

GEOGRAPHIC, PERIGLACIAL, AND CLIMATIC RELATIONSHIPS OF AMERICAN PIKA (*OCHOTONA PRINCEPS*) IN THE EASTERN SIERRA NEVADA AND WESTERN GREAT BASIN

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Photo: Jim Bishop

BACKGROUND

American pikas (*Ochotona princeps*) are small mammals related to rabbits that inhabit talus slopes of North American mountains (Smith and Weston 1990; Fig 1). A generalist herbivore, pikas do not hibernate but overwinter under snow on diverse forb, grass, and shrubby vegetation they collect in summer (Fig. 2). Pikas tolerate cold-climate environments through a combination of physiological and behavioral adaptations, some of which render them highly sensitive to warm temperatures. Vulnerability to warming coupled with decreasing habitat at higher elevations on mountain peaks has led pika to be considered a focal indicator of climate impacts on mountain biota. Concern for the fate of American pika prompted recent submission of state- and federal-level petitions to list the species as endangered from global warming.

Vulnerability of pika to warming motivates priority to monitor pika biogeography and population ecology. Re-surveys of historic populations have indicated significant extirpation at low elevations and warm margins of the species' range in the Great Basin (Beever et al. 2003). A similar trend is also suggested at a few sites in the Sierra Nevada (Mortiz 2007). Extensive survey of pika population locations and demographics are needed.

GOALS

1. Develop a rapid-survey method to search extensively and opportunistically for pika sites and apply it in the eastern Sierra Nevada and adjacent western Great Basin.
2. Characterize geographic, geomorphic, and climatic conditions of pika sites, and assess their relationships to rock-glacier and related periglacial rock-ice features (RIFs).
3. Observe and record natural-historical conditions that might influence pika demography.

METHODS

Study Area

Central-eastern Sierra Nevada (SN), CA, and adjacent southwestern Great Basin (GB) ranges, CA and NV (Fig. 3), from near Lk Tahoe to Rock Cr in the SN and six GB ranges: White Mtns, Monitor Pass Range, Glass Mtns, Bodie Mtns, Sweetwater Mtns, and Wassuk Range.

Field Methods

We searched opportunistically for pika signs over a range of conditions typical of pika habitat during the summer and fall 2007. We used no pre-selection criteria for season (other than access), time-of-day, aspect, elevation, substrate type, or vegetation context; we did not conduct timed transects or other systematic methods. Our search was biased to regions we traversed enroute to study sites on subalpine forest ecology, rock-glacier geomorphology, and alpine plant monitoring.

We defined a pika site as characterized by the presence of > 10 dark, solid, non-decomposing pika pellets within a single area <1.0 m² (Fig 4). All but 15 sites are vouchered with archived pellet collections and photographs. Sites within a local area are separated by at least 50m, which exceeds the largest nearest-neighbor distance and home-range diameter for pika (Smith and Weston 1990). Regional groups of such sites are separated by a few to tens of kilometers. Geographic locations of each site were determined by GPS.

For each site we described the geomorphic setting using the classification of active or relict rock-glacier or frozen-ground feature described for the SN (Millar and Westfall in press), or other non-RIF sites.



Fig 1. Typical pika habitat



Fig 2. Pika food cache ("haypiles")

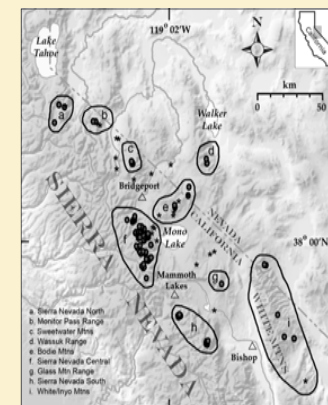


Fig 3. Study locations



Fig 4. Pika pellets in talus



Fig 6. Cirque rock glaciers, preferred talus habitat for pika.

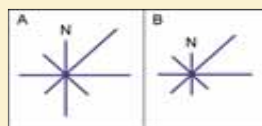


Fig 5. Orientation of pika site slope aspects. All sites (A), and sites below 2850m (B)

RESULTS

Geography, Elevation, and Geomorphology of Pika Sites. We located and described 173 discrete pika locations including 140 sites from the SN and 33 sites from the western GB Ranges (Table 1). The low number in the GB reflects the significantly less time we spent in these ranges; our search effectiveness per site was approximately equal in the GB and SN.

