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Seasonal Activity of the Florida Kingsnake Lampropeltis getula floridana (Serpentes: Colubridae) in Southern Florida

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ABSTRACT.—During a 2 y study (February 1993–January 1995) I searched a total of 519.4 km of canal and levee banks in 304.4 h to study Florida kingsnake (*Lampropeltis getula floridana*) activity. I gathered and compared data on seasonal activity patterns of two populations in southern peninsular Florida, around Lake Okeechobee and southern Dade County. Snakes from both populations exhibited two activity peaks, one in spring and one in fall. The highest frequency of encounters was in March and April during the peak of the breeding season. During this time males were encountered more often than females, possibly because they are actively searching for mates. Encounter rates are constrained by temperature rather than precipitation. The majority of snakes were found in the open aboveground between 24 C to 29 C, with the highest frequency at 27 C. At lower and higher temperatures encounter rates decreased as snakes may retreat into refugia. Adults were encountered more often than juveniles. Adults are primarily diurnal, whereas juveniles exhibit crepuscular and nocturnal behaviors. An apparent ontogenetic shift in diel activity occurred at approximately 90 cm SVL, where secretive juveniles gradually become more diurnal.

INTRODUCTION

The kingsnake, *Lampropeltis getula* (Linnaeus), ranges throughout much of temperate and subtropical North America, from Oregon to the Mexican plateau in the west and from southern New Jersey to southern Florida in the east. Historically, *L. getula* was abundant throughout Florida (Carr, 1940; Kauffeld, 1957; Duellman and Schwartz, 1958; Wilson and Porras, 1983; Krysko, 1995, 2001). Despite their previous abundance in Florida, kingsnake populations have severely declined or been locally extirpated for unknown reasons (Wilson and Porras, 1983; Krysko, 1995, 2001; Means, 2000), leaving only a few isolated populations scattered around the state. Similar local extirpations of other reptile species have taken place throughout the southeastern U.S. (Moler, 1992; Tuberville *et al.*, 2000), alarming herpetologists and conservationists. Although *L. getula* is one of the most familiar snake species in the U.S., life history data for this species are sparse and mostly based on captive individuals. Only two known studies have remarked on seasonal activity of *L. getula* in the wild. Gibbons and Semilitsch (1987) used drift fences and pitfall traps in the southeastern U.S. Coastal Plain of South Carolina, and Price and LaPointe (1990) conducted road surveys in the Chihuahuan Desert of New Mexico. Because the habitat and climate in southern Florida is remarkably different from that of South Carolina and the Chihuahuan Desert, I examined activity on two remaining Florida kingsnake (*L. g. floridana* Blanchard) populations in southern peninsular Florida.

METHODS

During a 2 y study (February 1993–January 1995), I gathered data on seasonal activity patterns of the Florida kingsnake (*Lampropeltis getula floridana*) from two populations in southern peninsular Florida.

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Lake Okeechobee population (LOP).—Study area 1 includes sugarcane fields around Lake Okeechobee in Glades, Hendry and Palm Beach counties. Since 1928, when the canal system designed to drain the Everglades was installed in southern Florida (DeGrove, 1984), approximately 280,000 ha of land around Lake Okeechobee have been drained and converted into rich agricultural lands (Gleason, 1984). Wilson and Porras (1983) reported that sugarcane fields around Lake Okeechobee supported large rodent populations and the black soil embankments along man-made drainage canals provided refuge for *Lampropeltis g. floridana*. Within these sugarcane fields are thousands of km of irrigation canals where abundant small mammal burrows are used as refugia by *L. g. floridana* and other animals.

Southern Dade County population (SDCP).—Study area 2 includes the boundary of Everglades National Park (ENP) in southern Dade Co., FL: Taylor Slough Entrance to ENP (formerly Chekika State Park), north C-111 canal basin within the Southern Glades Management Area and near Krome Avenue and Tamiami Trail. These areas contain hundreds of km of man-made canals near sawgrass (*Cladium jamaicense*) prairies, where excavated oolitic limestone is piled up alongside the canals creating roadside levees. The exposed oolitic limestone forms a network of interconnected burrows used by small mammals, turtles, amphibians and snakes.

Activity patterns.—Because *Lampropeltis getula floridana* spends much of its life in burrows yet appears aboveground as it becomes active each season (Wright and Bishop, 1915; Carr, 1940), I walked the edges of canals and levees during the daytime from just after sunrise to midafternoon searching for signs of activity: a capture, observation without capture, shed skin, skeleton or dead on road (DOR) specimen. Live specimens were photographed, marked using the ventral scale clipping system following Brown and Parker (1976) and released at their capture site. Representative voucher specimens were deposited at the Florida Museum of Natural History (FLMNH, UF collection): Dade County: UF 99740–41, 102087, 102089, 102156–59, 105382, 128290; Palm Beach County: UF 99739.

