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SHORT TERM MOVEMENTS OF THE SNAKES *CHIRONIUS CARINATUS*, *HELICOPS ANGULATUS* AND *BOTHROPS ATROX* IN AMAZONIAN PERU

ROBERT W. HENDERSON, MAX A. NICKERSON AND SHERMAN KETCHAM

ABSTRACT: Short term movements and habitat utilization of the colubrid snakes *Chironius carinatus* and *Helicops angulatus* and the viperid *Bothrops atrox* were studied using radiotelemetric methods in Amazonian Peru. The snakes were monitored for periods ranging from 50–111.5 h and the areas utilized by the snakes were 119.0 m² for *C. carinatus*, 29.1 m² for *H. angulatus*, and 43.0 m² for *B. atrox*. All three snakes moved in three dimensions. *Chironius carinatus* was diurnal and primarily arboreal and *H. angulatus* was nocturnal and highly aquatic. *Bothrops atrox* was nocturnal and at least young and subadult individuals are probably highly arboreal and might make daily vertical migrations between the ground and arboreal vegetation. Daily movements are comparable to those of some temperate zone species. Radiotelemetry appears to be a feasible means of studying the movements of rain forest snakes.

LITTLE is known about the movements, activity range and habitat utilization in Neotropical snakes. Information is available only for *Boa constrictor* (Henderson, 1976), *Leimadophis zweifeli* (Test et al., 1966), and *Oxybelis aeneus* (Henderson, 1974). *Boa constrictor* and *O. aeneus* were studied at mangrove edge in Belize and *L. zweifeli* was studied in Venezuelan cloud forest.

Movements of Neotropical rain forest snakes have not been previously studied. Rain forest snakes are found at low population densities and/or are secretive to such a degree that two individuals of the same species may not be found for months. For this reason the mark and recapture technique used in most temperate studies on snake movements is not feasible in the tropical rain forest habitat.

Using radiotelemetry we studied the movements of two colubrids (*Chironius carinatus* and *Helicops angulatus*) and one viperid (*Bothrops atrox*) in the Amazon Basin of Peru. The goal of the project was to determine the applicability of telemetry to the study of rain forest snakes for future studies over longer time periods.

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Materials and Methods

Snakes' movements were studied with radiotelemetry equipment. Each snake was marked with a transmitter (Model SM1-Mouse style; AVM Instrument Co., Champaign, Ill.) with an internal antenna and which weighed 0.8 g. The transmitters broadcast in the 150 MHz range and each was equipped with a mercury battery (either an RM 575 or an MP 675). Both transmitter and battery were encapsulated with epoxy. Unfortunately, epoxy was not a satisfactory encapsulating substance, and the *Chironius* and *Bothrops* both apparently digested the epoxy and the signals from their transmitters were lost in a short time. The transmitter and battery placed in the *Helicops* was coated with clear acrylic fingernail polish in addition to epoxy and the transmitter was still functioning after 4.5 days when it became necessary to terminate the project.

The transmitter-battery capsule was lubricated with petroleum jelly and then force-fed to the snake. A string was tied around the snake's body immediately anterior to the capsule to retard disgorgement of the capsule. After capsule placement snakes were calmed by keeping them confined for at least 1 h before being released at the capture sites.

Signals were directionally received with a receiver (Model LA 12, AVM Inst. Co.) and a handheld, 3-element yagi antenna. Signals were received from distances of 100–200 m depending upon the vertical location of the snake.

Areas used by the snakes during tracking were plotted on paper and were measured, as convex polygons, with a compensating polar planimeter.

Results

Chironius carinatus (Linnaeus)

A female *C. carinatus* ≈ 90 cm snout-vent length (SVL), was captured on 1 November 1974 at 1300 h along a trail 1.0 km S of the village of Mishana on the Rio Nanay, Loreto, Peru. The snake was 1 m above the ground on a bush in an aguajal swamp in disturbed closed canopy rain forest dominated by the aguaje palm (*Mauritia flexuosa*). Aguajales always have standing water and become flooded after every rain (Dixon and Soini, 1975). Canopy was broken allowing sunlight to penetrate and there were heavy tangles of undergrowth.

