

Ecology of Porcupines (*Erethizon dorsatum*) and Colorado Tick Fever Virus in Rocky Mountain National Park, 1975-1977

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ABSTRACT The involvement of porcupines, *Erethizon dorsatum* (L.), in the ecology of Colorado tick fever (CTF) virus in Rocky Mountain National Park was investigated from 1975 to 1977. Porcupine dens and feeding activity were found mostly on rocky knolls or on south-facing slopes within open stands of the montane coniferous forest, and 20 adult porcupines were trapped or captured by hand at those locations. An average of 24.6 ± 5.4 adult *Dermacentor andersoni* Stiles ticks were found per animal (annual range, 17.5-31.4 ticks). The minimum CTF virus infection rate of the ticks removed from porcupines varied from 129 to 257, whereas for questing adult *D. andersoni* ticks from the same geographic area was 205 in 1976. No virus was isolated from the 20 animals, but 85% had neutralizing antibody against CTF virus. Porcupines utilize the same habitats described for the CTF ecosystem in Rocky Mountain National Park and appear to be an important host for adult *D. andersoni*.

KEYWORDS Colorado tick fever, porcupine, Ixodidae

AN ECOLOGIC STUDY OF Colorado tick fever (CTF) in Rocky Mountain National Park in Colorado from 1974 to 1976 identified the primary rodent hosts for and tick vectors of CTF virus and described the habitats supporting virus transmission (Carey et al. 1980, McLean et al. 1981, Bowen et al. 1981, McLean et al. 1989). Whether porcupines, *Erethizon dorsatum* (L.), were involved in the ecology of CTF in Rocky Mountain National Park was not determined in those studies, although porcupines are known to be susceptible to CTF virus (Burgdorfer 1960), and porcupines in Colorado have been found infected (Eklund et al. 1958). This study was conducted from 1975 to 1977 to determine the relative abundance of porcupines and their use of habitats on the eastern slope of Rocky Mountain National Park and to determine their contribution to the maintenance of vector ticks and CTF virus.

Materials and Methods

Study Area. The study area consisted of a 5-km² area between 2,470 and 2,560 m elevation on the eastern slope of Rocky Mountain National Park (41° 22' N and 105° 37' W). The habitats in this area ranged from grassy meadows with willow, *Salix* spp., thickets along streams, to aspen, *Populus tremuloides*, stands between the meadows and forests,

and to the lower montane coniferous forests on the mountain slopes (McLean et al. 1981). On the drier, south-facing slopes of the montane forest, the predominant vegetation was open stands of ponderosa pine, *Pinus ponderosa*, with grasses, herbs, and shrubs between the scattered trees; thick stands of Douglas fir, *Pseudotsuga menziesii*, with some ponderosa pine and little ground cover, grew on the moist, northfacing slopes.

Trapping and Handling of Animals. The study area was searched to locate porcupine denning sites and evidence of feeding activity to evaluate habitat use and to identify active sites where animals could be trapped. Wire live traps (82 by 25 by 30 cm) (Tomahawk Live Trap, Tomahawk, WI) were set at 100-m intervals in transects of between five and eight traps each at five locations where porcupines were active, and individual traps were set at tree den sites. Double-door live traps (107 by 38 by 38 cm) were placed at the entrance to rock dens. Traps were baited with a combination of alfalfa and salt blocks and operated for 2-4 d, consecutively. Trapping was conducted intermittently from February to late June from 1975 to 1977, which is during the seasonal activity period of the vector tick species—Rocky Mountain wood tick, *Dermacentor andersoni* (Stiles)—from early March to late June (Eads & Smith 1983). Porcupines observed during the day in trees or along roadways were captured with a handheld snare. Captured porcupines were anesthetized with a mixture of ketamine hydroch-

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Table 1. Measurements (mean \pm SEM) of porcupines captured in Rocky Mountain National Park from 1975 to 1977

Sex	No. captured		Weight, kg	Body length, mm	Tail length, mm	Hindfoot, mm	Ear, mm
Female	16	Mean	6.2 \pm 0.5	563 \pm 27	189 \pm 9	82 \pm 3	29 \pm 1
		Range	3.5–9.5	430–765	152–280	60–100	21–35
Male	4	Mean	8.8 \pm 0.8	586 \pm 18	206 \pm 11	88 \pm 3	40 \pm 0.6
		Range	8.3–11.0	575–620	194–235	82–95	39–41

loride (20–30mg/kg) and acepromazine maleate (3–5 mg/kg), carefully examined for ectoparasites and measured; a blood specimen was taken from the brachial vein with a 5-ml syringe and 22-gauge needle. Porcupines were released at the point of capture after recovering from anesthesia.