A minimum of two sites within each study area were investigated each month. Data from both areas were compared and then combined. Encounters of *Lampropeltis getula floridana* per km and per h of habitat searched were recorded each month. Captured snakes were sexed as well as measured for snout-vent length (SVL, ±1 mm) by being stretched along a tape. Air temperature (C) was recorded (±0.2 C) at each live encounter by placing a Weksler thermometer (−10 C, +110 C) about 8 cm above the ground where the snake was captured or sighted. Live snakes were recorded as in the open (surface category) or undercover (under boards or carpet, in debris, etc. = subsurface category). Because I observed sexual maturity of wild collected individuals at 80 cm SVL, individuals were grouped as either juveniles (<80 cm SVL) or adults (>80 cm SVL). Size distribution within each study site was plotted. Climate data were acquired from the nearest station to study sites (National Climate Data Center, 2001), which included Clewiston (Cooperative Station ID# 081654) and Miami International Airport (Cooperative Station ID# 085663). All statistical tests were preformed using Statistical Analysis System (SAS Institute Inc., version 6.12) with $\alpha = 0.05$.

RESULTS

A total of 519.4 km of canal and levee banks was searched during 304.4 h of fieldwork. I encountered 84 signs of *Lampropeltis g. floridana* activity in LOP and 74 in SDCP (Tables 1, 2).

Encounter rates of *Lampropeltis g. floridana* per km and per h searched in LOP (Fig. 1a) and in SDCP (Fig. 1b) indicated two similar periods of activity, thus the data were combined into a single category (Fig. 1c). The first activity period took place from February through July. Within this period the highest frequencies of encounters were in March and April.

TABLE 1.—*Lampropeltis getula floridana* encounter categories on canal and levee banks in southern peninsular Florida. LOP = Lake Okeechobee population, SDCP = southern Dade County population, DOR = dead on road

Site	Live	DOR	Shed skins	Skeletons	Total
LOP	67	2	15	0	84
SDCP	32	0	35	7	74
Total	99	2	50	7	158

Encounters were uncommon in the hot summer months from August through September. The second activity period took place from October through December. One difference between populations occurred in January when no encounters were recorded in LOP (Fig. 1a). A second difference occurred in August through October when no encounters were recorded in SDCP (Fig. 1b).

Male *Lampropeltis g. floridana* were encountered significantly more frequent than females in LOP ($\chi^2 = 4.5$, df = 1, $P < 0.05$; Fig. 2a). There was no significant difference in frequency of males and females encountered in SDCP ($\chi^2 = 2.0$, df = 1, $P > 0.05$; Fig. 2b), possibly due to the smaller sample size relative to LOP. Since there was evidence for homogeneity among LOP and SDCP ($G_H = 0.009$, df = 1, $P > 0.05$), the data were combined into a single category. When combining these data, there was a significant difference in the frequency between genders ($\chi^2 = 6.5$, df = 1, $P < 0.05$; Fig. 2c), with males being found more often. Among adults only from this combined sample, a significant male bias of 54:32 (male: female) was found from February through June ($\chi^2 = 5.6$, df = 1, $P < 0.05$).

At both study sites *Lampropeltis g. floridana* were found at the surface from 18 C to 33 C (Figs. 3a, b). When data were combined into a single category (Fig. 3c), preferred air temperatures are more noticeable from 24 C to 29 C, with most encounters occurring at 27 C. Encounters decreased at cooler (<24 C) and warmer (>29 C) temperatures, and none were found >33 C.

There was a significant difference between juvenile and adult *Lampropeltis g. floridana* encountered in LOP ($\chi^2 = 21.0$, df = 1, $P < 0.01$; Fig. 4a) and in SDCP ($\chi^2 = 23.8$, df = 1, $P < 0.01$; Fig. 4b), adults being found more often. When data were combined into a single category (Fig. 4c), it is clear that both juvenile and adult activities peak during the mating season and only juveniles were found from August through October.

Adult *Lampropeltis g. floridana* from LOP had a significantly larger mean SVL than those from SDCP ($P < 0.05$). Size of *L. g. floridana* in LOP ranged from 20 to 160 cm SVL, yet most individuals were 90 to 140 cm SVL (Fig. 5a). Size distribution was much less diverse in SDCP. All individuals in SDCP clustered mainly between 60 to 100 cm SVL, except for

TABLE 2.—Demographic categories of *Lampropeltis getula floridana* encountered on canal and levee banks in southern peninsular Florida. LOP = Lake Okeechobee population, SDCP = southern Dade County population

Site	Male	Female	Total	Juvenile	Adult	Total
LOP	45	27	72	21	63	84
SDCP	24	15	39	16	58	74
Total	69	42	111	37	121	158

