ARTHROPOD ASSOCIATES AND HERBIVORY ON TARBUSH IN SOUTHERN NEW MEXICO

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ABSTRACT—Arthropod abundances, seasonality, and defoliation were measured on tarbush (*Flourensia cernua*) in southern New Mexico during 1990 and 1991. The arthropod assemblage on this desert shrub was dominated by five species of sap-sucking herbivores, four species of chewing herbivores, two ants, parasitic Hymenoptera, and two spider families. Species richness and abundances were highest during late summer. Several taxa present in substantial numbers at budburst in spring may overwinter on, or rapidly discover, this resource. Defoliation was caused primarily by a chrysomelid beetle (*Zygogramma tortuosa*) and amounted to about 30% by late summer. The arthropod functional group organization (e.g., proportions of chewing and sap-sucking herbivores, predators and detritivores) on tarbush is similar to that measured on other shrub species using comparable techniques.

Desert shrubs have increased in abundance in the southwestern U.S. as a result of desertification of arid grasslands (e.g., Schlesinger et al., 1990). Several of these shrub species are known to produce phenolic and terpenoid compounds that are toxic to or deter feeding by vertebrate grazers (Dollahite and Allen, 1975; Rhoades, 1977; Rodriguez, 1985). Selective herbivory by vertebrate grazers in response to these compounds significantly affects vegetation structure (Gibbens et al., 1993; Schlesinger et al., 1990). However, relatively few studies have addressed arthropods associated with these shrubs (Hurd and Linsley, 1975; Lightfoot and Whitford, 1987, 1989, 1990, 1991; Richerson and Boldt, 1995), even though some arthropods might be useful biocontrol agents or important components of desert biodiversity.

Tarbush, *Flourensia cernua*, is one of the major shrub species in the southwestern U.S. This species is a deciduous, woody, perennial composite, bearing foliage between May and November (Kearney and Peebles, 1960). It typically dominates vegetation on clay soils in flat drainage basins but also occurs in association with other shrub species on the rocky bajadas that grade into mountainous areas. The name derives from its resinous leaves that contain compounds distasteful and toxic to livestock and rabbits (Dollahite and Allen, 1975; Kearney and Peebles, 1960) and many insects (Rodriguez, 1985).

Despite the ecological and economic importance of tarbush and known biochemical interactions with vertebrate grazers, little information on arthropod associations with tarbush has been reported. Richerson and Boldt (1995) provided a species list, relative abundances, and seasonal occurrences of herbivorous insects sampled on tarbush in Texas, New Mexico and Arizona, and suggested that herbivorous insects had little effect on tarbush. This study was conducted to provide quanititative data on arthropod abundances, seasonality, and herbivory on tarbush in southern New Mexico.

MATERIALS AND METHODS—This study was conducted on the 104,000 ha Jornada Experimental Range Long Term Ecological Research (LTER) Site, operated by the USDA Agricultural Research Service in cooperation with New Mexico State University. This site is located 35 km north of Las Cruces, Doña Ana County, New Mexico (32°N, 106°W) in the northern Chihuahuan Desert. The climate of this site is warm and arid, with average annual temperature of 15.6°C, and average annual precipitation of 21 cm (53% during July–September). Droughts are frequent. Vegetation is representative of the northern Chihuahuan Desert, with five dominant community types: remnant black grama (*Bouteloua eriopoda*) grassland and playa grasslands, and three desertified shrublands, tarbush flats, mesquite (*Prosopis glandulosa*) dunes, and creosotebush (*Larrea tridentata*) bajadas (Schlesinger et al., 1990).

Six 50 m × 50 m plots were selected in a tarbush flat in the central portion of the experimental range by marking three points at 0.5 km increments along an access road and designating a sampling point on each side of, and at least 50 m from, the road. This plot distribution represented an area of 15 ha. Shrubs in this area reached heights of 0.5 to 1.0 m.

Arthropods were sampled on September 19 and November 2, 1990 and May 30 and August 31, 1991 to represent seasonal changes in arthropod populations during this period. Samples were collected from 4 to 5 shrubs at random angles (between 0° and 180° facing away from the road) and distance (≤20 m) from each sample point. A branch system from each shrub was quickly enclosed in a 20 l plastic bag, clipped from the shrub, and sealed in the bag (Schowalter, 1989, 1994; Schowalter et al., 1988). Arthropods rarely escaped from the bag using this technique and those that did could be observed and recorded. Even highly mobile flies and wasps were trapped.

Samples were chilled at 5°C until they could be sorted in the lab. Arthropods were tabulated by taxon and larvae reared for identification. Defoliation was estimated visually as proportion of leaf area missing, to the nearest 10% increment, by examining each leaf, averaging consumption of chewed leaves and their proportion of total leaves. More quantitative estimates of defoliation were impractical because of the large number and small size of tarbush leaves and their clustered arrangement. Some completely consumed leaves might have been overlooked but petioles or abscission scars were noticeable and few. Leaves were dried at 40°C to constant weight. Arthropod numbers divided by foliage mass provided a standardized measure of arthropod intensity for comparison with other studies (Schowalter, 1989, 1994; Schowalter et al., 1988).

