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Author(s): Robert A. Schorr and Jeremy L. Siemers

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NOTES

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CHARACTERISTICS OF ROOSTS OF MALE PALLID BATS (*ANTROZOUS PALLIDUS*) IN SOUTHEASTERN COLORADO

ROBERT A. SCHORR* AND JEREMY L. SIEMERS

*Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO 80523-1475***Correspondent: robert.schorr@colostate.edu*

ABSTRACT—Male pallid bats (*Antrozous pallidus*) from the Purgatoire River Valley of northern Las Animas County, Colorado, were fitted with telemeters and followed to 53 day roosts. A majority of roosts were in cliffs (89%), with fewer in free-standing rocks at the base of cliffs. Temperatures at roosts were moderate (27°C) but warmer than ambient temperatures. Roosts in cliffs were slightly warmer than ambient temperatures, while roosts in rocks usually were 5°C greater than ambient temperatures. Typically, bats roosted in crevices that faced east or southeast with much solar exposure. Roosts in cliffs were in long, narrow cracks that extended into the face of the rock. The high temperatures recorded at roosts of male pallid bat may be advantageous for regulating body temperature, avoiding costly torpor bouts, or preparing for reproduction.

RESUMEN—Se les pusieron telémetros a machos de murciélagos desérticos norteros (*Antrozous pallidus*) del valle del río Purgatoire en el norte del condado de Las Animas, Colorado, USA, y se les siguió la pista a 53 dormitorios diurnos. La mayoría de los dormitorios se ubicaron en acantilados (89%), con menos en rocas sueltas al pie de los acantilados. La temperatura de los dormitorios fue moderada (27°C), pero más caliente que la temperatura ambiental. Los dormitorios en los acantilados fueron un poco más calientes que las temperaturas ambientales, mientras los dormitorios en las rocas solían ser 5°C más calientes que la temperatura ambiental. Por lo general, los murciélagos posaron en grietas que daban al este o sureste con mucha exposición solar. Los dormitorios en los acantilados estuvieron en grietas largas y angostas que se extendían hacia adentro de la cara de la roca. Es posible que las temperaturas altas documentadas en los dormitorios de los machos del murciélago desértico sean favorables para la regulación de la temperatura corporal, para evitar los períodos costosos de sopor o para prepararse para reproducir.

The pallid bat is a large bat (13–30 g) that is light in color, has long ears (21–37 mm), and is found throughout arid lands of western and southwestern North America (Hermanson and O’Shea, 1983). In Colorado, pallid bats are found along the western border and the southeastern corner of the state (Armstrong et al., 2011) with the densest population in Colorado likely occurring in the southwestern canyonlands (Armstrong et al., 1994). The pallid bat is a gleaner, regularly landing on or near prey that is on the ground or vegetation (Bell, 1982). Its diet is dominated by insects and other invertebrates (Easterla and Whitaker, 1972; Johnston and Fenton, 2001; Lenhart et al., 2010), but pallid bats will eat vertebrates, such as lizards and rodents (O’Shea and Vaughan, 1977; Bell, 1982; Johnston and Fenton, 2001; Lenhart et al., 2010). Occasionally, pallid bats will visit cactus and agave

to feed on nectar or predate flower-visiting invertebrates (Herrera et al., 1993; Frick et al., 2009).

Pallid bats roost in a variety of structures, including crevices of rocks, caves, mines, cavities of trees, and human-made structures (Twente, 1955; Hermanson and O’Shea, 1976; Lewis, 1994), but most records of roosts of pallid bats identify geologic features as the predominant roosting structure (O’Shea and Vaughan, 1977; Lewis, 1996; Rambaldini and Brigham, 2008; but see Baker et al., 2008). Nursery colonies of adult females and young may number in the hundreds whereas bachelor roosts may be as large as 100 adult males (Davis and Cockrum, 1963; Vaughan and O’Shea, 1976). Young male pallid bats may roost with maternity colonies, but adult males typically roost separately (Vaughan and O’Shea, 1976; Hermanson and O’Shea, 1983). Much of what is known of the

