

Microhabitat selection in the spiny-tailed iguana *Ctenosaura bakeri* on Utila Island, Honduras

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Abstract. We studied the habitat use in the Utila iguana (*Ctenosaura bakeri* STEJNEGER, 1901) in a heterogeneous mangrove forest site on the north coast on Utila Island using 162 sightings of iguanas along a line-transect. Our results suggest ontogenetic size-related shifts of habitat use in this species. Hatchlings preferred the fringe area of the red mangrove zone and perched on the ground or at low heights (mean \pm SD = 0.8 ± 1.28 m). Similarly, juveniles were encountered most frequently in the red mangrove zone at mean tree heights of 3.6 ± 2.83 m, whereas adult iguanas preferentially selected the white mangrove zone. Males perched higher (4.9 ± 2.7 m) than females (3.75 ± 3.15 m). The habitat choice of hatchlings is seen as a predator avoidance strategy. Adult *C. bakeri* may select the white mangrove as the best opportunity to reach preferred body temperature for microbial digestion and fermentation processes. Sightings of juvenile and adult iguanas were associated with the presence of suitable cavities and trunks of mangrove trees as important sleeping and hiding-places.

Key words. Squamata, Iguanidae, autecology, line-transect, mangrove, perch height.

Introduction

Habitat selection has been studied in a variety of lizard species in their natural habitat as a function of thermal ecology, food and mate acquisition, and protection from predators (BECK & JENNING 2003, REANEY & WHITING 2003, QUIRT et al. 2006). Within a species, different size classes can show differences in interspecific habitat use due to the physiological structure of the environment, their physiology, food availability, and predator avoidance (JENSSEN et al. 1998, SHAW 2005, NEMES et al. 2006). Primary concerns for ectotherms are thermoregulatory requirements (microclimates) and protection from predators (BECK & JENNING 2003). For the spiny-tailed iguana *Ctenosaura hemilopha*, BLÍZQUEZ & RODRÍGUEZ-ESTRELLA (2006) provided evidence that predation risk is the strongest factor influencing habitat choice in Baja California Sur. The species select cardon cacti that offer woodpecker holes as retreat sites. Information about reptile habitat preferences in tropical tidal mangrove forests is scanty. On the one hand there are only few examples of reptiles inhabiting mangroves (GUTSCHE 2005b). On the other hand there is a lack of information due to the difficult accessibility of highly structured mangrove forests.

The spiny-tailed iguana, *Ctenosaura bakeri*, is endemic to only about 8 km² of mangrove swamp on the island of Utila, which is the smallest (41 km²) of the three major Bay Islands off the Caribbean coast of Honduras. This island hosts one of the largest mangroves in the Caribbean (CLAUSS & WILD 2002). The humid, periodically flooded mangrove swamp contrasts the main habitats of all other

congeners of *Ctenosaura*, which mainly inhabit exposed open habitats in arid and subhumid lowland areas from Mexico to Panama (GUTSCHE & KÖHLER 2008). The latter authors propose that the extraordinary lifestyle of *C. bakeri* is the result of ecological exclusion from more suitable habitats by the larger, more widespread and highly adaptable *C. similis*. Nowadays, the species can be found in open habitats due to the vast destruction of the mangrove for land use. Meanwhile, different aspects of the life history (reproduction, KUTTLER 2000, feeding and population ecology, GUTSCHE 2005a) and phylogenetic position and hybridization of the species have been studied (KÖHLER et al. 2000, GUTSCHE & KÖHLER 2004, GUTSCHE & KÖHLER 2008, PASACHNIK et al. 2009). GUTSCHE (2005b) demonstrated a high fidelity of adults to tree cavities as retreats. Nevertheless, little is known about the microhabitat preferences of this endangered species. To focus conservation efforts and understand the distribution patterns of this iguana, it is crucial to identify those preferences within the heterogeneously distributed and threatened mangrove habitats on the island. The purpose of this study was to characterize microhabitat selection in different age groups of *Ctenosaura bakeri* in its natural habitat.

Material and methods

Site description

Our study was conducted at Iron Bound situated on the north coast of Isla de Utila (UTM, WGS84 0510681/1782319).