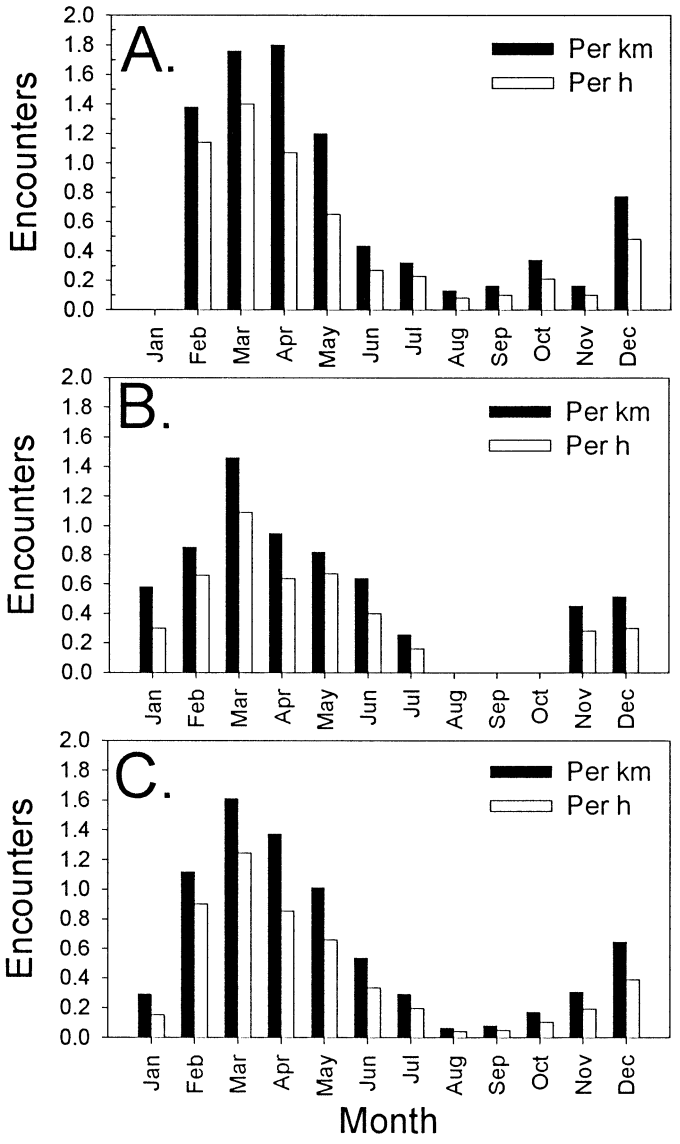

FIG. 1.—*Lampropeltis getula floridana* encountered per km and per h on canal and levee banks searched: A. Lake Okeechobee; B. southern Dade Co., FL; C. A and B averaged

one juvenile <30 cm SVL (Fig. 5b). As in LOP, a sharp increase in the number of individuals encountered was noticed at 90 cm SVL in SDCP, but no individuals were found >100 cm SVL. When the data are combined (Fig. 5c), the size distribution of individuals encountered gradually increases from 20 to 90 cm SVL, drastically increases at 90 cm SVL, and decreases at >100 cm SVL.

