

# Seasonal and Diurnal Activity Patterns in Ant Communities in a Vegetation Transition Region of Southeastern New Mexico (Hymenoptera: Formicidae)

by

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## ABSTRACT

The densities of active ant colonies were estimated in three habitats: creosotebush shrubland, grassland, and shinnery-oak mesquite dunes. Diurnal foraging patterns were studied at bait boards. Species richness of ant communities in this transitional region (8-12 species) was considerably lower than Chihuahuan Desert ant communities in an area with lower annual average rainfall. The numerically dominant species was *Forelius pruinosus*. *Crematogaster* spp. was subdominant in all of the habitats and exhibited relatively constant activity throughout the growing season. Harvester ants, *Pogonomyrmex* spp. exhibited different seasonal activity patterns in the three habitats. One species, *Trachymyrmex septentrionalis*, was not recorded until October, when its nests were conspicuous with discarded leaf fragments around the entrances. Several species of ants feeding at bait board extended their foraging times in comparison to colonies of the same species too distant from the bait boards for foragers to reach the baits. Only one species (*Pogonomyrmex apache*) exhibited a high-tolerance foraging behavior, by initiating foraging at the bait boards after soil surface temperatures exceeded 40°C and other species had ceased foraging. Foraging activity of most species continued throughout the day when cloud cover reduced soil surface temperatures to 40°C during midday.

## INTRODUCTION

There are a number of variables that affect the distribution and abundance of species of ants: latitude (Cushman *et al.* 1993) climate and vegetation structure (Andersen 1986, Whitford 1978a), competition (Savolainen and Vepsalainen 1988) land-use intensity (Bestelmeyer and Wiens 1996) and land degradation (Andersen 1990). There are fewer variables that affect the seasonal and diurnal activity patterns of ants: food availability, food stores in the nest, and microclimate. In arid

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regions, seasonal rainfall patterns largely determine the availability of food. Temperature at the soil surface directly affects the foraging activities of soil nesting species (Bernstein 1974, Whitford and Ettershank 1975, Whitford 1978b, Gano and Rogers 1983).

Geographic regions that are transitions between biomes provide opportunities to examine the factors that structure communities in the absence of the effects of latitude on climate. Transitions between biomes are generally characterized by a mosaic of vegetation where plant communities characteristic of one biome merge into plant communities characteristic of another biome. In areas that are transitions between biomes, there are opportunities to study the effects of vegetation structure and soils without the confounding climatic differences that affect studies on biomes that are separated by long distances.

Recent studies have examined the temporal structure of subtropical, semiarid, ant communities with respect to heat-tolerant and heat-intolerant species (Cerda *et al.* 1977, Cros *et al.* 1997, Cerda *et al.* 1998). These studies suggest that the foraging periods of potential competitors are temporally separated both diurnally and seasonally. Similar responses have been reported for Chihuahuan Desert ant communities (Whitford and Ettershank 1975, Whitford 1978a).

This study was designed to test two hypotheses. It was hypothesized that there would be large differences in species composition and richness of ant communities between Chihuahuan Desert habitats and southern Great Plains habitats. It was hypothesized that the dominant dolichorderines (*Forelius* spp. and *Conomyrma insana*) would dominate baits during the early morning hours when soil temperatures are moderate. Other species would be restricted to using baits to periods when higher soil temperatures produce greater thermal risk.

### **Study Area**

Southeastern New Mexico is a transition region between the Chihuahuan Desert and short – mid-grass prairie of the high plains of West Texas, western Oklahoma and western Kansas. Land use for commercial livestock production and periodic drought have resulted in change in many of the areas that were grassland in the recent past. Mesquite (*Prosopis glandulosa*) has increased in many of the grassland areas and in many areas mesquite captures blowing sand to form coppice dunes. Low coppice dunes also form in areas with dense stands of shinnery oak (*Quercus harvardii*) (Peterson and Boyd 1998). The landscapes in this transition region are a mosaic of Chihuahuan Desert habitats, prairie habitats, and mixtures of the two.