The area is characterized by sharp-edged coral rocks with lichen, cacti (*Mammalaria spec.*) and succulents (*Sesuvium portulacastrum*). Landwards, a beach forest belt on sandy ground (essential for egg-laying of *Ctenosaura bakeri*) disperses with typical pioneer species (*Ipomoea pres-caprae*, *Sesuvium portulacastrum*, *Coccoloba uvifera*, *Cocos nucifera*, *Terminalia catappa*). The more elevated area (20 m above sea level) of the coralline platform supports a belt of Caribbean dry forest dominated by species such as *Bursera simaruba*, *Begonia cf. lindleyi* and *Thrinax radiata* (CLAUSS & WILD 2002). Farther landwards, after passing mangrove associates (*Acrostichum aureum*, *Hibiscus tiliaceus*, *Conocarpus erectus*, *Tabebuia rosea*, *Batis maritima*), the mangrove basin of the island is reached (elevation above sea level: 2-8 metres), which is subjected to the periodical tides. As a result of different adaptations in their tolerance to tidal inundation and salinity, Utila's mangrove swamp contains three rather heterogeneous mangrove species. The red mangrove (*Rhizophora mangle*, Fig. 2A), with its characteristic aerial roots, can be found on the lowest elevation, on frequently flooded sites, especially around the channel and lagoons. The black mangrove (*Avicennia germinans*, Fig. 2B), which is less salt water tolerant, grows at humid sites which are not flooded too often. The white mangrove (*Laguncularia racemosa*, Fig. 2C) occurs on the landward fringe of the mangrove communities and readily colonizes disturbed sites (HOGARTH 1999).

General study procedures

Fieldwork was conducted during two periods from 20 November to 14 December of 2004, and from 12 June to 13 August of 2005 on Isla de Utila, Honduras, with a minimum of two persons in the mangrove. One permanently marked line transect with a total length of 556 metres, which contained all vegetation types that are important for *Ctenosaura bakeri*'s life history traits (Fig. 1), was established in the (Iron Bound) area. As we detected only on two occasions an individual of *C. bakeri* in the Caribbean dry forest and none in the beach forest, we analysed lizards sighting frequency in relation to microhabitat availability exclusively in the three different mangrove zones (427.3 m, for portions of zones see Table 1). While setting the transect, vegetation sampling was conducted in addition to available data (CLAUSS & WILD 2002). As it is known that tree cavities are important resources as sleeping and hiding places for this species and therefore control population density (GUTSCHE 2005b), all tree cavities along the transect line (10 m at each site) were noted. Tree cavities typically result from core-putridity with increasing age in black mangroves. White mangroves require a higher age to develop tree cavities, and in red mangroves bigger cavities are scarce.

On an average distance of 12 metres, large trees were permanently marked with 44 plastic tags. We subdivided