Arthropod intensities were pooled by site and sample date to provide six replicates per date. Data were compared among sample dates using Friedman's rank sum test and SAS software (SAS, Inc., 1982), to evaluate seasonal occurrence of taxa. Original data are available from the Forest Science/LTER Data Bank at Oregon State University.

RESULTS—The arthropod community on tarbush was composed of 56 taxa and dominated by two chrysomelid beetles (adult *Zygogramma tortusa* and all life stages of *Microrhopala rubrolineata*), two lepidopterans (including *Bucculatrix flourensiae*), three homopterans (a coccoid, a psyllid, *Kuwayama medicaginis*, and a flatid, *Mistharnophantia sima*), a heteropteran (a tingid, *Corythuca morrilli*), a thrips, two ants (*Pheidole* sp. and *Forelius pruinosus*), parasitic Hymenoptera, and spiders (Table 1). The relative proportions of the various taxa in the two late summer collections (September 1990 and August 1991) were similar, suggesting similar seasonal trends in populations of various species during the two years.

Sixteen taxa showed significant ($P < 0.05$) seasonality in abundance, including 2 Other Lepidoptera, and 1 each of Other Orthoptera, Other (herbivorous) Coleoptera, Other Homoptera, predaceous Coleoptera, Heteroptera, Other Predators, and Detritivores (Table 1). Lepidopteran 1 and a bdellid mite approached a significant seasonality at $P = 0.06$. Multiple comparison of mean abundance indicated that *Z. tortuosa* and *B. flourensiae* were significantly more abundant in late summer (August and September) than in fall or spring; *K. medicaginis* was more abundant in 1991 than in 1990 (Table 1).

Herbivory was substantial on tarbush during both years (Table 1). Leaf area missing rose from 1% (range 0 to 10%) in the May collection to about 30% (range 10 to 70%) by August ($P = 0.0001$).

DISCUSSION—This study provides the first quantitative data on seasonal abundances of arthropods associated with tarbush. Tarbush supported a modest arthropod community compared to other shrub species for which comparable sampling methods have been used. Tarbush supported twice the number of taxa associated with snowbrush (*Ceanothus velutinus*) in western Oregon (Schowalter et al., 1988) but fewer taxa than creosotebush (Schowalter and Lightfoot, unpubl. data) and forest trees (Schowalter, 1989, 1994). The bagging technique used in this study emphasizes taxa resident (and therefore continuously present) in the plant canopy. Longer-term trapping techniques would undoubtedly produce more of the species associated less frequently with the host plant (Hurd and Linsley, 1975; Richerson and Boldt, 1995).

The abundance of oribatid mites during spring (when these were the only detritivores present) was unexpected in this arid habitat, although arboreal specialists are known from forest canopies (e.g., Schowalter, 1989, 1994). The role of these mites in tarbush is unknown, but oribatids in forest canopies process detritus that accumulates in bark crevices (pers. obser.).

Although species richness and abundances of most taxa peaked during the summer, several herbivores were abundant in May, shortly after foliage appeared. These taxa may overwinter on (or near), or rapidly discover, suitable tarbush hosts. This study was not designed to evaluate the relative effects of host conditions and climate on arthropod population dynamics. However, seasonal variation in precipitation level likely af-

TABLE 1—Mean (and standard error of the mean) arthropod intensities (No./g dry wt. foliage) and leaf area missing (%) on tarbush (*Flourensia cernua*) at the Jornada Experimental Range in southern New Mexico between September 1990 and August 1991.

