Morphology, Diet, and Population Structure of the Southern White-lipped Mud Turtle Kinosternon leucostomum postinguinale (Testudines: Kinosternidae) in the Nus River Drainage, Colombia

Authors: Claudia P. Ceballos, Daniel Zapata, Carolina Alvarado, and Eisinhower Rincón

Source: Journal of Herpetology, 50(3) : 374-380

Published By: Society for the Study of Amphibians and Reptiles

URL: https://doi.org/10.1670/15-035

Journal of Herpetology, Vol. 50, No. 3, 374–380, 2016

Morphology, Diet, and Population Structure of the Southern White-lipped Mud Turtle *Kinosternon leucostomum postinguinale* (Testudines: Kinosternidae) in the Nus River Drainage, Colombia

Claudia P. Ceballos,[1,2] Daniel Zapata,[1] Carolina Alvarado,[1] and Eisinhower Rincón[3]

[1]*Grupo Centauro, Escuela de Medicina Veterinaria, Facultad de Ciencias Agrarias, Universidad de Antioquia, Medellín, Colombia*
[3]*Escuela Ambiental, Facultad de Ingenieria, Universidad de Antioquia, Puerto Berrío, Colombia*

Abstract.—Most existing studies on the White-lipped Mud Turtle, *Kinosternon leucostomum*, have been based on northern Central American populations, leaving a lack of information on populations from southern Central America and South America. Herein we studied morphology, diet, and population structure of a population of the southern *Kinosternon leucostomum postinguinale* inhabiting four creeks in Colombia. Observed habitats used were highly variable, ranging from relatively clean waters to streams used for sewage disposal of wastewater from a human settlement. Body size was smaller than that of other populations of southern *K. l. postinguinale* and also than that of the northern *K. l. leucostomum*. Sexual dimorphism was evident, with males heavier, longer, and wider than females. Body size was associated with the habitat of origin, with Barrio Nuevo individuals being the largest. The main components of the diet were plant material, insects, snails, and algae. We did not find evidence of sexual differences in the diet, but we found geographic differences in the body size. The population with the largest individuals, from Barrio Nuevo Creek, consumed more snails while those from Totumo Creek, the population with the smallest individuals, consumed more ants and plant material as compared to the other creeks. Additionally, we found a highly male-biased sex ratio, with 2.5 adult males per female, very few juveniles, and no nests, which suggests a dangerous risk of population decline. We suggest continued monitoring of the demography of this population, emphasizing its reproductive biology.

Resumen.—La información existente sobre la Tortuga Tapaculo, *Kinosternon leucostomum*, ha sido generalmente basada en las poblaciones del norte de Centro América, dejando un desconocimiento sobre las poblaciones del sur de Centro América y Sur América. En este trabajo nosotros documentamos la morfología, dieta, y estructura de una población de la subespecie del sur *K. l. postinguinale* que habita en 4 quebradas en Colombia. Los hábitats observados fueron muy variables, desde quebradas relativamente limpias hasta quebradas que reciben aguas negras de asentamientos humanos. El tamaño corporal fue menor a lo reportado por otras poblaciones de la misma subespecie e incluso de la subespecie del norte, *K. l. leucostomum*. El dimorfismo sexual fue evidente, con machos más pesados, largos, y anchos que las hembras. El tamaño corporal estuvo asociado al hábitat de origen, siendo las tortugas de Barrio Nuevo las más grandes. La dieta estuvo compuesta de material vegetal, insectos, caracoles, y algas. Nosotros no encontramos diferencias sexuales en la dieta pero si diferencias geográficas en el tamaño. Las tortugas de Barrio Nuevo que fueron las más grandes consumieron más caracoles, mientras que las tortugas más pequeñas de El Totumo consumieron más plantas y hormigas en comparación con los otras quebradas. Adicionalmente, encontramos una proporción sexual sesgada hacia los machos, con 2.5 machos por hembra, muy pocos juveniles y ningún nido, lo que sugiere un riesgo peligroso de disminución poblacional. Recomendamos un monitoreo continuo de la demografía de esta población y sobre su biología reproductiva en particular.

Within the order Testudines is the Neotropical family Kinosternidae, comprised of 26 species and 38 subspecies distributed from Canada to Argentina (van Dijk et al., 2014). The traditional phylogeny of Kinosternidae has been challenged by a recently proposed phylogenetic hypothesis (Iverson et al., 2013) in which some species were reallocated to a new genus and some subspecies were supported as distinct species. Other authors have objected to these new phylogenetic relationships (Spinks et al., 2014). Nevertheless, this debate highlights the need for further genetic and biologic studies covering the widest possible distributional range of all entities.

Within this family is the White-lipped Mud Turtle, *Kinosternon leucostomum* (Duméril and Bibrón, in Duméril and Duméril 1851), with its two subspecies: the Northern White-lipped Mud Turtle, *Kinosternon leucostomum leucostomum*, ranging from México to Nicaragua, and the Southern White-lipped Mud Turtle, *Kinosternon leucostomum postinguinale*, ranging from Nicaragua to Peru (van Dijk et al., 2014). This species is not currently assessed by the International Union for Conservation of Nature (IUCN, 2015) but it was listed as Least Concern in 1996 (van Dijk et al., 2014). In Colombia, *K. leucostomum* faces numerous problems including habitat degradation, human consumption, exploitation for the crafting of ornaments, and as pets (Giraldo et al., 2012).