Studies of ant communities were conducted on the Los Medanos area approximately 40km east of Carlsbad, N.M.. The topography is dis-

sected table lands with drainages to the Pecos River to the west via broad outwash plains. We selected 3 habitats within a 20km<sup>2</sup> area for studies of the ant communities: 1) creosotebush (*Larrea tridentata*), 2) mixed mesquite and shinnery oak dunes and interdunes, and 3) mesquite savanna grasslands dominated by black grama (*Bouteloua eriopoda*). The creosotebush and mesquite savanna grasslands were dominated by plants that are characteristic of the Chihuahuan Desert while the mesquite – shinnery oak dune communities were dominated by plants characteristic of the high plains.

The creosotebush communities were restricted to shallow soils with the caliche (calcium carbonate deposition layer) hardpan within 30cm of the soil surface. Creosotebushes provided sparse but fairly homogeneous cover of <1m tall shrubs. The soils ranged from sandy loams to clay-silts. Small shrubs (snakeweed, *Gutierrezia sarothrae*, some grasses (three awns, *Aristida* spp. and grama grasses, *Bouteloua* spp.) occurred in the creosotebush communities.

The mesquite savanna grasslands occurred on clay loam to sandy loam soils. The mesquite and other shrubs were largely restricted to the edges of dry washes. The caliche layer was between 70cm and 1m depth.

Shinnery oak-mesquite associations developed on deep sandy soils that were subject to wind erosion. In some of the areas, dunes ranging from 1m – 2m high developed around mesquite plants. In these areas the soils of the interdune spaces were compact and nearly devoid of vegetation. The shinnery oak coppice plants averaged <50cm in height and formed dense coppices on the tops of dunes. Other plants were sparse. Clump grasses (*Aristida* spp., *Sporobolus* spp., little bluestem, sand bluestem and witch grass), sand sage (*Artemesia filifolia*) and snakeweed (*G. sarothrae*) grow within the shinnery oak and in areas protected from wind deflation.

## METHODS

Densities of ant colonies (active nests) were estimated using quadrats of different sizes. In the creosotebush and mesquite savanna grassland habitats, we used 15, 1m x 2m quadrats and in the mesquite – shinnery oak habitats we used 40 1 x 2m quadrats. Quadrats were located at random by walking 30 paces in a randomly selected direction from the location of a previous quadrat. Direction was selected using a compass and selecting a direction using 5° increments (72 possible compass directions). Colonies were considered to be active if ants were moving into or out of the nest entrances. All areas were sampled in the early morning and after sunset to obtain estimates of abundance of active colonies of both nocturnal and diurnal species. In order to obtain

estimates of the abundance of colonies of widely dispersed, large body size ants such as *Pogonomyrmex* spp., *Aphaenogaster (Novomessor)* spp. and *Myrmecocystus* spp., we established six, 50m x 50m plots in each habitat. The locations of these plots were determined by centering the plots on alternate numbered quadrats on the first sampling date. During other studies in October and November, we encountered active colonies of a leaf cutter ant, *Trachymyrmex septentrionalis* in the shinnery oak dunes and mesquite savanna grasslands. In order to estimate densities of these ants, we established two, 2m x 100m transects in these habitats and recorded active nests.

Diurnal activity patterns were studied by using bait boards (Chew 1977). Bait boards were petri dish covers with small amounts of honey, cracked milo, tuna fish, and peanut butter spaced around the perimeter of the cover. One hundred bait stations were established on 10 x 10 station grids with 3m spacing between bait boards. One grid was established in each habitat on each sampling date. The petri dish covers were pushed into the soil to a depth that made the baited cover level with the soil surface. Ants that could not be sight-identified to species were collected from bait stations by aspirators. These ants were transferred to labeled, alcohol -filled vials and returned to the laboratory for identification. Observations of the behavior of the dominant ants at the bait stations were recorded at each sampling date. Air temperature at standard height and soil surface temperature was recorded for each habitat at hourly intervals. Soil surface temperatures were estimated by covering a thermometer with approximately 3mm of soil and allowing the thermometer to equilibrate.