roosting ecology of pallid bats is based on female groups or nursery colonies (Vaughan and O'Shea, 1976; O'Shea and Vaughan, 1977; Lewis, 1996). Few studies have addressed the roosting characteristics of male pallid bats (but see Baker et al., 2008; Rambaldini and Brigham, 2008). This study was initiated to identify and describe diurnal roosts of male pallid bats and describe roosting characteristics from the eastern part of its range. Because requirements for resources are sex-specific for many species of bats, strategies of conservation and management need to address the needs of each sex (Weller et al., 2009). Pallid bats currently are not a species of conservational concern in Colorado (L. E. Ellison et al., <http://www.cnhp.colostate.edu/teams/zoology/cbwg/consplan.asp>), but the species has shown sensitivity to human disturbance even in relatively remote areas (O'Shea and Vaughan, 1999).

We sampled pallid bats along the uplands of the Purgatoire River valley in northern Las Animas County, Colorado, south of the Comanche National Grasslands (37°30'N, 103°45'W). Habitats along the river were dominated by willow (*Salix*), cottonwood (*Populus*), cattails (*Typha*), and various grasses and forbs. The surrounding uplands were open steppe of mixed grasslands, interspersed snakeweed (*Gutierrezia sarothrae*), and sagebrush (*Artemisia*), with canyonlands of mixed grasses, forbs, skunkbush (*Rhus aromatic*), and juniper (*Juniperus*; Hazlett, 2004).

We captured bats using two mist nets (6 m × 2 m; Avinet, Inc., Dryden, New York) stretched over a metal water trough for 7 nights in June 2009 and another metal trough for 8 nights in July 2009. We established nets 30 min prior to sunset and monitored them until midnight, checking them at ≤10-min intervals. We weighed bats using a spring scale (Pesola AG, Baar, Switzerland) and aged them by observing the total epiphyseal gap at metacarpals (Brunet-Rossini and Wilkinson, 2009). We restrained bats manually in a soft cloth bag, keeping the interscapular area exposed. We trimmed hair between the scapula using blunt, curved manicure scissors and affixed a small radio-transmitter (0.42–0.60 g; Models BD2N and BD2, Holohil Systems Ltd., Carp, Ontario) using Skin-Bond adhesive (Smith and Nephew, Inc., Largo, Florida). We saved trimmed hair, applied it to the back of the telemeter for camouflage, and added a light dusting of talc to ensure no unset glue was exposed. We used a telemetry-receiver and folding directional antennae (R-1000, Communication Specialists, Orange, California) to locate bats at day roosts between 0600 and 1300 h, matching known times of day-roosting behavior from other studies (O'Shea and Vaughan, 1977; Rambaldini and Brigham, 2008). Capture and handling of bats and attachment of telemeters to bats was approved by the Animal Care and Use Committee of Colorado State University (Protocol 08-033A-02).

We collected environmental and site-specific data to

describe the habitats used by pallid bats. We classified each roost into one of four categories: human structure; tree; cliff; rock. We used a handheld compass (Silva Ranger, Johnson Outdoor Gear, Inc., Racine, Wisconsin) to determine the aspect of openings of roosts in cliffs and rocks, aspect of faces of cliffs and rocks, and direction to nearest tree. If the roost was in a tree, we recorded species of the tree and percentage of canopy cover within 2 m and 10 m using a spherical densitometer (Forest Densimeters, Bartlesville, Oklahoma). To better describe the topography of the roost, we measured the height of the roost above flat ground, distance from the roost to the flat ground immediately above the roost, height of the roost above the valley floor, and distance from the roost to the top of the mesa using a Bushnell Yardage Pro Trophy laser rangefinder (Bushnell Performance Optics, Lenexa, Kansas). We measured height, width, and depth of the opening of the roost using the laser rangefinder but measured or estimated shorter distances using a reference scale (ruler). We recorded ambient temperature using a handheld thermometer (Enviro-Safe Armor Case Thermometer, TWM Solutions, Inc., Trappe, Pennsylvania) and temperature of the roost using an infrared noncontact thermometer (Raynger ST, Raytek Corporation, Santa Cruz, California). Because bats were seen infrequently, temperatures of roosts were taken closest to the strongest telemetric signal and as deep into the opening as possible. Also, the presence of other bats and guano were noted. Because sources of water typically were not visible from roosts, we used a geographic information system (ArcGIS v.9.3.1, Environmental Systems Research Institute, Redlands, California) to determine the direction and distance to the nearest sources of water. The local landowner helped us locate troughs filled with water.