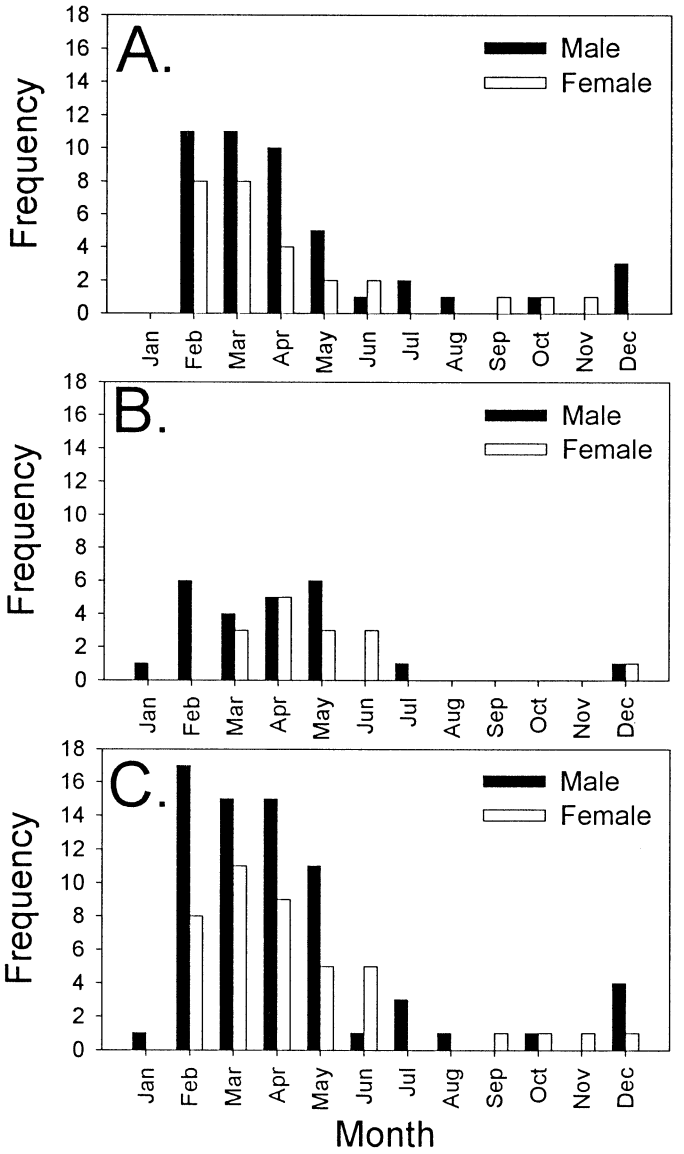

FIG. 2.—Frequency of male and female *Lampropeltis getula floridana* encountered on canal and levee banks: A. Lake Okeechobee; B. southern Dade Co., FL; C. A and B summed

DISCUSSION

The breeding season of *Lampropeltis getula* is typically March through June (Wright and Bishop, 1915; Fitch, 1970; Mattison, 1988), but can begin as early as February for *L. g. floridana* in southern peninsular Florida (Krysko *et al.*, 1998). Climatic variables including temperature and precipitation are reported to have major effects on snake activity patterns

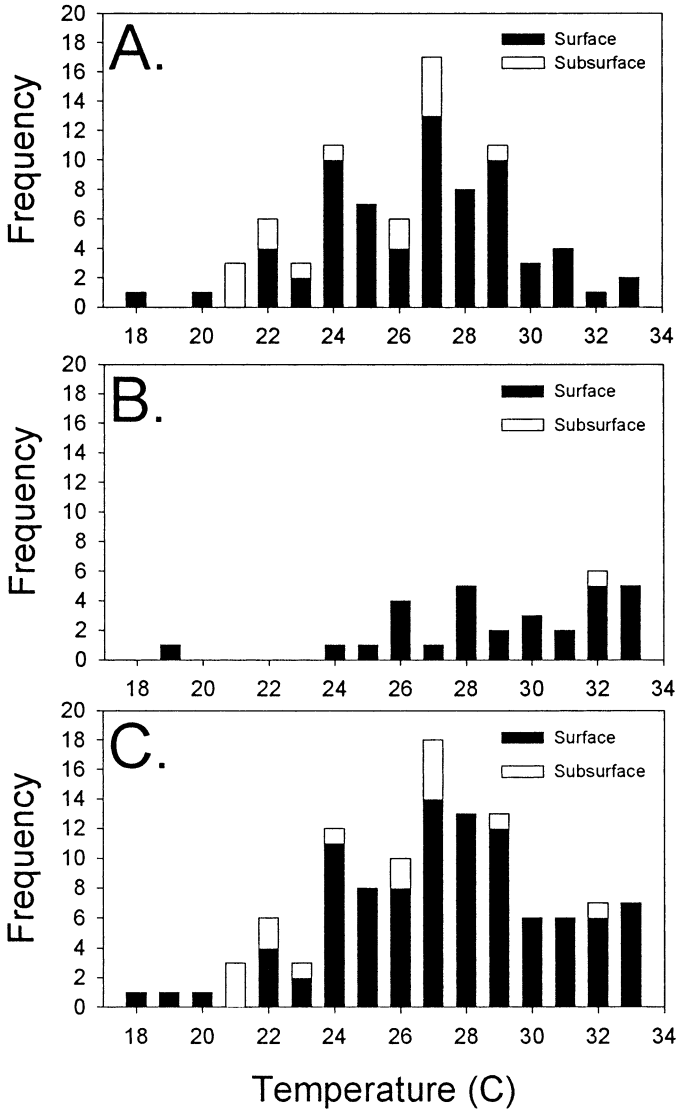

FIG. 3.—Ambient air temperatures (C) at times live *Lampropeltis getula floridana* were encountered on canal and levee banks: A. Lake Okeechobee; B. southern Dade Co., FL; C. A and B summed. Snakes were recorded either as in the open (surface category) or undercover (subsurface category)

(Gibbons and Semilitsch, 1987; Lillywhite, 1987; Price and LaPointe, 1990; Dalrymple *et al.*, 1991a). Single peaks of activity for *L. getula* were found in the Coastal Plain of South Carolina (Gibbons and Semilitsch, 1987) and the Chihuahuan Desert of New Mexico (Price and LaPointe, 1990). However, *L. g. floridana* populations in LOP and SDCP each have bimodal activity patterns (Fig. 1), also seen in many other snake species from southern peninsular Florida (Dalrymple *et al.*, 1991a, b; Bernardino and Dalrymple, 1992). The first

