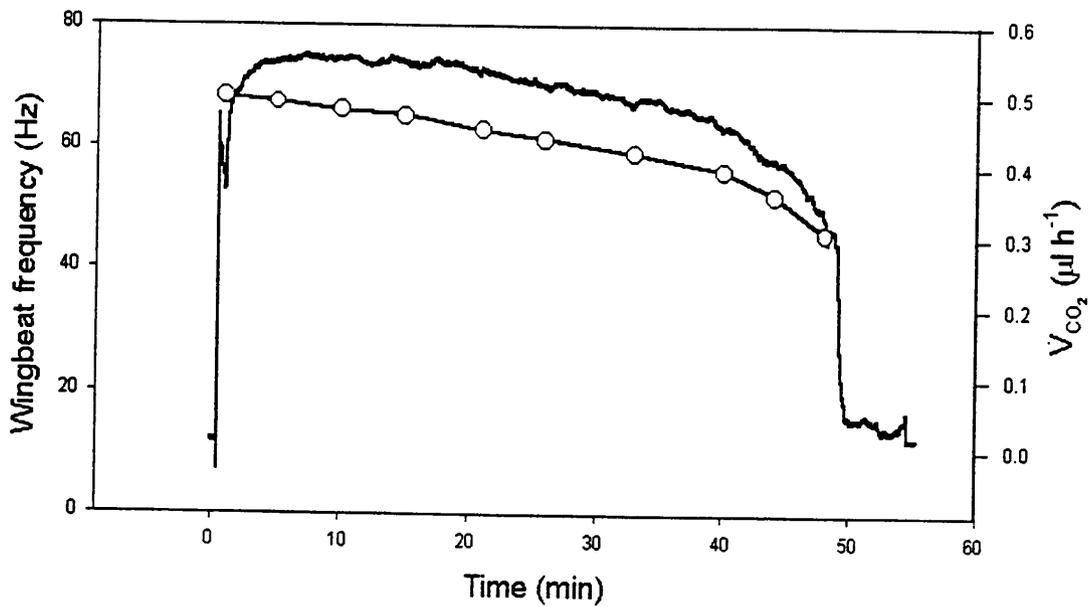


FIGURE 3. Real-time CO_2 emission and wingbeat frequency of an *S. invicta* female alate flying in a flow-through respirometer. The upper trace is \dot{V}_{CO_2} , the lower line and points are mean measurements of wingbeat frequency. Error bars are too small to project beyond the edges of the symbols. This pattern, including the rapid decline in \dot{V}_{CO_2} at approximately 45 min., was repeated in females flying to exhaustion.