	Number/g foliage			
Taxon	Sept. 90 $\bar{X}$ (*SEM*)	Nov. 90 $\bar{X}$ (*SEM*)	May 91 $\bar{X}$ (*SEM*)	Aug. 91 $\bar{X}$ (*SEM*)
Chewing herbivores				
Melanoplus sp.	0.01 (0.01)	0	0.12 (0.13)	0
Other Orthoptera (2)	0.02 (0.04)	0	0	0.02 (0.02)
Zygogramma tortuosa	0.15 (0.06)ab*	0b	0b	0.37 (0.13)a
Microrhopala rubro.	0.05 (0.02)	0.02 (0.02)	0.10 (0.05)	0.02 (0.01)
Other Coleoptera (5)	0.04 (0.05)	0.02 (0.04)	0.09 (0.11)	0.04 (0.03)
Bucculatrix flour.	0.03 (0.02)ab	0.01 (0.01)b	0.04 (0.04)b	0.21 (0.05)a
Lepidoptera 1	0.12 (0.07)a	0a	0.03 (0.03)a	0.04 (0.01)a
Other Lepidoptera (6)	0.09 (0.08)	0.12 (0.12)	0.03 (0.07)	0.04 (0.04)
Sap-sucking herbivores				
Coccoid	0.36 (0.20)a	0.15 (0.08)ab	0.02 (0.01)ab	0b
Kuwayama medicaginis	0.56 (0.22)ab	0.48 (0.33)b	1.22 (0.53)ab	1.69 (0.37)a
Mistharnophantia sima	0.06 (0.03)	0.03 (0.02)	0.34 (0.17)	0.04 (0.02)
Other Homoptera (2)	0.03 (0.05)	0.01 (0.03)	0.05 (0.11)	0.03 (0.02)
Corythuca morrilli	0.20 (0.20)a	0.18 (0.17)a	0.12 (0.11)a	0.22 (0.14)a
Lygus sp.	0a	0a	0a	0.04 (0.02)a
Thrips 1	0.06 (0.02)	0.05 (0.03)	0.17 (0.09)	0.05 (0.02)
Thrips 2	0.01 (0.01)	0	0	0.01 (0.01)
Thrips 3	0	0	0.14 (0.08)	0
Omnivores				
Pheidole sp.	0.42 (0.32)	0.15 (0.09)	0.04 (0.04)	0.01 (0.01)
Forelius pruinosus	0.08 (0.05)	0	0.19 (0.08)	0.02 (0.01)
Formicid 3	0	0	0.13 (0.09)	0
Other ants (2)	0.03 (0.06)	0.03 (0.08)	0	0.01 (0.02)
Predators				
Coleoptera (3)	0	0	0	0.03 (0.03)
Diptera (3)	0.02 (0.05)	0	0	0.01 (0.02)
Heteroptera (2)	0	0	0	0.03 (0.04)
Hymenoptera	0.01 (0.01)a	0a	0.01 (0.01)a	0.14 (0.04)a
Aranid	0.17 (0.04)	0.10 (0.08)	0.26 (0.11)	0.08 (0.02)
Thomisid	0.04 (0.01)	0.01 (0.01)	0.13 (0.07)	0.02 (0.01)
Other predators (5)	0.05 (0.03)	0.04 (0.05)	0.10 (0.20)	0.13 (0.07)
Detritivores (3)	0.06 (0.08)	0	0.15 (0.28)	0.01 (0.01)
Miscellaneous (4)	0.04 (0.04)	0	0	0.01 (0.02)
Defoliation (%)	27 (5.3)a	23 (2.0)a	1.0 (0.3)b	30 (4.9)a

* For taxa showing significant effects of sample date, means in the same row followed by the same letter do not differ at the experiment-wise error $P = 0.05$ by Friedman's rank sum multiple comparison test.

fects shrub physiology and arthropod population dynamics (Lightfoot and Whitford, 1987). The functional group organization of the tarbush entomofauna (relative proportions of sap-sucking herbivores, chewing herbivores, predators and detritivores) was similar to that found on creosotebush (Lightfoot and Whitford, 1987, 1989, 1991; Schowalter and Lightfoot, unpubl. data), snowbrush (Schowalter et al., 1988) and forests trees (Schowalter, 1989, 1994; Schowalter and Crossley, 1987).

Foliage removal reached a mean of 30% by late summer both years and resulted primarily from feeding by larval Lepidoptera and adult *Z. tor-*

tuosa. This defoliation level is relatively high, compared to normal levels of foliage removal from forest trees (Schowalter et al., 1986). The large numbers of sap-sucking Homoptera and Heteroptera indicate substantial additional drains on plant photosynthates from the sap stream.

Long-term data on defoliation of desert shrubs are not available to indicate the extent to which these data represent typical conditions. However, given the abundance and potentially water-stressed condition of this shrub species over an extensive area, elevated herbivore populations could be expected to occur frequently (e.g., Mattson and Haack, 1987; Schowalter et al., 1986). Defoliation of small shrubs with limited storage capacity could aggravate plant stress (e.g., Mattson and Haack, 1987), perhaps limiting growth and reproduction; stimulate compensatory growth (e.g., Bilbrough and Richards, 1993); or reduce interception of precipitation by shrubs (Tromble, 1988), making more water and nutrients available to competing plants, including grasses (Lightfoot and Whitford, 1990). Further study will be necessary to evaluate the effects of interactions between tarbush and its associated arthropods.

D. C. Lightfoot and C. S. Schowalter assisted in sampling; D. R. Davis (Smithsonian Inst.), J. D. Lattin (Oregon State University), and W. Smith (USDA, ARS, Las Cruces) identified *Bucculatrix*, *Corythuca* and other species, respectively; T. E. Sabin provided statistical analyses. D. C. Lightfoot and two anonymous journal reviewers provided constructive comments on the manuscript. This research was supported by NSF grant BSR-8612106 to New Mexico State University and by the Oregon Agricultural Experiment Station (paper #11082).

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