Colony densities were calculated from the quadrat data. Species richness and foraging activity patterns were derived from the bait board data combined with the quadrat data. •

## RESULTS

Species richness was difficult to assess based on the bait board and nest studies. The *Pheidole* could not be identified to species because we did not find major workers at the nests and no major workers were seen at the bait boards. There were at least two different species of *Pheidole* based on morphological differences of the minor workers that were collected. Both species of *Pheidole* were collected at bait stations in all of the habitats. We did not find nests of *Camponotus acutirostris* in our large and small quadrat sampling. However, *C. acutirostris* was abundant at baits in all of the habitats. *Solenopsis xyloni* was collected at two bait stations in the mesquite grassland savanna but no nest of this species was located. Twelve species were recorded in the mesquite

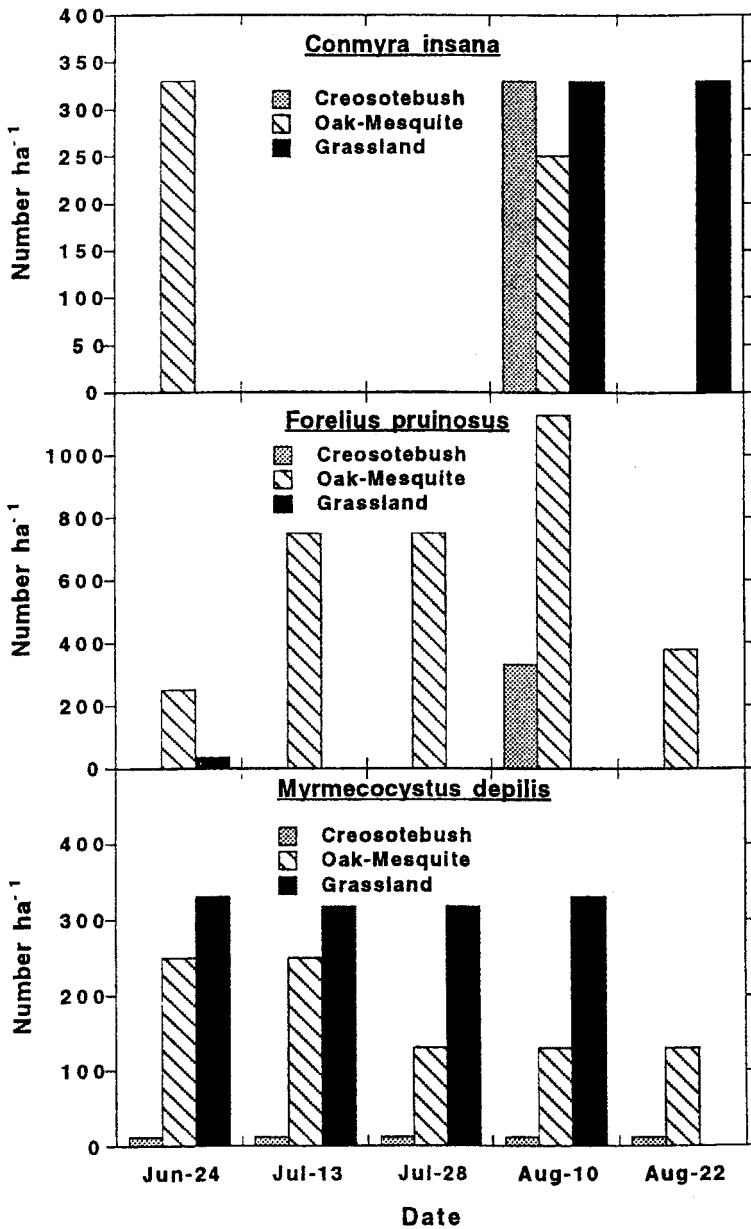


Fig. 1. Numbers of active dominant dolichorderine and subdominant *Myrmecocystus depilis* ant colonies per hectare in three habitats in southeastern New Mexico.