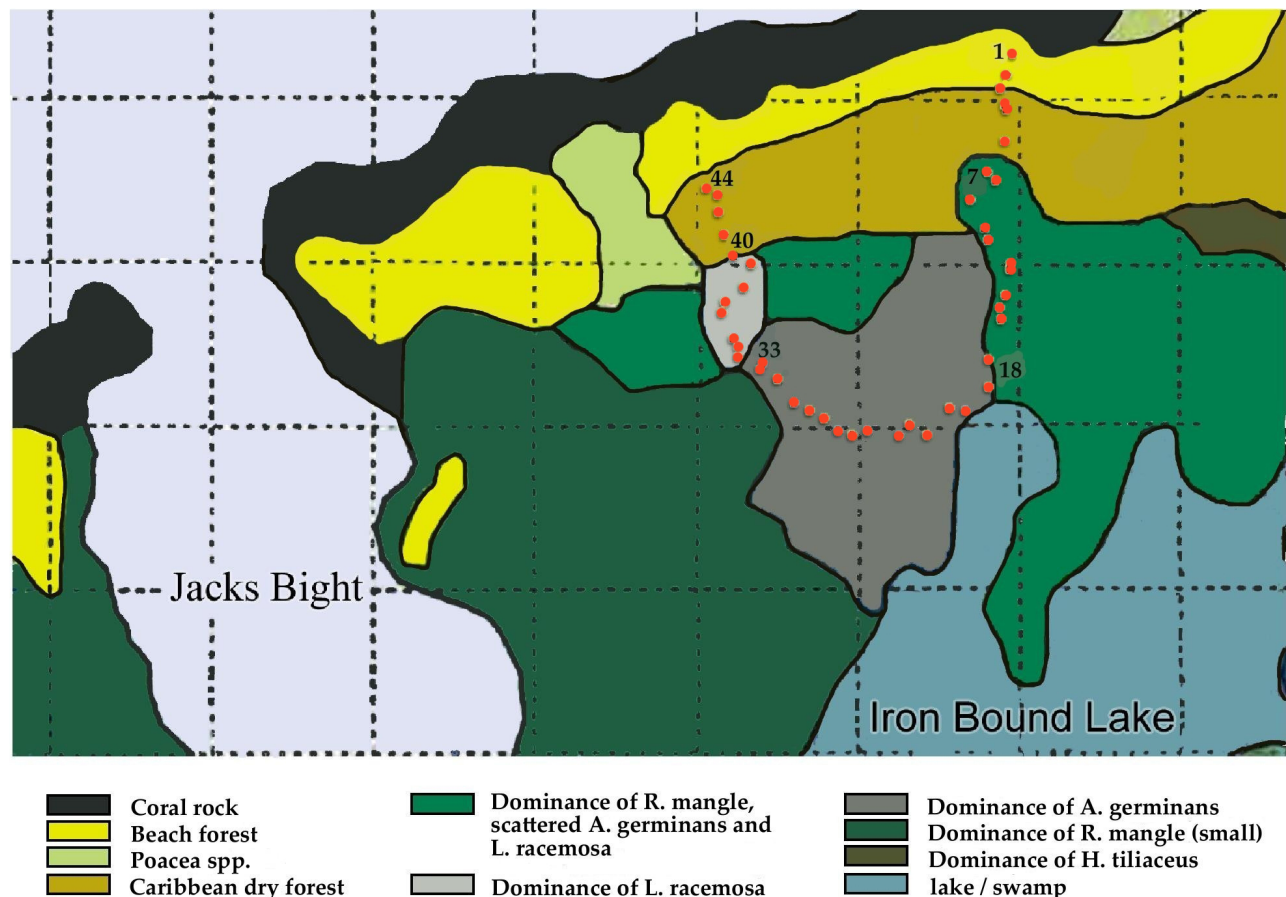


Figure 1. Delineation of the line transect, containing all important vegetation types for *Ctenosaura bakeri*'s life history traits on the Iron Bound coast on Utila Island.

the study site into adjacent sampling units. Geographic coordinates of all marked trees were determined with a GPS (Garmin Geko 201, UTM WGS84) and transformed with ArcView 3.2. software into GIS format (Fig. 1). On 28 surveys, distance sampling was conducted in a standardised manner from 12 June to 13 August 2005 by two persons from 10:00–11:30 in the morning. Iguanas were counted within a strip of 10 m wide to both sides of the transect line. Once an iguana was located, its age group (hatchling: SVL (snout vent length) > 55 mm, juveniles: SVL > 100 and < 150 mm, adults: SVL > 150 mm, according to GUTSCHE 2005a), sex, tree number, distance from the transect line, and perch height were recorded. Additionally, possible predators and other reptile species were recorded.

The deviation (D) of expected iguana sightings at each mangrove unit was calculated by the following formula: $D = (O - E) / E$, where O is the observed proportion of sightings (%) and E the proportion of vegetation units on the transect. Data are between -1 and 0, if an age group avoids a particular habitat, whereas data > 0 indicate a preference for a habitat, respectively (ČEIRĀNS 2004). Age group-specific (hatchlings: $n = 55$; juveniles: $n = 51$; adults: $n = 56$) and sex-specific differences in mean perch heights of adult individuals ($\sigma = 18$; $\phi = 32$) were visualized using box plots with SPSS 13.0 for windows. We opted for this approach, because we could not find any differences in the distribution of both sexes in the mangrove zones, which have different growth-heights. Considering that juvenile and adult *Ctenosaura bakeri* occupy and defend tree cavities perennially (GUTSCHE 2005b), sightings of these cohorts ($n = 107$) were compared with the presence of tree cavities.