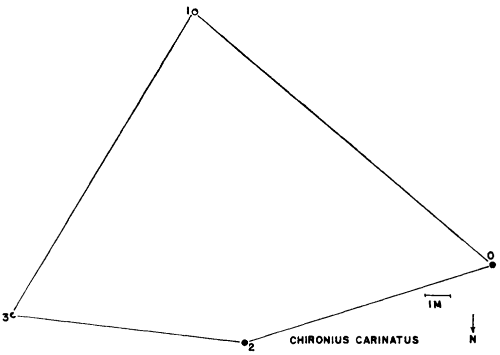

FIG. 1.—Points at which the marked *Chironius carinatus* was radiolocated. Point 0 was the capture and release point, and radiolocation sites are numbered in chronological sequence. See the text for details.

Figure 1 shows points at which this snake was radiolocated. On 2 November at 1325 h she was released where caught (Point 0). She immediately moved down to the ground and out of sight through the undergrowth headed southward. At 1550 h she was located, but not seen, at Point 1, ≈ 15 m from the release point and 2–3 m above the ground in a tangle of vegetation. At 1900 h she was still at Point 1 and on 3 November was located there three times between 0600 and 1600 h. A heavy rain occurred between 0800 and 1130 h. At 1515 h on 4 November she had crossed a trail clearing on the ground and was locate at Point 2. *Chironius* is diurnal and the move was probably made sometime between daybreak and 1515 h. It was above ground in a mass of leaves, branches and vines. The sky was clear. On 5 November at 0845 h it was still at Point 2 and the sky was overcast. On 6 November at 0630 h the snake was located at Point 3 above the ground, probably at 2–3 m and

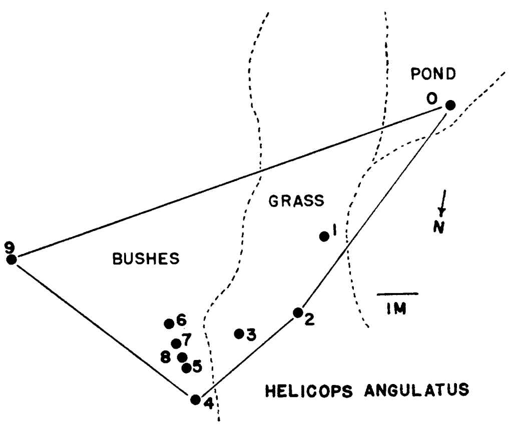

FIG. 2.—Points at which the marked *Helicops angulatus* was radiolocated. Point 0 designates the capture and release site, and radiolocation sites are numbered in chronological sequence. See text for details.

on the same side of the trail as Point 2 and 1 m from the trail.

The signal was lost on 7 November. During the 89 h that the snake was monitored after release, it was never seen but was always located above ground. It must have descended to the ground at least once. During the 89-h interval it moved, horizontally, a minimum of 37 m. Mean hourly known movement (MHKM), then, was 0.4 m/h and mean daily known movement (MDKM) was 9.6 m/day. The area utilized by the snake was plotted as a convex polygon of 119 m^2 (1.19 ares).

Helicops angulatus (Linnaeus)

Field work was at a site 2.4 km WNW of the Rio Amazonas on the outskirts of Iquitos, Loreto, Peru, at a pond 20 m × 30 m and 1 m deep in a pasture-like field. The pond was not shaded and the nearest tree was 30 m away. Northeast and east of the pool was aquatic grass 0.3–0.6 m tall and behind the grass were bushes 0.5–2.0 m tall. On four nights, usually 0.5–1.0 h after dark, between 22–28 October 1974 we collected four *H. angulatus* and one *H. polylepis* in the water at the edge on a submerged sandbar. Fish were abundant in the pond and the aquatic frog *Pipa pipa* was also taken there. The pond was regularly visited by humans for laundry, bathing, swimming and watering of livestock.

The study animal, a female 31 cm SVL, was collected on 27 November at 1835 h ($\approx$ 20 min after dark) within 1–2 m of a similar-sized *H. angulatus* and a *H. polylepis* at the pool edge close to aquatic vegetation. Only 5 min previously the snakes had not been there, and possibly they had spent the day in the vegetation and had just moved into the pool when found.