Pika site elevations ranged from 1827m to 3768m, and averaged 3073m. Sites were evenly distributed on all slope aspects (Fig. 5a). Grouped by elevation, pika sites below 2850m (n=37) had significantly different ($p < 0.001$) orientations than sites ≥ 2850 m, with more east- and southward aspects (Fig. 5b).

Of the 173 pika sites total, 3 were anthropogenic settings, including 2 mine tailings and 1 historic foundation wall. Of the remaining substrates, 105 were dark metamorphic, 7 were light metamorphic, 45 were granitic, and 13 were volcanic origin. Among the total, 55 sites were in areas of at least moderate human visitation; 8 of these were within 1m from the edge of heavily traveled foot and packstock trails.

80% of the pika sites were on RIF till (Table 1). The most common categories in which we found pika sites were scree boulder streams (BSC), cirque rock glaciers (RGC) (Fig 6), and valley rock glaciers (RGV).

Climate Analyses:

We evaluated climatic conditions of pika sites from the PRISM climate model (Daly et al. 1994), using the 30 arc-sec data and extracting annual, January, and July minimum and maximum temperatures, respectively; and annual, January, and July precipitation, respectively, for the period 1971 - 2000. In addition to the PRISM estimates, we recorded instrumental climatic data from eight RIF locations in the SN where we deployed temperature mini-dataloggers (Thermochron iButtons). These were placed in RIF till and adjacent open air locations.

Mountain Region	# of Sites	Elev (m)			Geomorphic Setting											
		average	minimum	maximum	RGC	RGV	BSC	BST	MVA	moraine	tor	Non-periglacial slopes	Eroding slopes	Cliff	Anthropogenic	
I. PIKA SITES																
Western Great Basin	55	2981	2113	3556	0	0	34	0	0	0	0	5	2	12	0	2
Bodie Mtns	10	2578	2173	2853					7						1	2
Glass Mtns	21	3028	3026	3231												
Monitor Pass	6	2577	2470	2689								1				
Sweetwater Mtns	8	3029	2310	3348											2	
Wassuk Range	7	2906	2539	3153											2	
White Mtns	22	3276	2442	3556					11					2	7	
Central Great Basin	9	2767	2637	2868											2	
Sierra Nevada	220	3093	1827	3768	38	10	133	6	2	3	0	0	7	19	2	0
Cascades CIR	5	2164	1903	2323											2	
All Pika Sites	289	3046	1827	3768	38	10	174	6	2	3	5	12	33	4	2	
II. WOODRAT-ONLY SITES																
Great Basin	32	2229	1637	2848	0	0	14	0	0	0	0	0	0	11	4	3
Sierra Nevada	8	2109	1815	2349	1	0	3	0	0	0	0	0	2	2	0	0
All Woodrat Sites	40	2205	1637	2848	1	0	17	0	0	0	0	2	13	4	3	

* Rock Glacier Cirque (RGC), Rock Glacier Valley (RGV), Boulder Stream Scree (BSC), Boulder Stream, Stream Course (BST), Mass Waste Alpine Slope (MVA). ** Includes volcanic breccia (Oregon)

Table 1. Distribution and geomorphic features of pika sites documented in our study

Climatic Relationships of Pika Sites. The PRISM model indicated a wide range of montane climates for our pika sites (Figs 7-9). Average precipitation ranged from 279 to 1610mm (mean 936mm; Fig 7). Minimum temperatures for all sites averaged -3.7°C, (range, -6.8°C to 0.6°C) and maximum temperatures averaged 8.9°C (range, 3.5°C to 15.8°C) (Figs 8, 9 respectively). The distribution of pika sites compared to normal distribution (red curves, Figs 8, 9) suggests skew in the data. For average and minimum temperatures, and less so for maximum temperature, the pika data are skewed toward colder temperatures. Apparent truncated parts of the distribution are in the warm ranges relative to normal. Tests of distribution indicate significant departure from normal for all minimum temperature distributions and for annual and July maximum temperature.