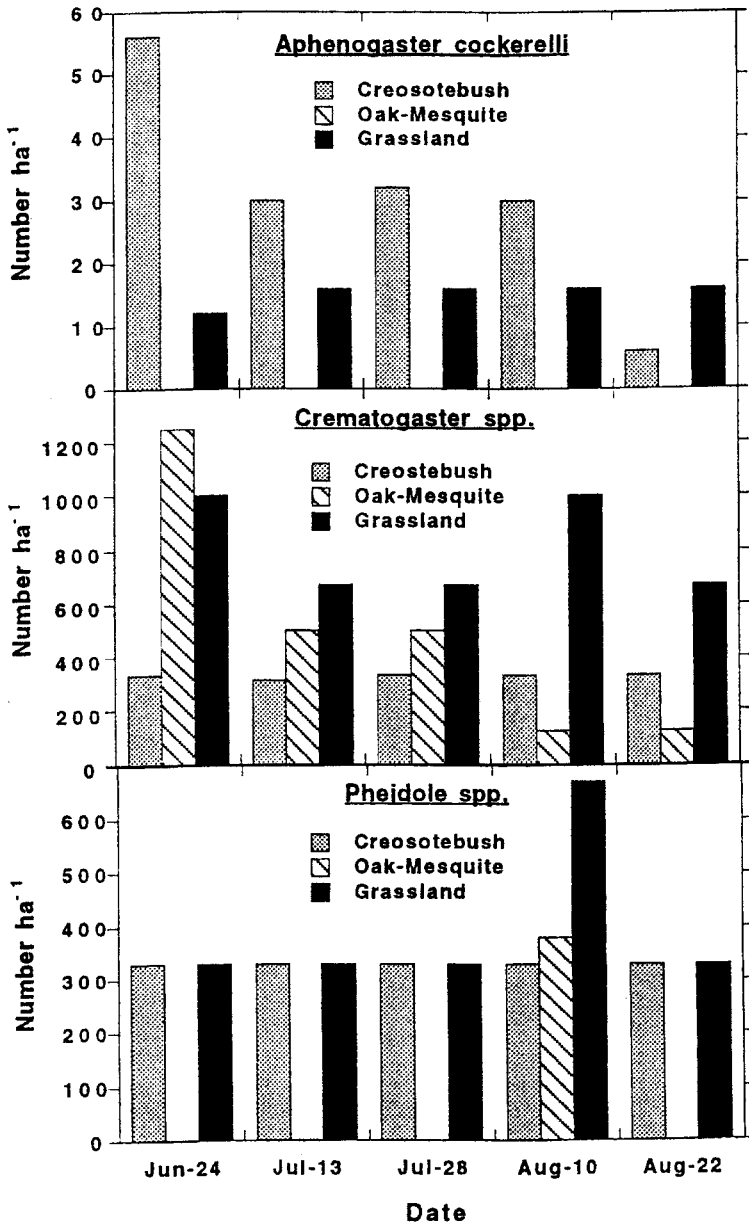


Fig. 2. Numbers of active ant colonies per hectare in three habitats in southeastern New Mexico. *Crematogaster larreae* is the species of *Crematogaster* in the creosotebush shrubland and *Crematogaster depilis* is the species in the other two habitats.