Figure 2 shows points at which the snake was radiolocated. It was released at the capture point (Point 0) at 1610 h on 29 November and immediately swam toward the aquatic grass along the "shelf" of the pond edge. It surfaced 1.5 m from Point 0 at the pond edge, remained motionless for 2.0 min then submerged and swam again toward the aquatic grass. At 1830 h, $\approx$ 25 min after dark, the snake was located in aquatic grass (0.3 m tall) with a spongy substrate and 30–60 mm of surface water. The sky was overcast. It had moved a straight line distance of 4.5 m, but 7.5 m by water (Point 1). At 2355 h the snake had moved farther into the aquatic grass (Point 2). The sky was overcast. On 30 November at 0720 h it was 1 m from Point 2 and deeper into the grass (Point 3). By 1850 h it had moved farther from the pond and into marginal bushes 1.6 m tall (Point 4). The substrate was soft, but there was less standing water and a thick, matted root system from the bushes. On 1 December at 0210 h the snake was 1 m from Point 4 (Point 5) and was relocated there at 1010 and 2020 h. By 0530 on 2 December it had moved 1 m along the line of brush to Point 6 and remained there all day. (At 1355 h the shaded air temperature was 33°C and the pond water temperature at a depth of 150 mm was 29°C.) At 2330 h it was at a point midway between Points 5 and 6 (Point 7). At 1835 h at Point 6 the substrate temperature was 27°C, the pond temperature 28.5°C, and the air temperature

26.5°C. By 3 December at 0745 h the snake had moved only slightly (Point 8). On 4 December at 0515 h the snake was located at Point 9 in tall bushes and a soft, watery substrate. The project was terminated at that time.

During the 111.5 h that the *Helicops* was tracked, it moved, horizontally, a minimum of 17.8 m. After release it was never seen again, but was always hiding in the soft, water-filled substrate. MHKM was 0.15 m and MDKM was 3.6 m. The area utilized by the snake was 29.1 m^2 (0.29 ares).

No other snakes were observed at the pond while the study was in progress although several had been taken previous to it. This suggests that factors other than transmitter implantation may have been keeping the snake from moving out into the pond. Sky conditions during the study ranged from cloudless to heavily overcast. Daytime human activity at the site seemed excessive.

Bothrops atrox (Linnaeus)

On 3 November 1974, a female *Bothrops atrox* (SVL = 62 cm) was taken from under a dead palm frond along a trail in an aguajal swamp in primary rain forest with closed canopy 2 km S of the village of Mishana on the Rio Nanay, Loreto, Peru.

The snake was released at the capture site (Point 0 of Fig. 3) at 1616 h on 4 November. By 1645 h it had moved 3 m away from the trail into the forest under a log (Point 1). At 2015 h it was at Point 2 in leaf litter and a tangle of fallen branches.

On 5 November at 0800 h the snake was deeper into the forest at Point 3, concealed by leaf litter and the root system at the base of a sapling of 20 mm dbh. The substrate was very wet with standing water nearby. The *Bothrops* stayed at Point 3 until at least 1845 h ($\approx$ 15 min after dark). At 1915 h it was 1.5 m above the ground (Point 4) in the same sapling with its head resting on a coil. By 2015 h it had ascended to 2.3 m in the same tree (Point 5). It was very alert; at the tracker's approach the head was raised, the tongue flicked, and

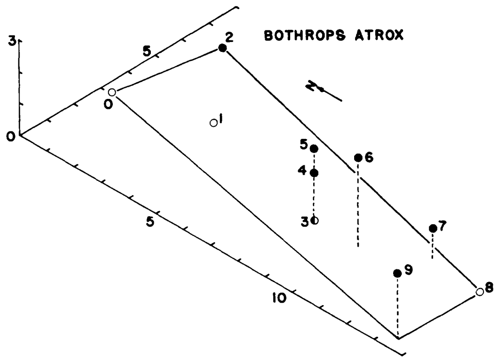

FIG. 3.—Points at which the marked *Bothrops atrox* was radiolocated. Point 0 was capture and release site, and radiolocation sites are numbered in chronological sequence. Open circles = daytime sites, closed circles = night sites and Point 3 was used by day and night. Vertical dashed lines signify arboreal sites. The snake's movements were plotted in this manner to illustrate movement in three dimensions. Scale is in metres.

the tail was vigorously vibrated. An hour later it was still at Point 5, but it was in a tight coil with the head resting on a coil. It remained in that position with only slight shifts of head position until at least 0215 h on 6 November. At 0410 h it was observed climbing on a vine at 2.6 m (Point 6). Thirty-five minutes later it was coiled at 0.9 m on a branch (Point 7) and concealed by a large dry leaf. By 0515 h the light was sufficient without a headlamp to see the snake still at Point 7. By 0600 it had descended to the forest floor beneath a moss-covered log (Point 8) 0.3 m in diameter. The log was in a damp area surrounded by low (0.6–2.0 m tall) vegetation, but there was no standing water. At 1515 h it was still at Point 8, but by 1815 h it had climbed approximately 2 m into a mass of vegetation. The signal from the transmitter had become weak and it was lost shortly thereafter.