Of the 13 pallid bats we captured, we fitted 12 males with telemeters and released 1 female. Two individuals were not found after release, and 10 individuals were tracked to 53 roosts (Table 1). Nearly all roosts were in cracks on walls of cliffs (=cliff roosts; $n = 47$), but three bats roosted in the cracks of six separate large rocks (=rock roosts; 1–3 m in diameter) near the base of cliffs. Aspects of roosts and cliffs varied, but most faced east to southeast (Table 1). Roosts were not surrounded by trees (mean distance from roost = 19 ± 14 m *SD*), and trees did not provide cover above roosts. Most roosts were in secluded areas of crevices that were inaccessible. We found guano below 14 roosts.

Crevices of cliff roosts were typically long (mean ± *SD* = 230 ± 380 cm, range of 9–1,500 cm) and narrow (mean = 8 cm, *SD* = 6 cm, range of 3–25 cm) and equally distributed in orientation (55% vertical, 45% horizontal). At the few locations where depth was measurable ($n = 5$), mean depth of crevice was 46 cm (± 32 cm *SD*). Most bats roosted in crevices that were high on walls of cliffs (>75 m) and near the top of mesas (Table 1). Cliff roosts were

TABLE 1—Characteristics of roosts and mass of male pallid bats (*Antrozous pallidus*) along the Purgatoire River Valley, northern Las Animas County, Colorado. Values are means (± 1 SD). For individuals combined, $n = 12$ for mass and $n = 10$ for the other characteristics.

Individual	Mass (g)	Number of roosts	Temperature of roost ($^{\circ}$ C)	Mean aspect of opening of roost ($^{\circ}$)	Mean aspect of wall of cliff ($^{\circ}$)	Mean roost height (m)			
						Above valley floor	Below top of mesa	Above nearest level ground	Below nearest level ground
1	17.0	0	—	—	—	—	—	—	—
2	16.5	1	29	50	80	64	20	14	20
3	19.0	6	25 \pm 9	154 \pm 46	156 \pm 42	22 \pm 9	3 \pm 4	20 \pm 8	3 \pm 4
4	18.0	1	34	65	30	200	100	3	2
5	19.0	8	24 \pm 3	195 \pm 46	192 \pm 39	78 \pm 41	9 \pm 7	17 \pm 11	8 \pm 8
6	19.0	2	33 \pm 1	2 \pm 40	16 \pm 20	140 \pm 85	75 \pm 7	12 \pm 12	38 \pm 46
7	20.0	1	27	42	14	200	80	5	3
8	18.5	8	28 \pm 1	194 \pm 60	188 \pm 74	81 \pm 40	27 \pm 27	10 \pm 9	11 \pm 9
9	17.5	0	—	—	—	—	—	—	—
10	17.5	9	25 \pm 6	174 \pm 46	173 \pm 36	84 \pm 31	13 \pm 4	25 \pm 11	13 \pm 4
11	23.0	8	25 \pm 5	155 \pm 63	157 \pm 39	120 \pm 26	10 \pm 9	56 \pm 29	10 \pm 9
12	20.0	9	24 \pm 3	233 \pm 52	206 \pm 34	85 \pm 24	10 \pm 10	20 \pm 11	6 \pm 7
All	19.0 \pm 2.0	5 \pm 4	27 \pm 4	126 \pm 79	121 \pm 78	107 \pm 58	35 \pm 36	18 \pm 15	11 \pm 11

