Andean bear use of the epiphytic bromeliad *Tillandsia fendleri* at Quebrada el Molino, Venezuela

Isaac R. Goldstein[1]

Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York 10460, USA

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Epiphytic bromeliads of the genus *Tillandsia* have been reported as important in the Andean (spectacled) bear diet throughout the bear's distribution (Mondolfi 1971, 1989; Peyton 1980; Jorgenson and Rodriguez 1986; Rodriguez et al. 1986; Suárez 1989; Goldstein 1990, Rodriguez 1991; Eulert 1995). Epiphytic bromeliads are locally abundant in Andean forests (Gentry and Dodson 1987). Because they are high in soluble carbohydrates, fat, and protein, bromeliads are a nutritious food for bears (Goldstein 1990).

Bears often leave sign of their activities in areas where they live; trails, scats, broken branches, claw marks on trees, and beds are common in bear habitats (Burst and Pelton 1983). Andean bears are no exception, leaving abundant sign especially while feeding on epiphytic and terrestrial bromeliads (Peyton 1980, Suárez 1989). In Venezuela, sign of feeding on epiphytic bromeliads by Andean bears has been found in mountain forests between 1,680 and 3,200 m and were the most abundant bear sign found in forests from 2,400 to 2,800 m (Goldstein 1990).

Spectacled bears usually produce 2 types of signs at epiphytic bromeliad feeding sites: claw marks on tree bark and piles of bromeliad leaves on the forest floor. Claw marks are visible on tree bark from 40–60 cm above the ground to the branches where the bear fed on the bromeliads. The length and depth of the scars depends on the bark of the tree species. Bears feed on the basal meristematic part of the bromeliads, causing the leaves to drop to the forest floor. Bears have been found to eat 1–10 or more plants at each tree, and *Tillandsia fendleri* plants have around 50 leaves. Depending on the number of bromeliads eaten, leaves can form a conspicuous carpet on the forest floor. Moreover, usually the central bunch of younger leaves stick together, with bite marks on the white basal meristematic part (Goldstein 1990).

Although there are several species of epiphytic bromeliads *Tillandsia* available in forests between 2,400–3,000 m at Quebrada El Molino (*T. compacta*, *T. complanata*, *T. tetrantha*, *T. spiculosa*), Andean bears at Quebrada El Molino have been found to only eat the largest species, *T. fendleri*. They also feed on the fruit of a Lauraceae tree (*Beilschmiedia sulcata*). In páramo areas, bears feed on the terrestrial bromeliad *Puya aristeguietae* (Goldstein 1990). *T. fendleri* plants can reach 2 m in height (including the single central erect inflorescence) and 1 m in diameter (Smith 1971), making them very conspicuous and easily distinguished from smaller *Tillandsia* species.

During work at Quebrada El Molino (Goldstein 1990, 2002), I found that Andean bear *T. fendleri* feeding sites were mostly located in tall, emergent trees with large canopies and in large trees at the forest–páramo edge, where the abundance of *T. fendleri* plants was higher (bromeliads/tree $\bar{x} = 16.95$ [SD = 10.89]; diameter at breast height [dbh] $\bar{x} = 51.84$ cm [SD = 22.80 cm]; tree height $\bar{x} = 10.03$ m [SD = 3.10]; $n = 51$). Because climbing is energetically costly and the distribution and abundance of bromeliads is clumped, I predicted that Andean bears would maximize expected reward for the effort of climbing trees with *T. fendleri*, preferentially using trees with the greatest bromeliad loads.

Study area

Quebrada El Molino, in the state of Trujillo, Venezuela, covers approximately 105 km^2 and varies in elevation between 2,400 and 3,600 m. The area includes 4 small basins radiating from the intersection of Fila Llano Grande and Páramo Castillejo. The topography is rugged, with steep slopes, rocky outcrops, and precipices.

The 3 characteristic vegetation types are high mountain cloud forest, transition cloud forest–páramo, and páramo. High mountain cloud forests are found on the valleys and mountain hillsides between 2,400 and 3,200 m and are composed of small to medium trees (5–10 m in height) with few emerging trees >15 m high. Within high mountain cloud forests are patches of undisturbed old growth forest, disturbed or regenerating forest, and patches dominated by *Alnus* spp. Undisturbed old growth is characterized by multi-stratified forest with undergrowth that is either open or closed (depending on the

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[1] igoldstein@wcs.org

presence and relative abundance of the bamboo *Rhipidocladum germinatum*), many small and medium sized trees, and few big emergent trees. The most common emergent tree species are *Podocarpus oleifolius*, *Beilshmiedia sulcata*, and *Clusia* spp., marked by irregular, horizontal branches and high loads of epiphyte vegetation. Disturbed or regenerating forest patches indicate past tree cutting or regenerating pastures or croplands. These are characterized by a homogenous canopy of *Miconia* spp., *Senecio* spp., and *Weinmannia* spp. trees, with no emergent trees. *Alnus*-dominated forest patches are homogeneous and result from natural landslides, usually near river beds. The transition cloud forest–páramo vegetation type is found between 3,100–3,300 m and is composed of trees <6 m tall with a clear dominance of *Clusia* spp. trees. The páramo vegetation type is basically treeless and dominated by graminoids and species of the *Espeletia* group.