In the 50 h that the activity of the *Bothrops* was monitored, it moved horizontally a minimum of 23.5 m. MHKM was 0.5 m and MDKM was 11.3 m. The area was plotted as a convex polygon of 43.0 m^2 (0.43 ares).

Discussion

There seems little doubt that radiotelemetry is a feasible means of studying the movements of rain forest snakes. However, maneuvering through the often-dense vegetation was difficult and frequently the tracker was unable to visually locate the marked animal even after being guided to it by the radio signal. The marked specimen of *C. carinatus* was not seen again after its release and it was always radiolocated above eye level in dense vegetation. We located it by maximizing signal strength in vertical and horizontal planes from at least three points near the tree or group of trees where the snake was situated. To determine the approximate height of the snake we adjusted the receiver on low gain so that if we could still detect a signal it indicated probable proximity of 1–2 m. Similar difficulty in visually locating marked arboreal snakes has also been encountered in telemetric studies of temperate species in more open habitat (H. S. Fitch, *personal communication*) and the same applies to rain forest lizards (Montgomery et al., 1973) and mammals (Montgomery et al., 1973).

Our data for *Chironius carinatus* suggest that it is essentially arboreal, but will descend to the ground. Beebe (1946) found similar habits in *C. carinatus* at Kartabo, British Guiana (= Guyana), but Test et al. (1966) found that individuals observed in Venezuela were usually on the ground. They speculated that the large eyes of *C. carinatus* suggested nocturnality although their specimens were active by day. However, *Chironius* is probably diurnal and the large eyes suggest it is visually oriented with relatively keen eyesight. We only observed active *Chironius* by day and a juvenile was taken sleeping in vegetation at night near Leticia, Colombia.

Helicops angulatus seems to be strictly nocturnal and was not seen in the daytime. Our limited temperature data show that at midday the pool was considerably cooler than the shaded air temperature and the matted substrate of the marginal vegetation was probably even cooler. At night the pool temperature approximated that of midday and was cooler than the air temperature, but warmer than the matted substrate.

We never observed *Helicops* out of water. One was found "in the jungle" by Beebe (1946) at Kartabo, but it had fish scales in its stomach.

The marked *H. angulatus* was probably very close to the surface of the matted substrate, where it spent the entire 111.5 h we tracked it, as we were able to receive the transmitter's signal even without the aid of our antenna.

Our ability to see the marked *Bothrops atrox* when it was located allowed us to learn about some aspects of its behavior. It is well documented that *B. atrox* and the closely related *B. asper* are nocturnal (e.g., Sexton, 1957; Sexton and Heatwole, 1965), and that young individuals are frequently arboreal (e.g., March, 1928; Test et al., 1966). Sexton and Heatwole (1965) observed Panamanian *B. asper* (a species that was, until recently, considered conspecific with *B. atrox*) under a log and in a tree at 1425 h and 1300 h, respectively. Although only small *B. atrox* are known to ascend into vegetation, Test et al. (1966) reported finding "large" individuals of the morphologically similar *B. venezuelae* (= *venezuelensis*) 1.5–2.0 m above the ground.

Our observations suggest that soon after dark young *B. atrox* ascend into the vegetation and lie in wait for prey. Probably it does not actively forage and it is not always alert while waiting. It may periodically move from one arboreal site to another, but our marked snake did not descend to the ground until daybreak and then it crawled underneath a log. It spent the entire day under the same log and did not emerge until early evening when it again ascended into the vegetation. Frogs and small mammals probably constitute the most important prey items for young *B. atrox*.

Tail vibrating by *B. atrox* is probably an innate defensive response and will occur whether the snake is in a tree or lying on the ground in dry leaves where a more effective "warning" sound could be produced. Carr (1969) suggested that *B. asper* in Costa Rica deliver "fangless," defensive strikes "when the need is just to scare somebody badly" because, unlike rattlesnakes, *B. asper* does not have an effective warning device. By inflicting bites with the fangs still folded against the roof of the mouth, *B. asper* is able to "warn" large hoofed animals (e.g., tapirs) of its presence yet not risk damage to its easily-breakable fangs. Carr evidently never heard *B. asper* vibrate its tail, but *B. atrox* has obviously evolved a warning response in at least part of its range.