at heights of 86% ($\pm 12\%$ SD) of the height of the wall and were well above horizontal ground (usually >10 m) and nearly as far below flat ground (usually >5 m; Table 1). At 32 cliff roosts, we could access the roost well enough to take temperatures that reflected internal conditions. Temperatures at cliff roosts ($25.4 \pm 5.1^{\circ}$ C SD) were comparable but slightly higher than ambient temperatures ($24.1 \pm 6.9^{\circ}$ C SD; one-tailed paired t -test = 1.69, $P = 0.06$, $df = 31$). However, rock roosts ($26.7 \pm 2.6^{\circ}$ C SD) were warmer than ambient temperatures ($21.3 \pm 6.1^{\circ}$ C SD; one-tailed paired t -test = 2.02, $P = 0.04$, $df = 5$).

Water was universally accessible to all roosts. Roosts were within 1.5 km (± 1.2 km SD) of the Purgatoire River and within 820 m (± 360 m SD) of the nearest water trough. Typically, a bat roosted within 1.5 km (± 0.9 km SD) of where it was captured, but one bat was found roosting 4.1 km from where it was captured. Foraging forays of pallid bats typically are within 3 km of a roost (O'Shea and Vaughan, 1977; Johnston and Fenton, 2001; Baker et al., 2008).

Similar to previous reports (O'Shea and Vaughan, 1976; Rambaldini and Brigham, 2008), male pallid bats along the Purgatoire River roost in remote crevices near the top of mesas. Many roosts were along vertical faces of cliffs and in long, thin crevices. Rambaldini and Brigham (2008) found comparable mean height (80 m) of roosts of pallid bat in cliffs of British Columbia. In forested habitats, pallid bats select similarly tall day roosts that are above the forest canopy, despite the availability of rock roosts (Baker et al., 2008). Such inaccessible sites may be advantageous for avoiding predators (Kunz and Lumsden, 2003) and consistent solar exposure. All roosts were in crevices that extended deep into the face of the rock or in large rocks (>2 m in diameter). As has been

documented for females (Lewis, 1996), no individual was found roosting behind thin slabs of rock.

Roosts and cliffs chosen by male pallid bats faced east to southeast. Similarly, roosts of male pallid bat in British Columbia had southern-facing aspects (Rambaldini and Brigham, 2008). Big brown bats (*Eptesicus fuscus*) in forests of Saskatchewan selected roosts in cavities with southerly orientations that may reduce the evaporative effects of east–west winds (Kalcounis and Brigham, 1998). Male pallid bats may derive a thermal advantage from southern-facing roosts, similar to that experienced by woodpeckers (Inouye, 1976; Inouye et al., 1981). Forest-dwelling long-legged bats (*Myotis volans*) and silver-haired bats (*Lasionycteris noctivagans*) tend to select roosts in trees that are above the surrounding canopy and allow more exposure to solar radiation (Betts, 1996; Ormsbee and McComb, 1998).

Temperatures at roosts of pallid bats are similar to those reported in previous studies (Rambaldini and Brigham, 2008); however, bats were seen infrequently, making it difficult to confirm that internal temperatures of crevices adequately represent the microclimate of the roost. The best opportunities to confirm roosting temperatures occurred when bats were observed roosting in rocks. Temperatures at these locations were comparable to those observed at crevices in cliffs but, generally were substantially warmer than ambient temperature (mean = 5.4° C, maximum = 12° C). In British Columbia, male pallid bats select warmer day roosts, minimizing bouts of deep torpor (Rambaldini and Brigham, 2008). At our study site, morning ambient temperatures routinely dropped below temperatures that induce torpor in pallid bats (Rambaldini and Brigham, 2008). Rock roosts that have been exposed to solar radiation throughout the previous day