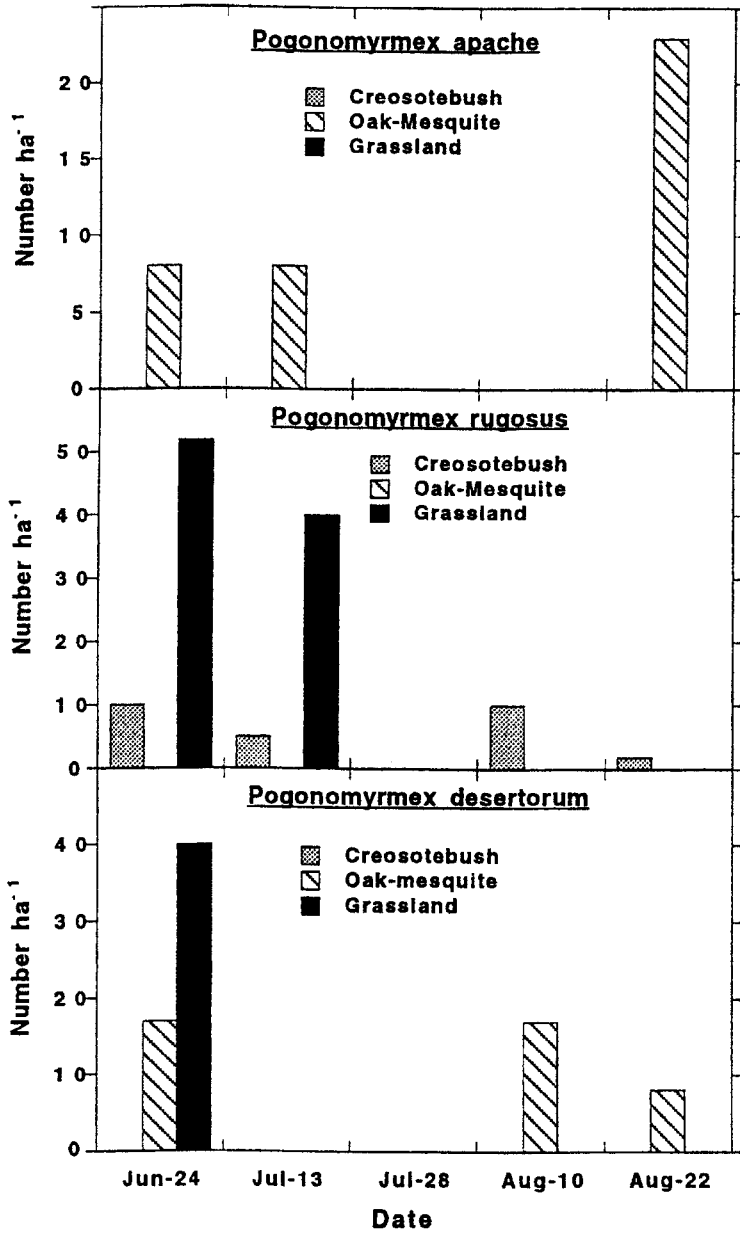


Fig. 3. Numbers of active seed harvester (*Pogonomyrmex* spp.) ant colonies per hectare in three southeastern New Mexico habitats.

grassland habitat, ten species in the oak – mesquite dune habitat, and eight species in the creosotebush habitat.

There were large seasonal differences in the abundance and activities of ants in the different habitats. *Conomyrma insana* colonies were active only in the oak-mesquite dune habitat in early summer and only in the mesquite-grassland habitat in late summer (Fig. 1). In July, there were no active nests of *C. insana* in any of the habitats, and in early August, there were active nests of this species in all of the habitats. The variability in temporal and spatial distribution of active colonies of *Forelius pruinosus* was similar to that of *C. insana*. This species was consistently active only in the oak-mesquite dune habitat and low numbers of active colonies occurred in the other habitats at various times during the sampling period (Fig. 1). *Myrmecocystus depilis* occurred in all of the habitats but at very low abundance in the creosotebush habitat (Fig. 1). Active nests of *M. mexicanus* were found in the creosotebush habitat on all sampling dates at estimated densities of 3 colonies per hectare. *M. mexicanus* was found on one sampling date in the mesquite grassland (estimated at 1 colony per hectare) probably because colonies of this species were widely scattered in these habitats.

Active nests of *Crematogaster depilis* were found in the sandy soil habitats and *Crematogaster larreae* were found only in the creosotebush habitat. Active *C. depilis* nests were more abundant early in the summer than during the remainder of the growing season (Fig. 2). Active colonies of *C. larreae* were remarkably constant over the sampling season (Fig. 2). *Aphaenogaster (Novomessor) cockerelli* was not found in the oak-mesquite dune habitat (Fig. 2). Active colonies of *A. cockerelli* were found on all sample dates in the grassland and creosotebush habitats. There was low abundance of active nests of this species on all sampling dates. Active nests of *Pheidole* spp. were abundant in the grassland and creosotebush habitats during the whole sampling period but were found in the oak-mesquite habitat only in August (Fig. 2).

The seed harvesters (*Pogonomyrmex* spp.) were restricted to one or two habitats and the densities of active nests were low in comparison to most of the other species (Fig. 3). *P. apache* and *P. desertorum* were restricted to the sandy soil habitats. *P. apache* was found only in the oak-mesquite habitat. *P. desertorum* was found in the grassland habitat in June, but was found in the oak-mesquite habitat in June and August (Fig. 3). Active colonies of *P. rugosus* were found in the grassland in early summer but were inactive in this habitat during late summer. There were low numbers of active *P. rugosus* colonies in the creosotebush habitat throughout the summer (Fig. 3).