Correlations between elevation of pika sites and climate values suggest several patterns of pika dynamics (Figs. 10, 11). Elevation and precipitation are positively correlated for winter values ($r = 0.51$; Fig 10B) but very weakly for summer precipitation ($r = 0.23$; Fig 10C). Similarly, minimum temperatures of pika sites correlate negatively but weakly in winter ($r = -0.45$; Fig 11B) and very weakly in summer ($r = -0.26$; Fig 11C). By contrast, correlations of elevation and maximum temperatures are very strong and negative: $r = -0.94$ for average annual maximum temperature, $r = -0.85$ for January maximum temperature, and $r = -0.97$ for July maximum temperature (Fig 11 D,E,F). These contrasting trends are revealed also in low correlations of minimum and maximum temperatures: the average annual correlation (r) was 0.37 and the correlation of July minimum and maximum temperatures was 0.22 (not graphed).

Table 2 summarizes warm-season temperatures from iButtons placed near pika sites on 8 RIFs ranging from 2981m to 3379m. The overall mean air temperature for all days for June through September was 10.7°C. The upper range of the iButtons (26°C) was met at all but two sites; in every case where this limit was reached it was less than 2 days. The lower range varied from 0°C to -6°C, the latter being the low limit of the units, and also was met only at most 1 day for the 2 units that recorded this low temperature.

Woodrat and other Animal Associations with Pika

Many papers indicate that woodrats (*Neotoma cinera*) cohabit talus with pika throughout its elevational range, but we noted woodrat sign only below 2850m. Further, we found that in otherwise excellent-appearing pika habitat below that elevation, where there was packrat evidence we detected no sign of pika. We documented 28 of these packrat-only sites within the lower elevation range in which we found pika (1827 – 2850m), and used the PRISM model to assess that the packrat-only sites were similar in aspect to pika but were significantly drier and warmer. Other than this negative association, we found signs of other species in pika dens, including yellow-bellied marmot (*Marmota flaviventris*), less commonly rabbit (*Lepus* and *Sylvilagus* spp) and mule deer (*Odocoileus hemionus*), rarely very small rodent feces (likely *Tamias*), and, in two instances, domestic horse (*Equus caballus*), which must have been hoarded by pika.

CONCLUSIONS

We documented application of a simple method to rapidly assess presence of pika populations. Documentation of pika sites from fresh (dark, solid) pika pellets is a useful method to survey pika over extensive areas and does not require observation at a particular season, time of day, or special equipment. Pika pellets are easy to identify to untrained observers, and virtually impossible to mistake for other species. We hypothesize that pellets represent relatively recent use; even in climates of the warm and drier sites in our study region, we speculate that pellets remain dark and un-decomposed for less than 5 years. Thus, although this method does not guarantee active occupation of a site, it likely indicates relatively recent use, and can be successfully used to document recent historic extent of pika across large areas. Application of this method would provide an extensive list of sites that could subsequently be the focus of intensive surveys to corroborate active use or extirpation.

Documentation of 173 sites ranging from 1827m to 3768m indicates a broader distribution of pika in SN and adjacent GB ranges than has been described in recent or historic literature; widespread abundance of our studies is reminiscent of early 20th C pika studies rather than recent indications of a trend toward extirpation. Our elevations include lower values than recorded by either recent or historic literature for this area: the lowest previous record in this region was 2350m (Grinnell and Storer 1924).

Strong association of pika sites to rock glaciers and related RIFs has not been previously documented, and could be used as a tool for narrowing searches in other regions, as well as a predictive indicator for searching potential sites in under-explored regions. RIF environments provide unique microclimatic situations that have been little understood as biological habitat (Delaloye and Lambert 2005). Periglacial processes involved with RIF environments create downslope migration of permafrost and cold/summer-warm/winter conditions that suit pika habitat needs well.

Our PRISM and iButton climatic values compare reasonably with other estimates of pika climatic envelope, although our large number of sites yields a greater climate envelope on all extremes. Our lowest estimated annual precipitation was 279mm, which is similar to Hafner's (1994) 300 mm minimum.

