

Short communication

## Seed harvester ants (*Pogonomyrmex rugosus*) as “pulse” predators

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### Abstract

Seed harvesting ants, *Pogonomyrmex rugosus*, collected grass cicadas at a high rate ( $>5 \text{ min}^{-1}$  taken into the nest) at one location where cicada emergence exceeded  $3 \text{ m}^{-2}$ . Dry conditions in the winter-spring resulted in no annual plants in the northern Chihuahuan Desert. *P. rugosus* colonies were inactive in areas where grass cicada emergence was less than  $1 \text{ m}^{-2}$ . *P. rugosus* initiate intense predatory activity in response to pulse of large numbers of prey. This study demonstrates that predatory behavior of seed harvesting ants is not limited to incidental encounters with prey during seed harvesting activities. Pulse predation demonstrates the importance of protein to seed harvester ant colonies.

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Patterns and processes of arid and semi-arid ecosystems are characterized by temporal and spatial heterogeneity. The temporal dynamics of desert ecosystem processes have been described by the pulse reserve paradigm (Noy-Meir, 1973). In the pulse-reserve conceptual model, rainfall stimulates a pulse of activity (new growth, reproduction etc.) drawing on reserve resources. At the end of the pulse, reserves are replenished (production of seeds, energy storage, etc.). Thus arid and semi-arid ecosystems are typically viewed as “pulsed” systems in which all ecosystem processes proceed in short burst of intense biological activity initiated by water availability (Noy-Meir, 1979/80).

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Seed harvester ants, *Pogonomyrmex rugosus*, forage intensively on the seeds of herbaceous annuals and annual grasses. Intense foraging by *P. rugosus* is limited to time periods when seeds are available on the soil surface (Whitford, 1976, 1978). Although many studies document the dependence of species of *Pogonomyrmex* on seeds (MacMahon et al., 2000) some of the data on foraging documents predatory behavior of these ants with termites as the most frequent prey returned to the colonies of harvester ants (Whitford, 1978). These studies suggest that predatory behavior of harvester ants is an opportunistic activity that occurs when ants encounter suitable insect prey while hunting seeds. Here we report a brief study that demonstrates that seed harvester ants exhibit a “pulse” of predation in response to a short duration episodic event (the emergence of a large number of prey). Our study was limited to one area where the numbers of emerging grass cicada were apparently sufficiently abundant to stimulate intensive foraging on emergent cicadas by harvester ants (*Pogonomyrmex rugosus*). Additional sites were not included because harvester ants were not actively foraging in other areas where there were low numbers of emerging cicadas.

Not all desert organisms exhibit a rainfall “pulse” phenology. Some desert species follow seasonal patterns of development that are independent from the timing of rain events. Cicadas are an example of rain event independent seasonal species. In the Chihuahuan Desert, the emergence of cicadas is synchronous and seasonally predictable (mid-May to mid-June). The synchronized, short period of emergence of grass cicadas is important for some fraction of the cicadas to avoid predation. Chihuahuan Desert grass cicadas (*Beameria vanosa* (Uhler)) inhabit fine textured soils in grasslands dominated by burrograss (*Scleropogon brevifolia*), alkali sacaton (*Sporobolus airoides*) tobosa grass (*Pleuraphis mutica*) and grama grasses (*Bouteloua* spp.). In May 2000, surveys of 10 m radius circular plots in these habitats on the USDA-ARS Jornada Experimental Range (JER; 50 km NNE of Las Cruces, Dona Ana Co., NM) yielded less than 1 grass cicada emergence hole  $\text{m}^{-2}$ . The harvester ant (*P. rugosus*) colonies in these habitats on the Jornada were not active during the period that grass cicadas were emerging. The absence of foraging activity by harvester ants was attributed to the dry conditions of the preceding 6 months (total rainfall—8.38 mm) and the absence of seed producing spring annual plants.

In late May, while visiting potential study sites at the Sevilleta Long-Term Ecological Research Site (approximately 25 km N of Socorro, NM), we found an area with numerous active colonies of harvester ants (*P. rugosus*). *P. rugosus* foragers were returning to the nests with grass cicadas. The active harvester ant colonies were on an ecotone that was a mixture of blue grama (*Bouteloua gracilis*)—black grama (*Bouteloua eriopoda*) grassland on fine textured soil on a low slope bajada of the Pino Altos mountains (N  $34^{\circ}0.209'$ , W  $106^{\circ}37.656'$ ). This area had burned in June 1998 by a lightning set fire. Grass cover in May 2000 was close to pre-burn values.