The density of *T. septentrionalis* nests was approximately 150 colo-



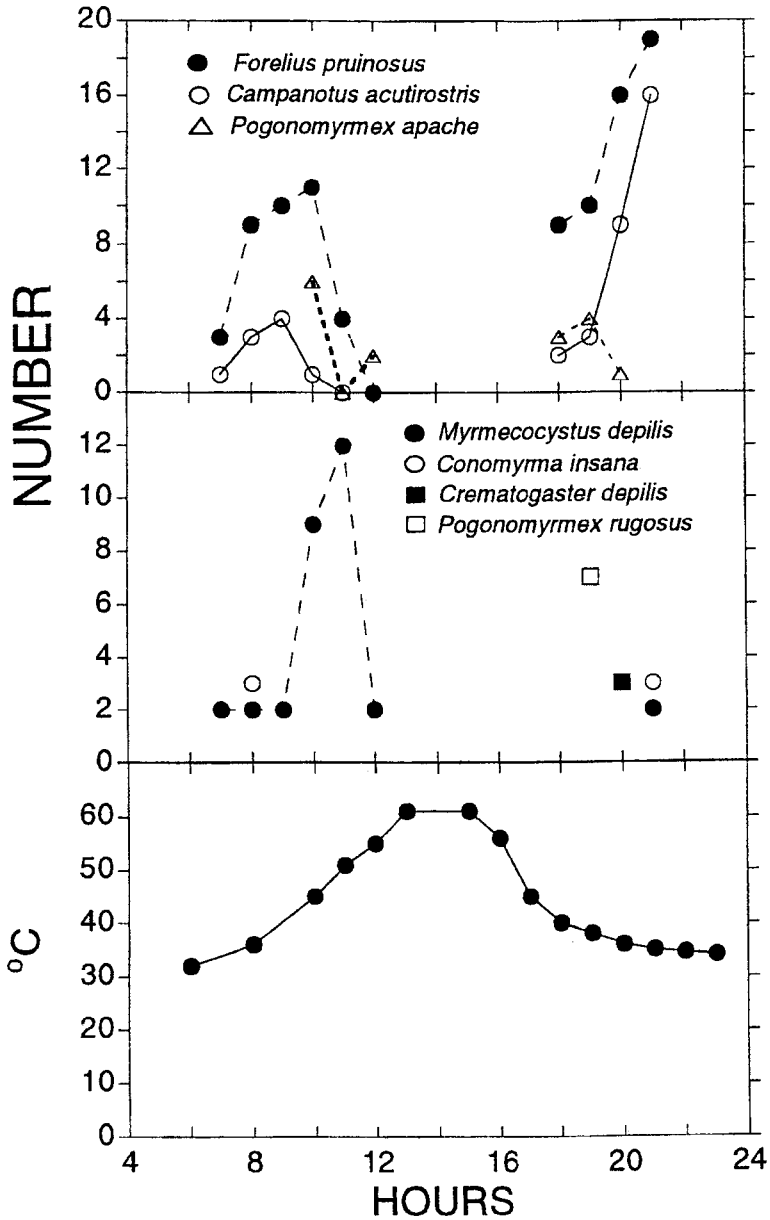


Fig. 4. Average number of ants at bait boards during the sampling period from dawn (0600hrs) to 3 hours after sunset during days with full sun or scattered clouds. The lower panel presents the average soil surface temperature at the hours indicated.