Laboratory Procedures. Collected ticks were placed in labeled vials and returned to the Centers for Disease Control laboratory in Fort Collins, CO, where they were identified, pooled, ground, and tested for virus isolation in suckling white laboratory mice (Eads & Smith 1983). Blood specimens were kept cool for 3–5 h, then centrifuged. The sera and blood clots were removed and stored separately. The blood clots were washed, ground, and tested for virus isolation in suckling mice and Vero cell culture, and heat-inactivated serum specimens were tested for neutralizing antibody against CTF virus (71V-11 strain) in a serum-dilution, constant-virus, plaque-reduction neutralization test in Vero cell culture (Bowen et al. 1981).

Results and Discussion

In total, 28 rock dens used by porcupines were located; 19 were on south-facing slopes, 8 on rocky knolls in meadows, and 1 on a ridgetop. The dens on the south-facing slopes were under rocks 2.4–21.3 m in diameter. Den entrances were usually triangular, 47.3 \pm 19.4 cm (mean \pm SD) high and 74.3 \pm 61.2 cm at the base. Dens were generally cone-shaped and 139.3 \pm 7.6 cm deep. Eight conifers that were used as den trees were found—five ponderosa pine; two lodgepole pine, *P. contorta*; and one juniper, *Juniperus scopulorum*. The pine trees were 25–53 cm diameter at breast height (dbh) and 9–18 m tall; the juniper was 46 cm dbh and 4.5 m tall. All were on south-facing slopes. Damage to pine tree limbs caused by porcupines also was observed on the south-facing slopes. No den sites were found on north-facing slopes. The description and location of den sites found in the eastern slopes of the mountains in Rocky Mountain National Park during the study were similar to the typical locations of rock outcroppings in open pine forest at moderate elevations found elsewhere in Colorado (Lechleitner 1969, Armstrong 1975).

Food habits of the porcupines at the locations in the park were determined by the microhistologic examination of fecal pellets collected at winter and summer den

sites and at both rock and tree dens (Johnson & Carey 1979). Porcupines utilized pine needles, *P. ponderosa*, and dwarf mistletoe, *Arceuthobium campylopodium*, during the winter and leaves from a variety of shrubs and forbs, *Potentilla*, *Astragalus*, *Ribes*, *Koeleria*, and *Rhus*, during the summer months.

Twenty porcupines were captured (16 females and 4 males), and their average measurements are presented in Table 1; males generally were larger than females. All of the animals were considered adults as determined by size, reproductive condition, and season of capture (Taylor 1935). Seven of the 20 animals were captured by hand (all but 1 in trees), and 15 were captured on south-facing slopes. Two of the animals were recaptured from 3 to 12 mo after the original capture. The animals were captured every month between 16 February and 26 June of each year.

The only ectoparasites found on the porcupines were ticks and 448 adult wood ticks, *D. andersoni*, were collected from 18 porcupines (Table 2); the two porcupines captured in February did not have ticks. One adult male winter tick, *D. albipictus* (Packard), was collected from an adult male porcupine in June 1976. Only one immature tick, a nymphal *D. andersoni*, was found. Porcupines were infested with 1–72 ticks per animal, with an overall average of 24.6 \pm 5.4 ticks. The annual average infestation rate varied from 17.5 to 31.4 ticks per animal and the minimum CTF virus infection rate of the ticks removed from porcupines varied from 129 to 257 (12.9–25.7%) for each of the 3 yr (Table 2). The

Table 2. Number of adult *D. andersoni* ticks collected from porcupines in Rocky Mountain National Park from 1975 to 1977 and the infection rates of the ticks with CTF virus

Category	1975	1976	1977
No. porcupines captured	7	4	9
No. with ticks	7	4	7
% infested	100	100	78
Total no. of ticks	158	70	220
Mean no. of ticks per infested animal	22.6	17.5	31.4
No. of ticks tested	152	68	217
No. positive pools	39	10	28
Minimum infection rate per 1,000 ticks	257	147	129

minimum infection rate of 791 questing adult *D. andersoni* ticks collected in the same general area from February to July 1976 was 205 (D.B.F., unpublished data). The porcupine appears an important host of adult wood ticks in Rocky Mountain National Park. Besides humans, the other host species for adult ticks in the park are lagomorphs, canines, and ungulates.