Truncated curves in the warm values of minimum temperature suggest that pika are sensitive to warm temperatures, that population distributions are in disequilibrium with temperature, and that warm sites may have been recently extirpated. Lack of correlations between elevation and minimum temperatures and high correlations of pika habitat with RIFs points to the likelihood that pika are able to exploit cold environments created by RIFs that are not directly predicted by elevation. A potential interaction of pika and woodrat is suggested at lower elevations.

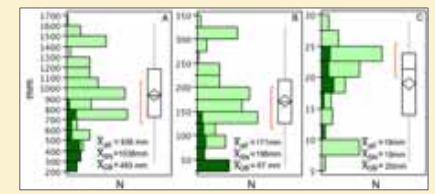


Fig 7. Precipitation ranges for pika sites (PRISM). (A) Average Annual (B) January (C) July

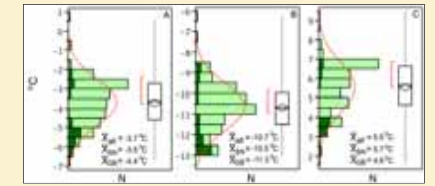


Fig 8. Maximum temperature ranges for pika sites (PRISM). (A) Average Annual (B) January (C) July

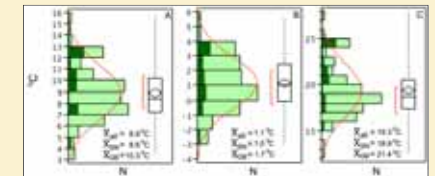


Fig 9. Minimum temperature ranges for pika sites (PRISM). (A) Average Annual (B) January (C) July

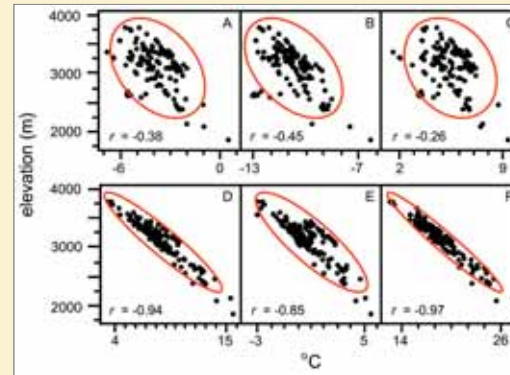


Fig 11. Correlations of elevation and minimum temperature (A-C) and maximum temperatures (D-F) for pika sites. (A&D) Average Annual (B&E) January (C&F) July

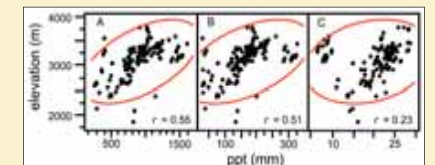


Fig 10. Correlations of elevation and precipitation for pika sites. (A) Average Annual (B) January (C) July

Site	Elevation m	RIF type	Rock Matrix or Ambient Air	Mean temp All °C	Median temp All °C	Temp Range ¹		Period of Record
						low °C	high °C	
Oneida Lk	2981	RGC	Ambient	11.8	15.6	-4	26	8/1 - 9/30
Oneida high	3064	RGC	Rock	12.5	13.4	-3	20	8/1 - 9/30
Barnes Lk	3134	RGC	Ambient	10.7	9.0	-5	26	6/1 - 9/8
Ellery Cyn	3184	RGC	Rock	8.8	9.1	-1	26	6/1 - 8/7
Deer Lk	3340	RGC	Rock	12.2	12.4	0	26	6/1 - 9/8
Kuna Lk	3379	RGC	Rock	10.3	10.4	-5	26	6/1 - 9/30
Heien Lk	3344	BSC	Ambient	7.8	8.8	-6	23	8/1 - 9/30
Gibbs Cyn	3101	BSC	Ambient	11.8	11.4	-8	26	8/1 - 9/30
AVERAGE	3191			10.7	11	-6	26	

¹ iButton instrumental minimum and maximum ranges are -4.0°C and 26°C respectively. These values were reached during no more than 1-2 days for the relevant instrument during its period of record.

Table 2. Summary of climatic data from 8 iButtons in RIF locations near pika sites

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