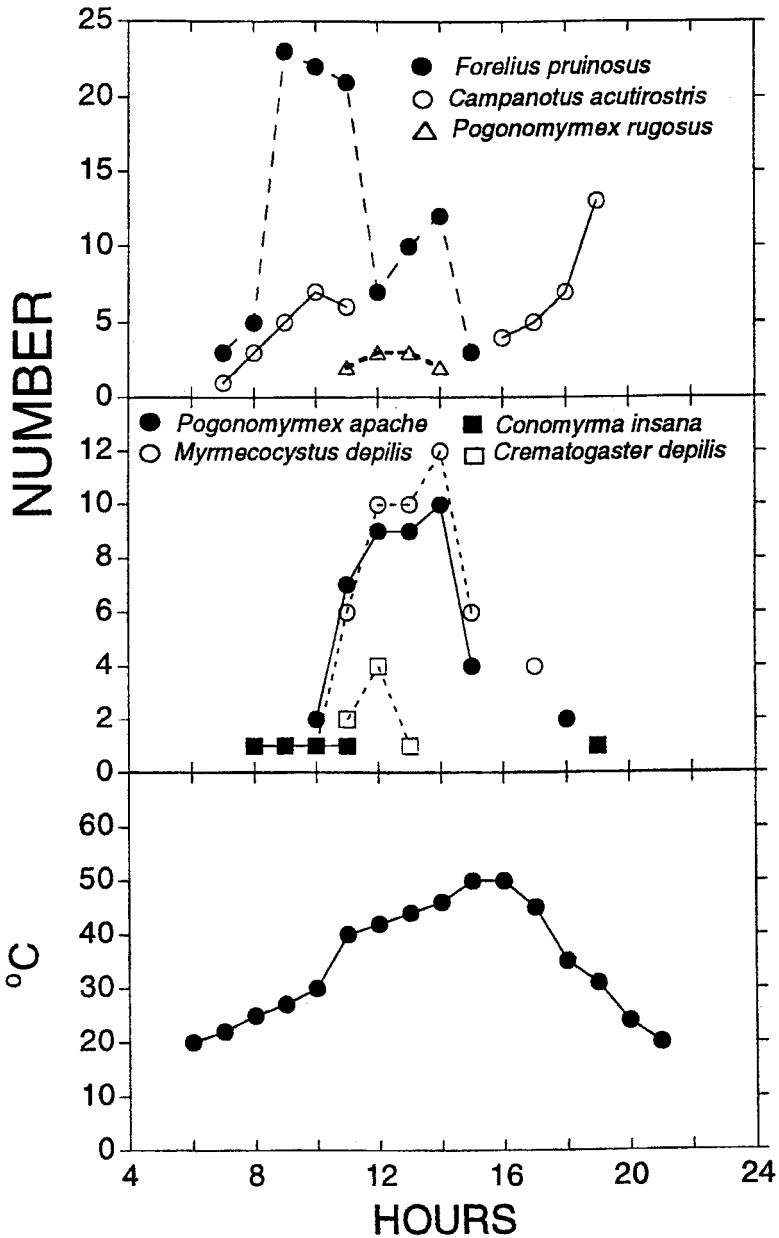


Fig. 5. Average number of ants at bait boards during the sampling period from dawn to 3 hours after sunset during days with continuous cloud cover. The lower panel presents the average soil surface temperature at the hours indicated

nies · ha<sup>-1</sup> in the shinnery oak dune and mesquite-shinnery oak habitats. These ants were harvesting leaves that had fallen to the ground. During October and November, the nest entrances of *T. septentrionalis* were conspicuous because the piles of leaf fragments at the nest entrances.

The daily activity patterns of ants at bait stations were similar in the three habitats that were studied. On clear days, soil surface temperatures reached 60°C by midday (Fig 3). On clear days, all of the ant species ceased foraging at bait stations by noon MDT (mountain daylight time). On days with continuous cloud cover, soil surface temperatures reached a maximum of 45°C and several species of ants continued intensive foraging at bait stations (Fig. 4). All of the species of ants taken at bait boards, were utilizing the tuna baits but only a subset of the ants was using the other baits. Only three species (*C. insana*, *C. depilis*, and *F. pruinosus*) were found on the peanut butter baits and these species used the peanut butter much less frequently than the tuna or honey. On both clear days and cloudy days, *F. pruinosus* dominated the honey and tuna baits and actively excluded *C. insana*. *M. depilis* shared dominance at the tuna and honey baits. Seed harvester ants, *Pogonomyrmex* spp. exhibited very restricted foraging times but used both the grain baits and tuna (Figs. 3 & 4). *P. apache* extended its foraging time at the baits during days with complete cloud cover as did *M. depilis* and *F. pruinosus* (Figs. 3 & 4). When we compared the foraging activity of ants from nests near baits with those from nests 10 m away from the bait grids, we found that *F. pruinosus* and *C. acutirostris* from the distant colonies ceased foraging by 10:30 or 11 AM when soil surface temperatures were <45°C.