Methods

I established 10 transects (200 × 5 m) in the ecotone between forest and páramo vegetation types during 3 visits to the study area, July 1997–January 1998. The transects' initial points were subjectively selected throughout the 7 km of the páramo–forest ecotone within the Quebrada El Molino watershed, reflecting the feasibility of walking downslope regardless of compass bearing. Height, dbh, and number of *T. fendleri* were measured for all trees >10 cm dbh. Two observers tallied *T. fendleri* in the canopy of the trees, and the results were averaged. In trees showing sign of bear feeding in the canopy, we counted the bromeliad leaves on the forest floor and divided by 50 (average number of leaves per bromeliad plant), approximating the number of the bromeliad plants consumed in that tree.

Because dbh, height, and the number of bromeliads per tree were not normally distributed (Kolmogorov-Smirnov test, $P < 0.05$), all statistical tests were non-parametric. To quantify relationships between number of *T. fendleri* and tree size, I used Spearman's rank order correlation. I performed separate correlation analyses on all trees, trees used by bears, and trees not used by bears. I used the 2-sample Mann-Whitney test to compare sizes of used and not used trees.

Results

A total of 123 trees >10 cm dbh were sampled. Mean dbh was 28.19 cm (SD = 22.61 cm), mean height was 6.94 m (SD = 2.28 m), and mean number of *T. fendleri* was 3.16/tree (SD = 7.10). Andean bear feeding sign on epiphytic bromeliads was observed at 13 trees. Sixty seven *T. fendleri* plants were found eaten, and 263 were still present in the canopy of the 123 trees observed (20.3% of the available plants were consumed). Number of *T. fendleri* per tree was positively correlated with tree dbh ($r_s = 0.455$, $P < 0.001$) and tree height ($r_s = 0.625$, $P < 0.001$). For trees lacking evidence of use by bears, the number of *T. fendleri* per tree was similarly correlated with dbh ($r_s = 0.532$, $P < 0.01$) and height ($r_s = 0.401$; $P < 0.01$). However, for trees used by bears, correlations between the number of *T. fendleri* per tree and dbh ($r_s = 0.401$, $P = 0.175$) and height ($r_s = 0.208$, $P = 0.495$) were not significant. Trees showing use by bears had significantly greater dbh (Mann-Whitney $U =$ 1384.5, $P < 0.05$), height ($U = 1432.5$, $P < 0.05$), and number of bromeliads ($U = 1485.0$, $P < 0.05$) than unused trees.

Discussion

The results of this small-scale study support the hypothesis that Andean bears use trees with higher loads of epiphytic bromeliads *T. fendleri*, which happen to be the larger trees. *T. fendleri* appears to be a canopy specialist species, being more abundant in higher emergent trees. Gentry and Dodson (1987) found that Bromeliaceae species are usually habitat-restricted, with different species restricted to the understory, middle story, or canopy of the trees. Specialization to open and wind exposed habitats is common among members of the subfamily Tillandsoidea having plumed, wind propelled seeds. Because wind is the main dispersal agent, the probability of seeds landing and establishing themselves is higher where seeds are exposed to wind than in sites protected from wind. Tall emergent trees, trees at the forest–páramo edge, and solitary trees are all wind-exposed. Moreover, emergent and solitary trees collect more water from horizontal precipitation than trees inside the forest (Vogelmann 1973), and epiphytes are particularly able to take advantage of horizontal precipitation, being more abundant in the highest trees (Nadkarmi 1984). Thus, if humidity and wind exposure are important to the life cycle of *T. fendleri*, a positive correlation between the height of the trees and the number of *T. fendleri* is expected.

Although I documented only 13 trees used by bears, the number of *T. fendleri* used by bears implied by this sample is quite high. I sampled only 1 ha within the 105 km^2 study area; within the trees used for bromeliad feeding there was a mean of 5.15 eaten bromeliads. At least half of the study area is forested (52 km^2); extrapolating the number of trees used and bromeliads eaten to the entire study area yields an estimate of 68,250 used trees and 351,487 *T. fendleri* plants eaten.

The preference of *T. fendleri* as the main food item may not apply to other Andean bear habitats. However, the tendency to use particular areas or patches where availability of the preferred food (usually an epiphytic or terrestrial bromeliad) is above the average for the area appears to be a common tendency for Andean bears. In Machu Picchu, Peru, Peyton (1986) divided types of vegetation available according to family life forms, using the relative abundance of plant species. Peyton found that the types of vegetation used by bears for feeding had relative abundance values >5% for the plants used as bear food. At El Tambor (Mérida, Venezuela), Goldstein and Salas (1993) found that the probability of Andean bears feeding on individual *Puya aristeguietae* plants depended exclusively on the abundance of *Puya* plants within the patch.

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