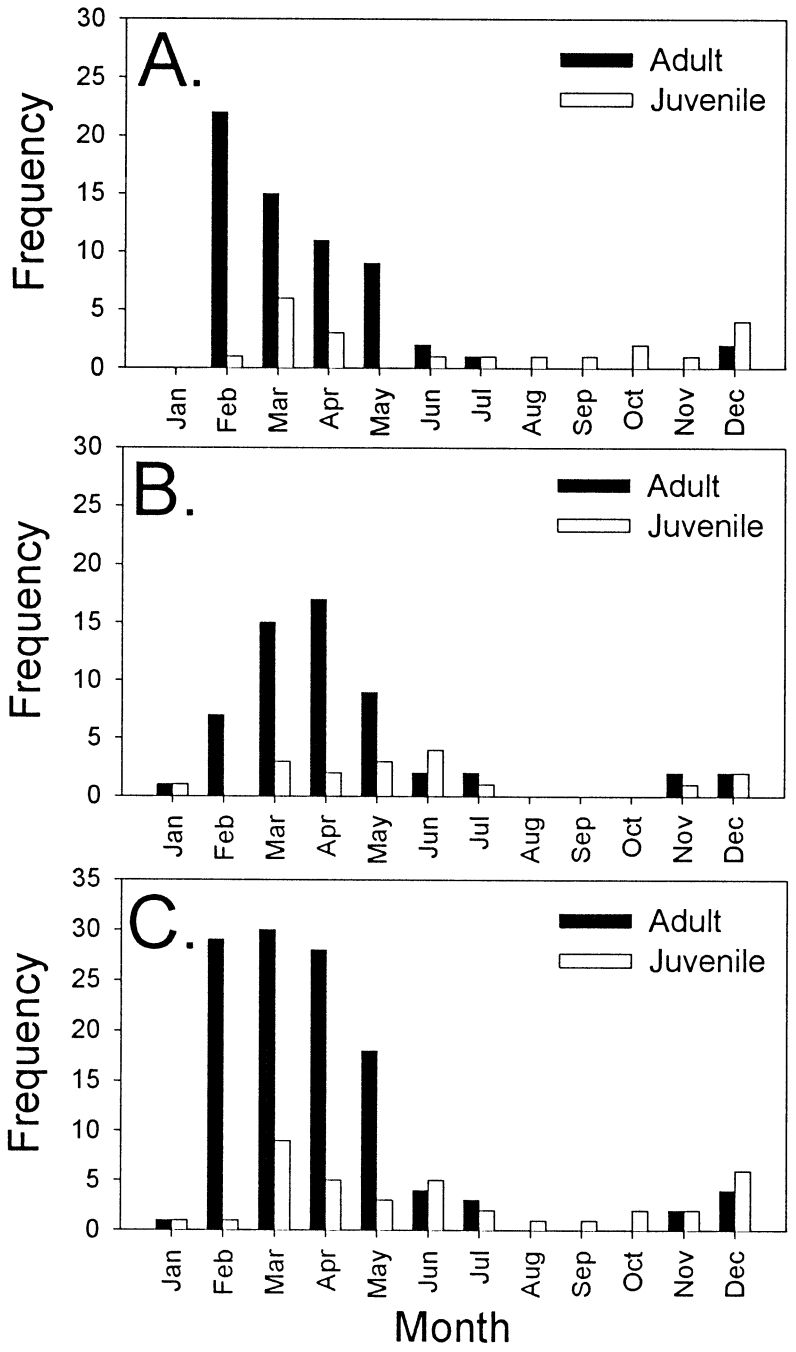

FIG. 4.—Frequency of juvenile and adult *Lampropeltis getula floridana* encountered on canal and levee banks: A. Lake Okeechobee; B. southern Dade Co., FL; C. A and B summed