## DISCUSSION

The species richness in these transitional habitats was less than half that reported for a variety of Chihuahuan Desert shrubland and grassland habitats (Chew 1977, Whitford 1978a, Whitford *et al.* 1999). They reported 18-30 species in Chihuahuan Desert habitats. Since the southeastern New Mexico area is transitional between the Chihuahuan Desert and Southern Great Plains, we should expect higher species richness in this area than in either the desert or plains areas. The ant communities in the habitats studied in southeastern New Mexico were composed of both desert and high plains species and were distinguished by species that were absent (such as several species of *Solenopsis*, and *Pheidole*) rather than by those present. It is doubtful that the low species richness is an artifact of sampling, since we used both bait boards and visual estimates of densities of active nests on several dates

during the growing season to obtain the species richness estimates. The reduction in species richness may be characteristic of areas where the soils of the habitats are unstable and prone to wind erosion. The low number of species reported here are comparable to those reported by Wisdom and Whitford (1981) for an unstable mesquite dune area in south-central New Mexico.

*C. insana* is the dominant ant species in the Chihuahuan Desert both in terms of abundance and behavior. The dominant ants in the transitional habitats of southeastern New Mexico were *Crematogaster* spp.. *Crematogaster* spp. are minor components of the Chihuahuan Desert ant communities (Chew 1977, Whitford 1978a, Whitford *et al.* 1999). Most of the ant species encountered in the transitional habitats were species that are relatively abundant in the desert habitats of southeastern Arizona and southern New Mexico. The aridity of the area appears to be a more important factor affecting the ant community, than the presence of plant species that are characteristic of the southern Great Plains. One species reported here, *Trachymyrmex septentrionalis* has not been reported in other desert habitats. The distribution of *T. septentrionalis* has been reported to be north and east of the study sites in areas considered to be plains grasslands (Creighton 1950, Moody and Franke 1982).

Several factors probably interact to determine the activity periods of ants in these habitats. Some species exhibited extremely variable seasonal activity e.g., *C. insana*, *F. pruinosus*, and *Pogonomyrmex* spp., while other species exhibited stable patterns of activity. It has been suggested that availability of seeds and colony satiation are the most important determinants of foraging activity in *Pogonomyrmex* spp. (Whitford 1975, Whitford *et al.* 1976, Whitford 1978b). The unstable soils in the oak-mesquite dune areas may be the most important factor excluding *A. cockerelli* from those habitats. *A. cockerelli* was not found in mesquite coppice dunes on the Jornada Experimental Range but was found in grasslands on the same soil series (Whitford *et al.* 1999). This distribution pattern was attributed to the instability of soils in the dune areas.

The thermal relationships of the ant species in the present study, as revealed by the data from the bait boards, reflect the tolerance for high temperatures in several desert ant species reported by Kay and Whitford (1978). In order for these small insects to remain at the bait boards when the soil surface temperatures were 50°C or higher, the ants would have to survive body temperatures of 45°C to 50°C. Whitford *et al.* (1975), Schumacher and Whitford (1974) and Kay and Whitford (1978) reported that several species of ants have critical thermal

maxima around 50°C. Ants at bait boards when soil temperatures are close to 50°C are thus operating at very near their critical temperature. The observation that colonies of the same ant species that were beyond the foraging range of the workers to reach the bait boards, ceased foraging when soil surface temperatures reached 40°C. The ants that remained at the bait boards, were concentrating on the tuna bait. These observations suggest that ants will risk thermal damage in order to forage at high quality food sources. The observations at bait boards also provide some insights into the variability of active ant colonies recorded from the quadrat sampling. Many of the species were able to continue foraging for extended time periods on days when cloud cover reduced soil surface temperatures. These data suggest that soil surface temperature is the most important variable affecting the foraging activity of arid region ants. In studies of factors affecting foraging intensity in *Pogonomyrmex* spp., Whitford and Ettershank (1975) found that while soil surface temperature was the most important variable affecting foraging intensity for a single day, other factors such as colony satiation, food availability, and food quality were more important determinants of seasonal patterns.

The heat-tolerant species in this inter-biome transitional area was limited to a single species (*P. apache*) using the definition of Cerda *et al.* (1998). However the data from this study shows that heat-tolerance and/or intolerance is dependent upon the quality of the food resource available to a species.

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