may maintain consistently warm temperatures and be the first roosts to warm in the early morning. These thermally advantageous, but protected, crevices may be ideal for rewarming from bouts of torpor (Warnecke et al., 2008). Pallid bats using rock roosts may minimize torpor by selecting roosts that warm quickly. The bats we found in rock roosts fled after detection, suggesting they were not in deep torpor (Geiser and Baudinette, 1990). Limiting prolonged bouts of torpor may be important for the reproductive physiology of male pallid bats, as suspected in other bats (Kurta and Kunz, 1988).

Similar to males, female pallid bats maintain high body temperatures (Beasley and Leon, 1986), but females typically roost in colonies or clusters, taking advantage of the energetic savings experienced through colonial roosting (Vaughan and O'Shea, 1976; Trune and Slobodchikoff, 1976). For reproductive female pallid bats, warmer temperatures of roosts mean lower metabolism (Trune and Slobodchikoff, 1976) and higher reproductive activity (Lewis, 1993). Clusters of pallid bats are able to maintain warm temperatures and lower metabolism more than would singly-roosting pallid bats (Trune and Slobodchikoff, 1976). Female pallid bats switch between roosts on thin slabs during cool seasons and in deeper rock-crevices in warmer seasons (Lewis, 1996). During cooler seasons, roosts on slabs allow easier access to solar radiation and warmer microclimates, whereas deeper rock-crevices provide respite from extreme temperatures during the warmer seasons. Also, females will move deeper into a roost or closer to the egress to satisfy microclimatic needs (Vaughan and O'Shea, 1976). We expected males to roost in deep, vertical crevices because of the stability of temperatures (Lausen and Barclay, 2003) and the broad thermal gradient these structures provide (O'Shea and Vaughan, 1977). It is possible that males move among and within day roosts to acquire the desired thermal climate (Lewis, 1996).

We found no male bats roosting together, but, on one occasion, a male pallid bat used a diurnal roost that was previously used by another pallid bat. It is possible that ideal thermoregulatory microclimates are shared and communicated among local male pallid bats (Arnold and Wilkinson, 2011). No bat was found in the same crevice it used previously; however, a bat returned to the same general wall of a cliff. Lewis (1996) found low roost-site fidelity in female pallid bats, switching roost approximately every 1.5 days. For females, this behavior may have been driven by ectoparasitic load (Lewis, 1996). Many of the male pallid bats we observed had bat flies (Family Nycteribiidae), which are common parasites of pallid bats that spend their life cycle on bats and at roosts of bats (Whitaker and Easterla, 1975; Lewis, 1996).