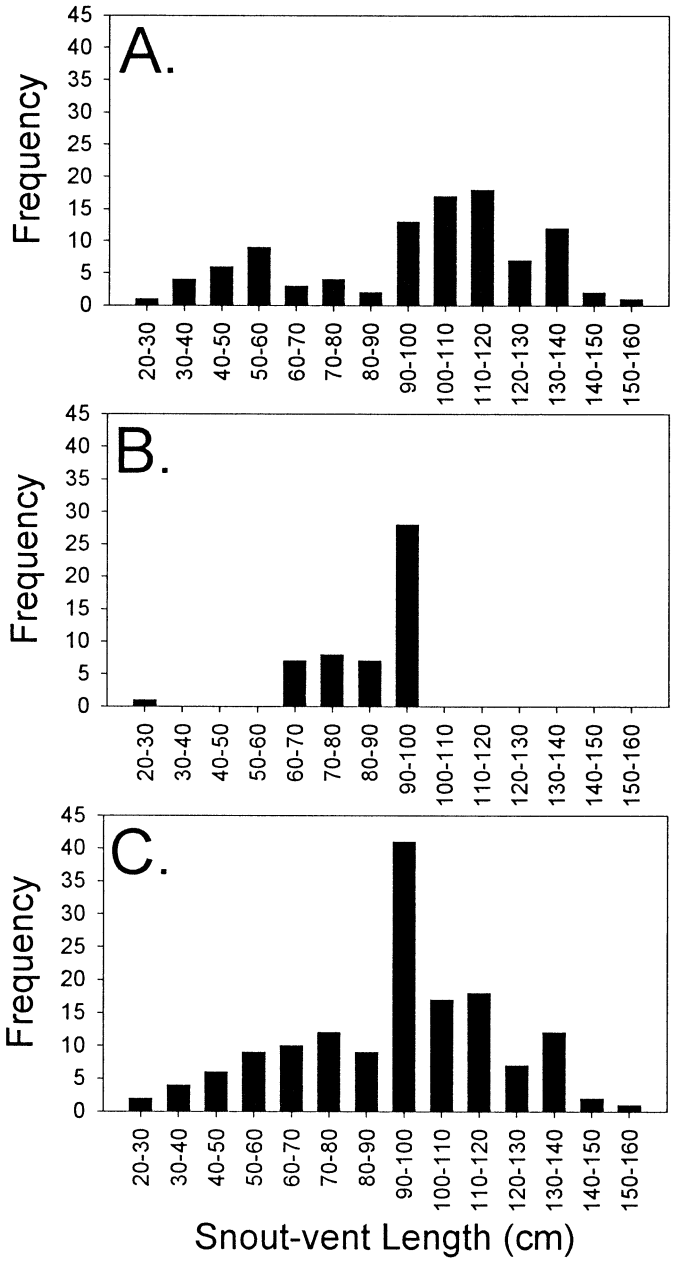

FIG. 5.—Size distribution of *Lampropeltis getula floridana* encountered on canal and levee banks: A. Lake Okeechobee; B. southern Dade Co., FL; C. A and B summed

