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**Title**

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**Permalink**

https://escholarship.org/uc/item/2150k0v3

**Journal**

The American Naturalist, 111(979)

**ISSN**

0003-0147

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**Publication Date**

1977-05-01

**DOI**

10.1086/283187

**Copyright Information**

Peer reviewed

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      May 2, 1975

## LOW PREFERRED FORAGING TEMPERATURES AND NOCTURNAL FORAGING IN A DESERT HARVESTER ANT

Bernstein (1974) showed that three species of harvester ants in the Mojave Desert, *Veromessor pergandei*, *Pogonomyrmex rugosus*, and *P. californicus*, have their peaks of abundance at different altitudes. The preferred foraging temperatures of each of these species coincide with the prevailing daylight temperatures at the seasons when seeds are most abundant within the altitudinal range of each species. These preferences result in ants in the high deserts foraging at higher temperatures than ants in the low deserts, because seeds in the high deserts are most available during the hot summer months, while in the low deserts seeds are in greatest abundance in the cooler months (Bernstein 1974).

For *V. pergandei*, which has its peak abundance at lower elevations (Bernstein 1974), nocturnal foraging has been reported as nonexistent (Creighton 1953) or very rare (Tevis 1958). Bernstein developed her model of resource partitioning on the assumption that none of the above species of ants forages at night.

On all six summer nights when we visited our study site (July 22 and 23, August 13 and 17, October 11, 1974; and August 24, 1975), we observed nocturnal foraging of *V. pergandei* near Salton City, California (elevation approximately 30 m). In 20 checks of 10 colonies while the moon was out or shortly after it had set, we found in all cases well-organized foraging columns with seed being transported nestward. For 20 cases, when these same 10 colonies were checked prior to moonrise, only three had active foraging columns and these were poorly organized. In contrast, on the 12 nights between November and May when we visited the study site, no nocturnal foraging was seen.

Workers of *V. pergandei* were observed conducting nocturnal foraging when air and soil temperatures ranged from 21.5° to 31° C. In contrast, daytime foraging in winter may commence in sunlight with air and soil temperatures of 13.5° and 11.5° C, respectively. *Veromessor pergandei* ceased daytime activity in July and August between 08:00 and 09:00 when air and soil temperatures

reached 30.3° and 38° C, respectively, and activity did not recommence in the evening until 21:00 or 22:00 h, well after sunset. Thus moonlit nights provide a major portion of the time available for *V. pergandei's* summer foraging at our study site. In contrast, *P. californicus*, which is also found at our study site, was not observed engaging in nocturnal foraging.

Tevis (1958), who worked with *V. pergandei* in a nearby low desert area (elevation 73 m), states that nocturnal foraging is rare and only occurs when night temperatures are higher than usual. On the basis of climatological data available for the 5 years 1969–1973 (Environmental Data Service 1969–1973), we calculated that minimum nocturnal temperatures were 21.1° C or above on 54.4% of the nights and above 24.0° C on 35.1% of the nights between May 1 and September 30. Because summer nocturnal temperatures at this site rarely remain over 32.2° C for the entire night, *V. pergandei*, with an observed ability to forage at temperatures between 21.5° and 32° C, would have considerable potential opportunity for night foraging. Holldobler (1974) has also recently reported night foraging in *P. rugosus* in Arizona, lending credence to the possibility that nocturnal foraging is more frequent in desert harvester ants than previously thought.

The evolution of a low preferred foraging temperature may not only provide maximum access to seasonally abundant seeds during daylight hours, as Bernstein suggests, but may also permit nocturnal foraging, an option probably not available to ants restricted to foraging at high temperatures. Nighttime foraging may be important for *V. pergandei* in hot summer months when seeds are less abundant (Bernstein 1974). The finding of nocturnal foraging in *V. pergandei* does not refute Bernstein's model, but allows the relaxation of one of her assumptions and explains how an ant with low preferred foraging temperature could survive in low deserts where high summer temperatures limit diurnal foraging to a short period daily.

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## EXPONENTIAL AND LOGARITHMIC SPECIES-AREA CURVES

Some comments have been made by P. H. Haas (1975) on the use of the species-area curve, and this is an attempt to answer at least some of his questions.

The equation considered was the exponential relation

$$S = CA^z, \tag{1}$$

where $S$ and $A$ are species number and area, respectively, while $C$ and $z$ are constants. This particular species-area curve, which was first introduced by Arrhenius (1921), has been proposed for many different types of biological communities (Preston 1962; Kilburn 1963, 1966; MacArthur and Wilson 1967). Gleason (1922) criticized Arrhenius's formula and proposed the logarithmic relation

$$S = B \ln A. \tag{2}$$

The first statistical analysis of this problem, which was carried out by R. A. Fisher in collaboration with A. S. Corbet and C. B. Williams (1943), was a support to Gleason's proposal. Fisher arrived at the well-known equation

$$E(S) = \alpha \ln \left( \frac{\alpha + v}{\alpha} \right) \tag{3}$$

where $\alpha$ is a population parameter depending on the patterns of species abundance in the community and $v$ is the expected number of individuals in the sample (the "sample size"). It is usually realistic to assume that $v = \rho A$ where $\rho$ is the density of animals, or the expected number of individuals per unit area. For relatively large values of $A$, (3) may be approximated by

$$E(S) = \alpha \ln A - \alpha \ln (\rho/\alpha), \tag{4}$$

which, apart from the constant $\alpha \ln (\rho/\alpha)$, is equivalent to Gleason's relation.

I have generalized Fisher's model (Engen 1974) using the same gamma distribution but also demonstrating that all values of the shape parameter $k$