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LITERATURE CITED

- ARMSTRONG, D. M., J. M. FITZGERALD, AND C. A. MEANEY. 2011. Mammals of Colorado. Second edition. Denver Museum of Nature and Science and University Press of Colorado, Boulder, Colorado.
- ARMSTRONG, D. M., R. A. ADAMS, AND J. FREEMAN. 1994. Distribution and ecology of bats of Colorado. University of Colorado Museum, Natural History Inventory of Colorado 15:1–83.
- ARNOLD, B. D., AND G. S. WILKINSON. 2011. Individual specific contact calls of pallid bats (*Antrozous pallidus*) attract conspecifics at roosting sites. *Behavior, Ecology, and Sociobiology* 65:1581–1593.
- BAKER, M. D., M. J. LACKI, G. A. FALXA, P. L. DROPPelman, R. A. SLACK, AND S. A. SLANKARD. 2008. Habitat use of pallid bats in coniferous forests of northern California. *Northwest Science* 82:269–275.
- BEASLEY, L. J., AND M. LEON. 1986. Metabolic strategies of pallid bats (*Antrozous pallidus*) during reproduction. *Physiology and Behavior* 36:159–166.
- BELL, G. P. 1982. Behavioral and ecological aspects of gleaning by a desert insectivorous bat *Antrozous pallidus* (Chiroptera: Vespertilionidae). *Behavioral Ecology and Sociobiology* 10:217–223.
- BETTS, B. J. 1996. Roosting behavior of silver-haired bats (*Lasionycteris noctivagans*) and big brown bats (*Eptesicus fuscus*) in northeast Oregon. Pages 55–61 in *Bats and forest symposium* (R. M. R. Barclay and R. M. Brigham, editors). British Columbia Ministry of Forests, Victoria.
- BRUNET-ROSSINI, A. K., AND G. S. WILKINSON. 2009. Methods for age estimation and the study of senescence in bats. Pages 315–328 in *Ecological and behavioral methods for the study of bats* (T. H. Kunz and S. Parsons, editors). Johns Hopkins University Press, Baltimore, Maryland.
- DAVIS, R., AND E. L. COCKRUM. 1963. "Malfunction" of homing ability in bats. *Journal of Mammalogy* 44:131–132.
- EASTERLA, D. A., AND J. O. WHITAKER, JR. 1972. Food habits of some bats from Big Bend National Park, Texas. *Journal of Mammalogy* 53:887–890.
- FRICK, W. F., P. A. HEADY, III, AND J. P. HAYES. 2009. Facultative nectar-feeding behavior in a gleaning insectivorous bat (*Antrozous pallidus*). *Journal of Mammalogy* 90:1157–1164.
- GEISER, F., AND R. V. BAUDINETTE. 1990. The relationship between body mass and rate of rewarming from hibernation and daily torpor in mammals. *Journal of Experimental Biology* 151:349–359.
- HAZLETT, D. L. 2004. Vascular plant species of the Comanche National Grassland in southeastern Colorado. United States Department of Agriculture Forest Service, General Technical Report RMRS-GTR-130:1–36.
- HERMANSON, J. W., AND T. J. O'SHEA. 1983. *Antrozous pallidus*. *Mammalian Species* 213:1–8.
- HERRARA, M. L. G., T. H. FLEMING, AND J. S. FINDLEY. 1993. Geographic variation in carbon composition of the pallid bat, *Antrozous pallidus*, and its dietary implications. *Journal of Mammalogy* 74:601–606.
- INOUE, D. W. 1976. Non-random orientation of entrance holes to woodpecker nests in aspen trees. *Condor* 78:101–102.