No virus was isolated from the blood of any of the porcupines, but 85% had N antibody against CTF virus. Reciprocal antibody titers ranged from 80 to >640. The high prevalence of antibodies against CTF virus, the fact that CTF virus was not isolated from any adult porcupines, and the finding that the CTF virus isolation rate from adult *D. andersoni* ticks removed from porcupines was similar to, or lower than, the infection rate of questing adult ticks in the same general area indicate that porcupines are exposed to CTF virus early in their life, probably during the first few months. The young would be readily exposed to adult ticks because they are born from April to June during the tick activity period and are actively moving around within days after birth (Nowak & Paradiso 1983). Porcupines living within an established CTF ecosystem such as that found in the park (Carey et al. 1980), would be exposed to a number of infected ticks and most would be immune to CTF virus by the time they become adults at ≈ 2.5 yr (Nowak & Paradiso 1983). Therefore, adult animals would unlikely be viremic and thus would no longer be involved in amplifying CTF virus transmission within the CTF ecosystem. The significantly lower ($P < 0.01$) infection rate of attached adult ticks removed from porcupines in 1976 (minimum CTF virus infection rate of 147) compared with the infection rate of questing adult ticks (minimum CTF virus infection rate of 205) in the same general area suggests that the immune porcupines may be suppressing or neutralizing the detectable CTF virus infection in attached ticks.

The preference of the porcupines for habitats on south-facing slopes and rocky sites brings them into contact with the habitats of the free-ranging wood ticks that are the principal vectors of CTF virus and with the habitats of the principal rodent hosts of the immature stages of this tick species and of CTF virus (Carey et al. 1980, Bowen et al. 1989, McLean et al. 1989). The porcupine appears an important host for the adult stage of *D. andersoni* in Rocky Mountain National Park, and immature porcupines may be a source of CTF virus for infecting adult ticks; however, porcupines contribute little to the maintenance of CTF virus in the park because only adult ticks, which are a dead end for the virus, attach to them.

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References Cited

- Armstrong, D. M. 1975.** Rocky Mountain mammals. Rocky Mountain Nature Association, Estes Park, CO.
- Bowen, G. S., R. G. McLean, R. B. Shriner, D. B. Francy, K. S. Pokorny, J. M. Trimble, R. A. Bolin, A. M. Barnes, C. H. Calisher & D. J. Muth. 1981.** Colorado tick fever in Rocky Mountain National Park in 1974. II. Infection in small mammals. *Am. J. Trop. Med. Hyg.* 30: 490-496.
- Burgdorfer, W. 1960.** Colorado tick fever. II. The behavior of Colorado tick fever virus in rodents. *J. Infect. Dis.* 107: 384-388.
- Carey, A. B., R. G. McLean & G. O. Maupin. 1980.** The structure of a Colorado tick fever ecosystem. *Ecol. Monogr.* 50: 131-151.
- Eads, R. B. & G. C. Smith. 1983.** Seasonal activity and Colorado tick fever virus infection rates in Rocky Mountain wood ticks, *Dermacentor andersoni* (Acari: Ixodidae), in north-central Colorado, USA. *J. Med. Entomol.* 20: 49-55.
- Eklund, C. M., G. M. Kohis & W. L. Jellison. 1958.** Isolation of Colorado tick fever virus from rodents in Colorado. *Science* 128: 413.
- Johnson, M. K. & A. B. Carey. 1979.** Porcupine pellet pH, color, and composition. *Southwest Nat.* 24: 544-545.
- Lechleitner, R. R. 1969.** Wild mammals of Colorado. Pruett, Boulder, CO.
- McLean, R. G., D. B. Francy, G. S. Bowen, R. E. Bailey, C. H. Calisher & A. M. Barnes. 1981.** The ecology of Colorado tick fever in Rocky Mountain National Park in 1974. I. Objectives, study design, and summary of principal findings. *Am. J. Trop. Med. Hyg.* 30: 483-489.
- McLean, R. G., R. B. Shriner, K. S. Pokorny & G. S. Bowen. 1989.** The ecology of Colorado tick fever in Rocky Mountain National Park in 1974. III. Habitats supporting the virus. *Am. J. Trop. Med. Hyg.* 40: 86-93.
- Nowak, R. M. & J. L. Paradiso. 1983.** Mammals of the world, vol. 2, 4th ed. John Hopkins University Press, Baltimore, MD.
- Taylor, W. P. 1935.** Ecology and life history of the porcupine (*Erethizon epizanthum*) as related to the forests of Arizona and the southwestern United States. *University of Arizona Bulletin*, 6: 1-177.

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