Results

Mangrove preferences

A total of 162 observations were made (55 hatchlings, 51 juvenile and 56 adult iguanas.) We found conspicuous differences in the distribution of all age classes, whereas we could not observe sex-specific habitat differences. Strikingly, the majority (69.1%, $n = 38$) of all hatchling sightings occurred in a mangrove zone dominated by the red mangrove, which has the highest prevalence of cavities. 23.6% ($n = 13$) of all sightings were made in the black mangrove, and only very few hatchlings were seen in the white mangrove (Table 1). Sightings of juvenile iguanas were common in the red mangrove (43.1%, $n = 22$), as well as in the black mangrove (37.2%, $n = 19$). Adult *C. bakeri* preferred the white mangrove zone (41.1%, $n = 23$), while sighted at about the same rate in the red (30.3%, $n = 17$) and black mangrove (28.6%, $n = 16$).

Perch heights, tree cavities and predators

Sightings of hatchlings ($n = 55$) were mostly at perch heights (\pm SD) of 0.8 ± 1.28 m (Fig. 3). Juvenile iguanas ($n = 51$) perched at an average height of 3.6 ± 2.83 m. Sightings of adult *C. bakeri* ($n = 56$) occurred at an average perch height of 4.3 ± 3.16 m. Males ($n = 18$) were sighted at an average height of 4.9 ± 2.7 m, whereas females ($n = 32$) were seen at 3.75 ± 3.15 m (Fig. 4).

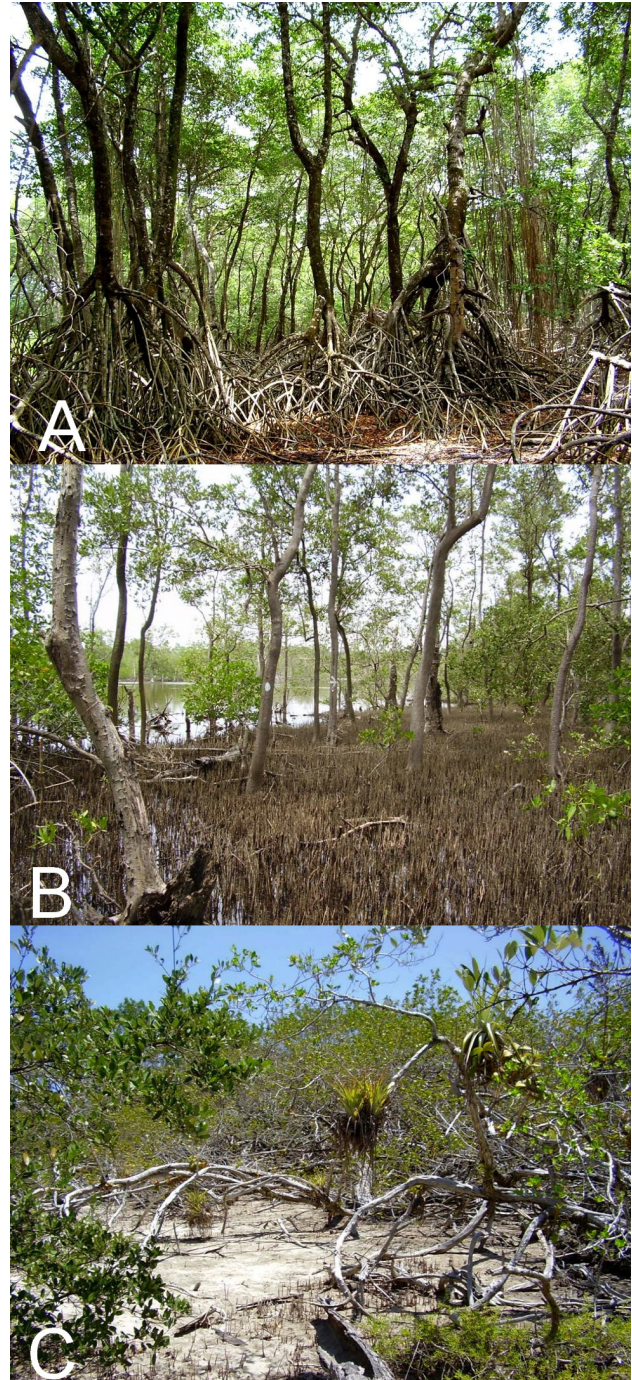


Figure 2. A) Red mangrove (*Rhizophora mangle*), B) Black mangrove (*Avicennia germinans*), C) White mangrove (*Laguncularia racemosa*).