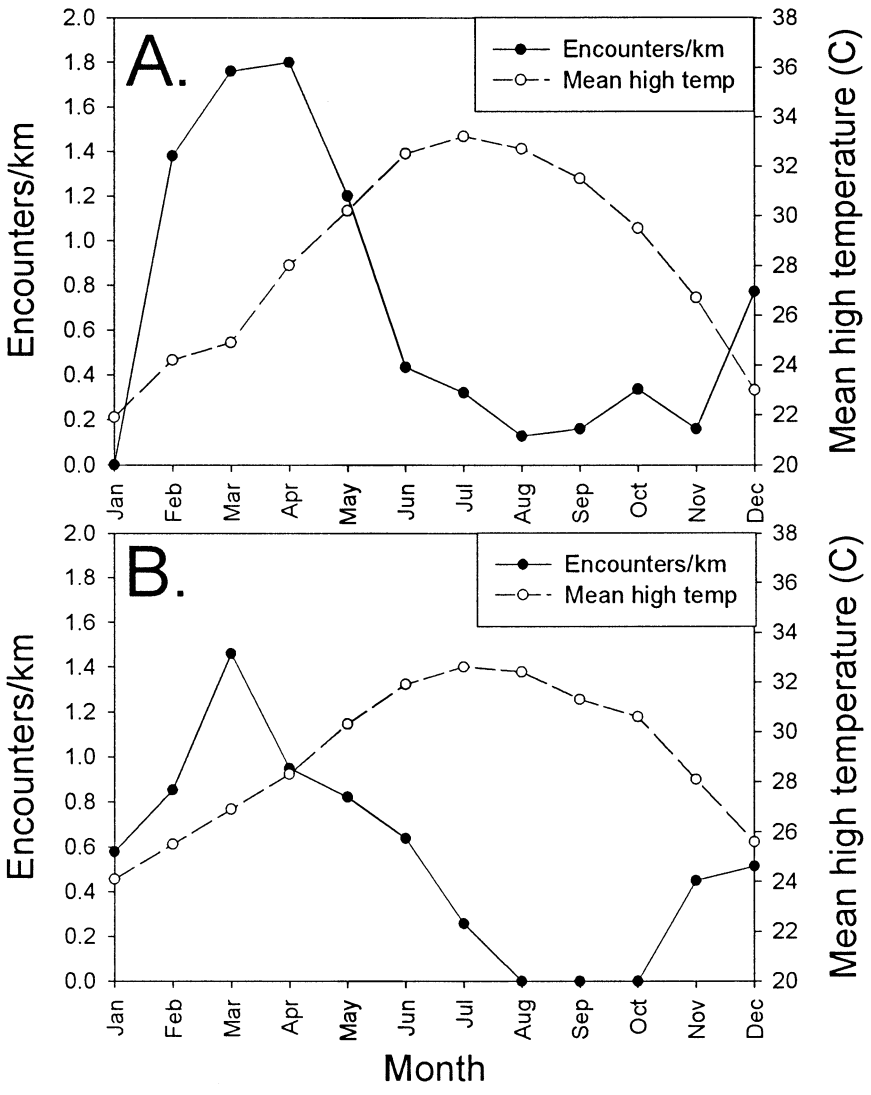

FIG. 6.—Encounter rates (closed circles) of *Lampropeltis getula floridana* compared to monthly mean high temperatures (open circles) from: A. Lake Okeechobee and B. southern Dade Co., Florida

activity peak occurred from February through July, correlating with the breeding season and increases in day length and mean high temperature (Fig. 6). The second activity peak occurred from October through December, correlating with decreases in day length, mean high temperature (Fig. 6) and mean precipitation (Fig. 7). One difference between the two populations occurred in January when no signs of activity were found in LOP, possibly due to the cooler climate just 145 km to the north of SDCP (Fig. 6). A second difference between the two populations occurred in August through October when no signs of activity

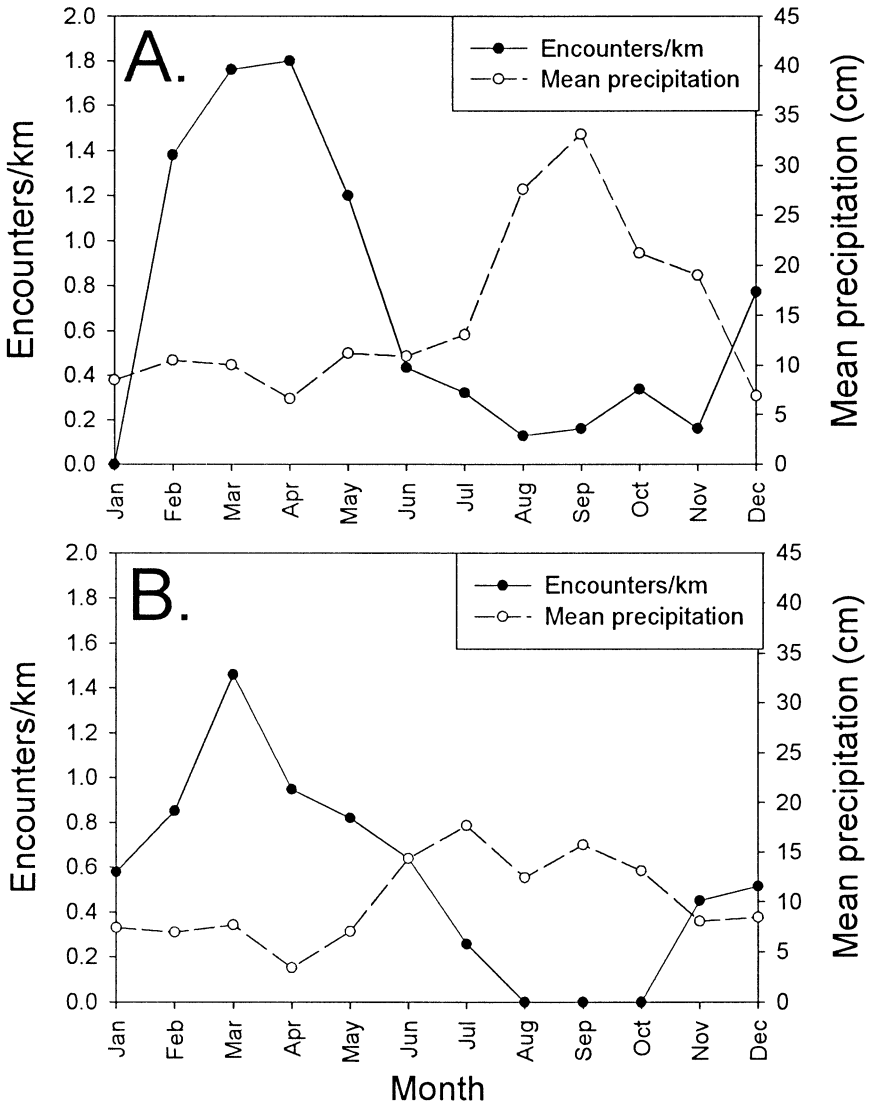

FIG. 7.—Encounter rates (closed circles) of *Lampropeltis getula floridana* compared to monthly mean precipitation (open circles) from: A. Lake Okeechobee and B. southern Dade Co., Florida

were found in SDCP, possibly due to the typical extra month it takes for the first substantial northern cold front to reach the southern tip of Florida.