The movements of only one species of Neotropical snake have been extensively studied (*Oxybelis aeneus*), but not in the rain forest, and it was shown by Henderson (1974) that its activity range was small compared to those of most temperate zone species for which data were available. None of our marked animals were monitored long enough to determine the size of their respective activity ranges. In all three species, there was a tendency to move farther from the capture-release site (Point 0) with each successive point. If home range boundaries exist at all, the snakes apparently did not have time to reach them.

Comparisons with data presented by Fitch and Shirer (1971, Table 2) however, show that mean daily movements were comparable to some temperate zone species. For example, *Natrix sipedon* moved 4 m/day compared with 3.6 m/day for *Helicops angulatus* and the viperid *Agkistrodon contortrix* moved 7.5 m/day compared with 11.3 m/day in *B. atrox*. All of these were much exceeded by the 45 m/day in *Crotalus horridus*. However, it should be noted that all three of the snakes we tracked moved in three dimensions, and we measured their movements on the basis of surface areas, not volumes. Thus, the sizes of their respective activity ranges are considerably larger than our figures indicate. Our data show a positive correlation between SVL and area utilized, but not between area and length of time monitored.

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THREE NEW LEPTODACTYLID FROGS (GENUS *ELEUTHERODACTYLUS*) FROM THE ANDEAN SLOPES OF COLOMBIA AND ECUADOR

JOHN D. LYNCH

ABSTRACT: *Eleutherodactylus gladiator* (valley of the Río Papallacta, elevation 2350–2910 m), *Eleutherodactylus leoni* (both slopes of the northern Andes, 2590–3400 m), and *Eleutherodactylus pyrrhomerus* (Pacific slopes, 2600–2900 m) are named from the Andean slopes of northern Ecuador and southern Colombia. The three are more similar to one another than any is to other species of the genus. All have high, vaulted heads, truncate snouts, stocky bodies with slender limbs, appear to lack digital pads, and are small, ground-dwelling frogs. *Eleutherodactylus leoni* and *E. pyrrhomerus* have red areas on the concealed limb surfaces; these areas are orange in *E. gladiator*.

MOST of the species of *Eleutherodactylus* encountered in the cloud forests of Andean Colombia and Ecuador are arboreal and have broad digital pads. Collections on both Pacific and Amazonian slopes contain a distinctive assemblage of small, ground-dwelling *Eleutherodactylus* having bright-red or orange colors in the groin. The assemblage is defined as follows: small frogs (♂♂ 14.9–18.9 mm SVL, ♀♀ 19.8–25.0 mm SVL) with stocky habitus and slender limbs, a series of prominent post-tympanic and postrictal tubercles, tuberculate skin, prevomerine odontophores, small digital pads, and in lacking cranial crests. These are members of the *E. unistrigatus* group (Group II of Cochran and Goin, 1970) and are distinctive in having truncate snouts and relatively vaulted skulls (in contrast to the flatter heads seen in most small species of the group). Three allopatric species were found at localities at elevations of 2600–3400 m on the Pacific slopes and 2350–2910 m on the Amazonian slopes.

In the following descriptions, certain measurements are identified by abbreviations: SVL—snout-vent length; HW—greatest head width, usually just posterior to the eyes; IOD—narrowest distance between the upper eyelids; E–N—distance between the anterior edge of the eye and the posterior edge of the nostril.

Eleutherodactylus **pyrrhomerus** sp. nov.

Holotype.—KU 131606, an adult ♀ collected at the east edge of Pilalo, Cotopaxi Province, Ecuador, elevation 2580 m, 4 July 1970 by Thomas H. Fritts.

Paratypes.—KU 131607–11, 3 km E Pilalo, 2900 m; KU 152038, 4.6 km E Pilalo, 2600 m; KU 142167–70, 6 km E Pilalo, Cotopaxi Province, Ecuador, 2670 m.

Diagnosis.—(1) Skin of dorsum, upper flanks, and limbs minutely tuberculate, that of venter areolate; some large conical warts on head (one on eyelid, others near ear); no dorsolateral folds or discoidal folds; (2) tympanum prominent, round, its length ⅓–⅖ that of eye, not sexually dimorphic; (3) snout short, acuminate in dorsal view (tip rounded), semitruncate in profile; (4) interorbital space flat (no cranial crests), broader than upper eyelid;