We recorded the rate of grass cicada harvest by *P. rugosus* by counting the number of foragers entering a nest with cicadas in their mandibles within a 1-min period. Counts were made at 12 nests within a 5-ha area beginning at 1630 h. Repeat counts were made over a 1.5-h period. The abundance of grass cicadas was estimated by counting emergence holes in seven, 4 m radius circular plots centered on points located by a surveyors pin tossed at random behind the observer. The following day, counts of active foragers with and without cicadas were made at 12 nests beginning at 0900 h; ending at 1130 h.

The average density of grass cicada emergence holes was  $3.1 \pm 2.1 \text{ m}^{-2}$  (range 0.9–6.7  $\text{m}^{-2}$ ). Emergence holes were contagiously distributed with highest concentrations

in close proximity to globe mallow (*Sphaeralcea subhastata*) plants and small cacti (*Mammalaria* spp. and *Opuntia* spp.). Emergence holes had very little fresh soil around the opening. In northern Kentucky forests, emergence of periodic cicadas (*Magicicada* spp.) produced between 40 and 170 emergence hole mounds  $\text{m}^{-2}$ . The material ejected from emergence holes deposited large quantities of A horizon soil on the surface (Luken and Kalisz, 1989). Although the densities of emergence holes was considerably lower and there was little soil deposited on the surface as a result of tunnel construction in the Chihuahuan Desert grassland, the holes represent a large, seasonal contribution to soil macroporosity. Soil macropores are continuous tubes or spaces in the soil. Macropores transport water by bulk flow to the deeper parts of the soil profile faster than predicted by infiltration models based on soil texture (Whitford, 2000). The emergence of cicadas prior to the beginning of the monsoon air flow patterns into the Chihuahuan Desert has the potential to enhance soil water storage from the rains at the beginning of the summer wet season.

The rate of grass cicada harvest by the ants was  $5.75 \pm 2.49 \text{ min}^{-1}$  (range = 1–9  $\text{min}^{-1}$ ). Numerous foragers returned to the nest with no booty. The average rate of foragers entering the nests was  $29.2 \pm 18.9 \text{ min}^{-1}$  (range 5–56  $\text{min}^{-1}$ ). The average number of foragers returning with seeds was  $1.2 \text{ min}^{-1}$ . Approximately 1–2 foragers  $\text{min}^{-1}$  were transporting small pebbles, which were placed on the nest disk.

When winter-spring rainfall is insufficient to produce a crop of spring ephemeral plants, harvester ants do not forage in the late spring and early summer (Whitford and Ettershank, 1975). This generalization was confirmed by our observations at the JER that harvester ants (*P. rugosus*) colonies were not active in late May and early June even in areas where grass cicada emergence occurred. Winter-spring rainfall at the JER (a single 8.13 mm rainfall in March) was insufficient for growth of annuals or water storage in the upper 30 cm of soil. Emergence of less than 1 grass cicada  $\text{m}^{-2}$  was not sufficient to induce foraging in the harvester ants at JER.

The foraging activity of *P. rugosus* at the Sevilleta site was in response to the high numbers of emerging grass cicadas at that site during one afternoon. The following morning, only 17% of the *P. rugosus* nests had foragers leaving and returning and the rates were less than one returning forager in a 3-min count period. There were virtually no grass cicadas emerging during that period and there were less than 1 cicada  $\text{m}^{-2}$  on the grass plants. In this desert grassland, the emergence of cicadas is highly synchronized. The absence of foraging activity by most colonies of *P. rugosus* the following morning is consistent with the hypothesis that intense foraging occurs when scouts are successful in capturing prey or in locating seeds in a short period of time (Whitford, 1976). When food is sparse, *P. rugosus* colonies become inactive (Whitford, 1976). Although there were grass cicadas at other locations that we visited at the Sevilleta, *P. rugosus* colonies were not foraging and grass cicadas were present in low numbers at those locations ( $< 1 \text{ m}^{-2}$ ). The Sevilleta had experienced little rainfall during the January to May period and there was no evidence of annual plants in the grasslands. At the Pinos Altos site, the harvester ants had access to an abundant source of protein in the form of a pulse of emerging grass cicadas and this pulse appeared to stimulate intense predation on the cicadas. Studies using protein baits have shown that *P. rugosus* will continue to forage even when the thermal environment is near lethal (Whitford, 1999). The low numbers of foragers returning with grass seeds demonstrates that the cicadas were the primary forage. When there are flushes of ephemeral plant seeds, *P. rugosus* forage for certain species of ephemeral seeds and insects (primarily termites) make up less than 2% of the items carried to the nests

(Whitford, 1978). Our observations of harvester ants foraging on grass cicadas show that the ant colonies will respond to episodic high concentrations of insect prey or insect carrion even when there are insufficient seeds to stimulate foraging activity in *P. rugosus* colonies.

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