During the breeding season, male *Lampropeltis g. floridana* are encountered more often than females, apparently because they are actively searching for mates (Fig. 2). From February through June an adult male bias of 54:32 (male:female) was found. Females are also observed in higher frequency during the breeding season than at any other time of year possibly because they are waiting for males to pick up their pheromones, increasing yolk

masses by feeding more frequently or basking before oviposition occurs. On several occasions males were observed following females during the breeding season (D. B. Means, pers. comm.), which is consistent with mate searching by pheromone trailing reported in other male snakes (Mason, 1992). Graves and Duvall (1993) reported that gravid female prairie rattlesnakes (*Crotalus viridis viridis*) maintained higher body temperatures than nongravid females. Additionally, Tu and Hutchison (1994) noted that gravid female water snakes (*Nerodia rhombifera*) preferred longer periods of exposure to higher temperatures than nongravid females.

The majority of *Lampropeltis g. floridana* were found in the open, aboveground between 24 C to 29 C, with the highest frequency occurring at 27 C (Fig. 3). At lower and higher temperatures encounter rates decreased suggesting that individuals may enter refugia including underground burrows, shade of sugarcane fields or water. On 5 March 1993 at 28 C an individual was observed among water lettuce (*Pistia stratiotes*) in a canal in Hendry Co., Florida, showing that individuals enter water. Additionally, Godley (1982) found 58 *L. g. floridana* in a water hyacinth (*Eichhornia crassipes*) community in Rainey Slough, Glades Co., Florida, with evidence of individuals actively foraging in water. However, encounter rates of *L. g. floridana* appear to be constrained by temperature in the summer months as encounter rates decreased when mean high temperatures approached 30 C (Fig. 6).

Adult *Lampropeltis g. floridana* are encountered more often than juveniles (Fig. 4). Adults are primarily diurnal, whereas juveniles appear to have more secretive behaviors. Of 24 live juveniles encountered, 7 were found in debris, 10 were active aboveground at dawn, dusk or at night and only 7 were in the open during the day suggesting that juveniles are more secretive than large conspicuous diurnal adults. However, from June through October, adults also may exhibit crepuscular and nocturnal behaviors like that of juveniles. Within these months, only one live adult was found during the day and all other adult encounters consisted of shed skins and skeletons. After this study took place adults and juveniles were found during the summer, crossing roads just before or after dark, illustrating crepuscular and nocturnal behaviors of both age classes. Other possible explanations for adults being encountered more often than juveniles are observability bias as well as different microhabitat preferences of juveniles (Reinert, 1993).

Encounter rates of *Lampropeltis getula floridana* increased gradually from newborn to adult size <90 cm SVL (Fig. 5c) suggesting an ontogenetic activity shift toward diurnal behavior. Once attaining 90 cm SVL individuals may become less wary of diurnal predators such as birds and other snakes and move about more freely during the day. Evidence of avian predation was found on 5 March 1994, when a *L. g. floridana* skeleton (80 cm SVL) was found 2 m off the ground on an Australian pine tree (*Casuarina equisetifolia*) in the C-111 basin, Dade Co., Florida. Also, on 6 November 1994 skeletons of a *L. g. floridana* and a Florida green water snake (*Nerodia floridana*) (both 85 cm SVL) were found under a red-shouldered hawk (*Buteo lineatus*) roost in the C-111 basin. The sizes of these snake skeletons suggest that snakes <90 cm SVL may be more susceptible to avian predators. Godley (1982) noted that great blue herons (*Ardea herodias*) and great egrets (*Casmerodius albus*) were common predators on small snakes in southern Florida. These wading birds and diurnal ophiophagous snakes including racers (*Coluber constrictor*), cottonmouths (*Agkistrodon piscivorus*) and garter snakes (*Thamnophis sirtalis*) (*see* Fitch, 1965) were frequently seen during this study suggesting that they may be potential predators on smaller *L. g. floridana*. Because *L. g. floridana* is also ophiophagous and cannibalistic, it would be advantageous for smaller juveniles to have different behaviors than larger adults.

Presently, *Lampropeltis getula* is not afforded legal protection in Florida. Most *L. getula* populations in Florida have declined severely or been extirpated over the last few decades

(Wilson and Porras, 1983; Krysko, 1995, 2001; Means, 2000), leaving few remaining isolated populations scattered around the state. In only 6 y after concluding this study, only two kingsnakes were found at my SDCP study sites despite searches during the breeding season. During this study I observed local collectors take every kingsnake they encountered from the wild, illustrating the intense collecting pressure on these southern Florida populations. The widespread decline of *L. getula* in Florida is a serious conservation problem that requires further documentation and attention, and the causes are in need of prompt resolution.

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