- INOUE, R. S., N. J. HUNTLY, AND D. W. INOUE. 1981. Non-random orientation of Gila woodpecker nest entrances in saguaro cactus. *Condor* 83:88–89.
- JOHNSTON, D. S., AND M. B. FENTON. 2001. Individual and population-level variability in diets of pallid bats (*Antrozous pallidus*). *Journal of Mammalogy* 82:362–373.
- KALCOUNIS, M. C., AND R. M. BRIGHAM. 1998. Secondary use of aspen cavities by tree-roosting big brown bats. *Journal of Wildlife Management* 62:603–611.
- KUNZ, T. H., AND L. F. LUMSDEN. 2003. Ecology of cavity and foliage roosting bats. Pages 3–89 in *Bat ecology* (T. H. Kunz and M. B. Fenton, editors). University of Chicago Press, Chicago, Illinois.
- KURTA, A., AND T. H. KUNZ. 1988. Roosting metabolic rate and body temperature of male little brown bats (*Myotis lucifugus*) in summer. *Journal of Mammalogy* 69:645–651.
- LAUSEN, C. L., AND R. M. R. BARCLAY. 2003. Thermoregulation and roost selection by reproductive female big brown bats (*Eptesicus fuscus*) roosting in rock crevices. *Journal of Zoology London* 260:235–244.
- LENHART, P. A., V. MATA-SILVA, AND J. D. JOHNSON. 2010. Foods of the pallid bat, *Antrozous pallidus* (Chiroptera: Vespertilionidae), in the Chihuahuan Desert of western Texas. *Southwestern Naturalist* 55:110–142.
- LEWIS, S. E. 1993. Effect of climate variation on reproduction by pallid bats (*Antrozous pallidus*). *Canadian Journal of Zoology* 71:1429–1433.
- LEWIS, S. E. 1994. Night roosting ecology of pallid bats (*Antrozous pallidus*) in Oregon. *American Midland Naturalist* 132:219–226.
- LEWIS, S. E. 1996. Low roost fidelity in pallid bats: associated factors and effects on group stability. *Behavioral Ecology and Sociobiology* 39:335–344.
- ORMSBEE, P. C., AND W. C. MCCOMB. 1998. Selection of day roosts by female long-legged myotis in the central Oregon Cascade Range. *Journal of Wildlife Management* 62:586–603.
- O'SHEA, T. J., AND T. A. VAUGHAN. 1977. Nocturnal and seasonal activities of the pallid bat, *Antrozous pallidus*. *Journal of Mammalogy* 58:269–284.
- O'SHEA, T. J., AND T. A. VAUGHAN. 1999. Population changes in bats from central Arizona: 1972 and 1999. *Southwestern Naturalist* 44:495–500.
- RAMBALDINI, D. A., AND R. M. BRIGHAM. 2008. Torpor use by free-ranging pallid bats (*Antrozous pallidus*) at the northern extent of their range. *Journal of Mammalogy* 89:933–941.
- TRUNE, D. R., AND C. N. SLOBODCHIKOFF. 1976. Social effects of roosting on the metabolism of the pallid bat (*Antrozous pallidus*). *Journal of Mammalogy* 57:656–663.
- TWENTE, J. W., JR. 1955. Some aspects of habitat selection and other behavior of cavern-dwelling bats. *Ecology* 36:706–732.
- VAUGHAN, T. A., AND T. J. O'SHEA. 1976. Roosting ecology of the pallid bat, *Antrozous pallidus*. *Journal of Mammalogy* 57:19–42.
- WARNECKE, L., J. M. TURNER, AND F. GEISER. 2008. Torpor and basking in a small arid zone marsupial. *Naturwissenschaften* 95:73–78.
- WELLER, T. J., P. M. CRYAN, AND T. J. O'SHEA. 2009. Broadening the focus of bat conservation and research in the USA for the twenty-first century. *Endangered Species Research* 8:129–145.
- WHITAKER, J. O., JR., AND D. A. EASTERLA. 1975. Ectoparasites of bats from Big Bend National Park, Texas. *Southwestern Naturalist* 20:241–254.

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AVOIDANCE OF NEEDLE RUST FUNGUS BY LARVAL SAWFLY ON PINYON PINE

OWEN D. V. SHOLES

Department of Natural Sciences, Assumption College, Worcester, MA 01609
Correspondent: osholes@assumption.edu

ABSTRACT—Larvae of the sawfly *Neodiprion edulicolus* fed on needles of *Pinus edulis* and were abundant below 1,850 m in elevation at sites near Sunset Crater, Arizona. *Coleosporium* needle rust, in contrast, infected *P. edulis* above 1,850 m in elevation and rarely occurred on the same trees as did *N. edulicolus*. Larval sawfly transferred to *P. edulis* above 1,850 m fed less frequently on infected twigs and moved off twigs more quickly when transferred to infected trees. Though the negative interactions involved only a small percentage of larval sawfly and rust fungus during this study, the interaction might become more significant in the future if sawflies spread to higher elevations in response to changes in climate or habitat.

RESUMEN—Larvas de moscas serra *Neodiprion edulicolus* se alimentaron de agujas de *Pinus edulis* y fueron abundantes a una elevación inferior a 1,850 m en zonas cercanas a Sunset Crater, Arizona, USA. En contraste,