Surprisingly, the black mangrove unit (36.4%, $n = 20$) harboured fewer tree cavities than the red mangrove unit (41.8%, $n = 23$), although in the latter unit most tree cavities were recorded in the few scattered black mangrove trees. This may be due to the very heterogeneous distribution of mangrove species in the red mangrove zone. The occurrence of juvenile and adult iguana sightings suggests a correlation with the occurrence of tree cavities.

Table 1. Lengths of transects (TL) in the three different mangrove units and deviation (D) from the expected data of iguana sightings. Data are between -1 and 0 if an age group avoids a particular habitat, whereas data > 0 indicate a preference for a habitat, respectively. Additionally, mean perch heights and standard deviations are presented.

Mangrove type	TL (m)	hatchlings (n = 55)	juveniles (n = 51)	adults (n = 56)	tree cavities (n = 55)
Dominance of red mangrove	139.7 (32.7%)	1.17	0.35	-0.1	23 (41.8%)
Dominance of black mangrove	192.6 (45.1%)	-0.48	-0.16	-0.37	20 (36.4%)
Dominance of white mangrove	95 (22.2%)	-0.75	-0.19	0.85	12 (21.8%)
Perch height (mean \pm SD) (m)		0.8 \pm 1.28	3.6 \pm 2.83	4.3 \pm 3.16	

Most avian predators (*Cathartes aura*, *Buteogallus anthracinus*, *Coccyzus minor palloris*, *Melanerpes aurifrons*, *Bubulcus ibis*, *Fregata magnificens*) were observed in the black mangrove. As a potential predator of hatchlings and juveniles, *Ctenosaura similis* reaches high densities in the Caribbean dry forest and was occasionally recorded in the white or red mangrove. Single observations of *Basiliscus vittatus* (a possible predator of hatchlings) were made in the red mangrove. In the black mangrove, the colubrid snake *Leptophis mexicanus* as well as the southern opossum (*Didelphis marsupialis*) were detected.

Discussion

The first hatchlings of 2005 were observed in the first week of June in open sandy areas of the more elevated beach forest (L. DIRKSEN pers. comm. 2005). Immediately after hatching, they migrate into the periphery of the mangrove swamp. We assume that avoidance of *Ctenosaura similis*, adult conspecifics (cannibalism) and avian predators could explain the observed preference for the mangrove edge (red mangrove vegetation) of the hatchlings. *Ctenosaura bakeri* hatchlings are coloured relatively consistently grey-brown

with laterally indicated dark staining and crossbands on the tail. This coloration is strikingly different to the greenish coloration of freshly hatched and juvenile *C. similis* (KÖHLER 1998). Considering behavioural (perching near the forest ground) and habitat characteristics (soil coloration), the coloration of *C. bakeri* hatchlings is an excellent cryptic coloration and thermoregulatory feature. Numerous aerial roots and dead wood at the swamp edge in combination with a shrub stratum of *Batis maritima* and mangrove ferns (*Acrostichum speciosum*) provide the best predator avoidance refuges and highest structural heterogeneity of all mangrove zones. Most hatchlings were observed perching on the mangrove soil or at heights of 1-3 m. Similar observations were made on juveniles of *C. melanosterna*, which were far more terrestrial than adult individuals within hill forests and wind scrubs on Cayo Menor, Honduras (SHAW 2005). Great numbers of small hiding and safe perching places at suitable heights for hatchlings are only available in the periphery of the red mangrove (although not quantified in our study), and neither in the more exposed tall black mangrove nor in the white mangrove. Although all age groups are predominantly herbivorous, the herbal contingent increases with age (GUTSCHE 2005a), indicating an ontogenetic dietary shift in a manner similar to that known

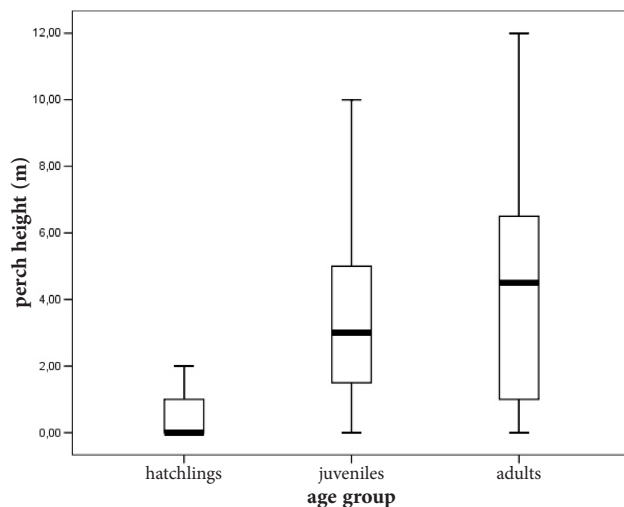


Figure 3. Perch heights for the different age groups (hatchlings: n = 55; juveniles: n = 51; adults: n = 56).

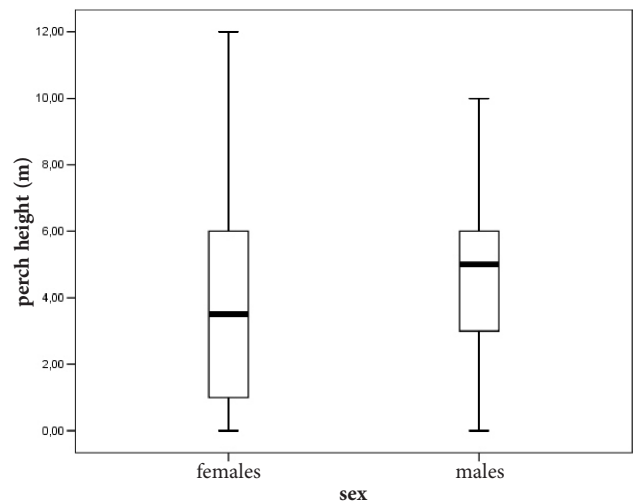


Figure 4. Perch heights for both sexes ($\sigma^7 = 18$; $\phi = 32$).

from *C. pectinata* (DURTSCHKE 2000). Hatchlings and juveniles predate more frequently on insects, and start to predate on fiddler crabs (*Uca rapax*) with a total length of 64–70 mm (GUTSCHE pers. comm. 2006), which reproduce in the summer (DA SILVA CASTIGLIONI & NEGREIROS-FRANZOZO 2005). Predating on insects might be easier and more efficient at the terrestrial fringe of the red mangrove.

None of the age groups preferred the homogeneous black mangrove with its nearly barren ground and linear growth, although it represented the largest vegetation portion of the whole transect. Our data differ from KUTTNER's (2000) observations that pure black mangrove stands would host the highest iguana densities (172 individuals/ha), followed by red mangrove (131 individuals/ha) and white mangrove zones (73 individuals/ha). However, the very heterogeneous composition of all three mangrove species on the Iron Bound coast makes comparisons between these studies difficult. In the black mangrove, we found the highest densities of avian predators. GUTSCHE's (2005a) finding that iguana density is correlated with the occurrence of tree cavities is consistent with our observations. We could not find obvious differences or limitations in the availability of crabs (*Uca rapax*) as the most important protein-source (content: 32.7%, GUTSCHE 2005a) or in deciduous mangrove leaves and flowers between the mangrove zones.

Most adult *Ctenosaura bakeri* sightings were recorded in the white mangrove. The occasionally turquoise body coloration of adult iguanas represents an adaptation towards the stronger pronounced arboreal mode of life in the mangrove canopy. The observed sex-specific difference in perch heights is most likely the result of higher territoriality in males, which survey their home ranges and display visual communication. Large lizards require high insolation for maintaining their preferred body temperature. Large adult iguanas depend more than other age groups on perching places with high solar radiation intensity. The digestion of the scytophyllous mangrove leaves is highly temperature-dependent because it relies on the microbial fermentation pathway in the colon. We assume that the white mangrove zone with its marginal foliation (high insolation) and brightly lit sandy ground (little absorption) is selected, because it offers the best conditions for thermoregulation to adult iguanas. Additionally, white mangrove leaves (*Laguncularia racemosa*) have the highest content of sugar, water and amylose of all species (GUTSCHE 2005a), and crabs are easier to predate on the dryer ground (reduced searching costs).

However, further studies on habitat selection in *C. bakeri* should be conducted during different seasons to evaluate the validity of our results. Nevertheless, it becomes clear that protecting the heterogeneous composition of Utila's mangrove and beach forest is the primary key to the conservation of this species.

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