In general, *K. leucostomum* is recognized for its unicarinate carapace, plastron with two hinges, and head with a yellow to brown stripe that extends from the eye to the neck (Berry and Iverson, 2001; Giraldo et al., 2012). *Kinosternon leucostomum* exhibits sexual dimorphism (e.g., males are recognized by a longer and thicker tail and the presence of a patch of horny scales on the inner surface of the hind limbs; Berry and Iverson, 2001). Their habitat includes slow waters with soft substrates and abundant vegetation (Ernst et al., 1997) but also creeks with abundant rocks and fast-flowing water (Acuña-Mesén, 1993). Turtles may move 2–3 m away from their aquatic habitat and between 50–200 m parallel to the shoreline, though they can move up to 600 m away to nest or aestivate (Morales-Verdeja and Vogt, 1997). This species is omnivorous with its diet including snails, grasses, algae, aquatic insects, and seeds consumed in an opportunistic pattern (depending on the habitat quality or displacement in the feeding niche by coexisting turtle species; Vogt and Guzman, 1988; Acuña-Mesén, 1993). Most of the studies of their ecology have been conducted on the northern subspecies, with fewer on the southern subspecies and none in Colombia (Giraldo et al., 2012).

[2]Corresponding Author. E-mail: claudiaceb@gmail.com
DOI: 10.1670/15-035

FIG. 1. Map of San José del Nus, Antioquia, Colombia, indicating sampling sites of *Kinosternon leucostomum postinguinale* in this study.

Given the lack of information on the southern subspecies, *K. l. postinguinale*, we monitored a population inhabiting the Corregimiento San José del Nus, Departmento de Antioquia, Colombia. During four field trips in 2013–2014 we trapped turtles in four creeks that drain into the Nus River. Herein we report on the morphometrics of this subspecies and test for differences associated with sex and creek of origin. We identify and quantify the diet at each site from fecal samples and quantify the population abundance, structure, and the sex ratios. We also describe habitat quality by identifying and quantifying the aquatic macroinvertebrates and some physical parameters of each creek to discuss potential relationships between habitat, morphology, and diet. In spite of its wide distribution in Colombia, *K. l. postinguinale* populations have not been studied, so we provide new information on the biology of this southern subspecies. We expect this information will contribute to the understanding of conservation status for this species and provide insight for future management plans at the local and national levels.

MATERIALS AND METHODS

Site Description.—We conducted this study in Corregimiento San José del Nus, Municipio San Roque, Departmento de Antioquia, Colombia. San José del Nus has an average temperature of 23.3°C; two rainy seasons, April–May and October–November; and two dry seasons, January–March and July–September. The main land use is cattle grazing (Corporación Autónoma Regional de las Cuencas de los Ríos Negro y Nare, CORNARE, 2012).

Habitats.—We trapped turtles in four shallow creeks that drain into the Nus River during four field trips of 4–7 days each: Barrio Nuevo, Puente Tierra, Totumo, and Vega (Fig. 1). The Nus River drains into the Magdalena River, a Caribbean drainage. Trips were done in June, August, and October 2013 and in April 2014. To characterize the four creeks, we measured four variables at each site: water velocity (m/s), water depth (cm), transparency (percentage of visibility of the water depth), and water temperature (°C) recorded between 0700–0900 h. To determine water velocity, we measured the time it took for a leaf to drift 5 m downstream. To measure water depth, we used a pole and a metric tape in the deepest point, where the traps were then set. We used a Secchi disk to measure water transparency and a thermometer submerged 30 cm for 1 min to measure temperature.

Because populations of the same species may have different feeding habits, depending on habitat quality (Vogt and Guzman, 1988), we also surveyed the aquatic macroinvertebrates of each creek (indicative of water quality). These organisms have relatively long life cycles and are widely distributed and sedentary; therefore, their presence is considered to correspond with their tolerance of the water quality (Roldán-Pérez, 1999; Aguirre-Ramírez and Caicedo-Quintero, 2013). For this purpose we collected all macroinvertebrates present in the water with a nylon fish net during 1 h in a 10-m long transect along the shoreline at each trapping site. We separated all collected macroinvertebrates from organic material, stored them in 70% ethanol, and transported them to the lab to be identified to the lowest taxonomic level possible. We used a taxonomic key of the most-commonly found macroinvertebrate families in Antioquia, Colombia (Roldán-Pérez, 1988). We assigned a tolerance score to each family and placed the sum of all scores into six habitat quality categories: <15 indicated the water is critically polluted, 16–36 very polluted, 36–60 moderately polluted, 61–100 slightly polluted, 101–150 clean, and >150 very clean (Roldán-Pérez, 1999).

Turtle Sampling.—Because our objective was to trap the largest number of individuals possible, we set 2, 1, 4, and 3 traps on Barrio Nuevo, Puente Tierra, Totumo, and Vega creeks, respectively, depending on water depth in each creek. We captured turtles using hand-made hoop traps (175 cm long × 80 cm in diameter) from 3-inch fishing-net mesh. We baited the traps with small pieces of fresh pork viscera (lung, liver, heart, or spleen), checked them every morning, and replaced the baits daily. All captured turtles were taken to a nearby fish culture station, property of the Universidad de Antioquia (6°29′23′′N, 74°59′24′′W) (Web Coverage Service [WCS], Bogotá), for processing.

TABLE 1. Average physical and water quality characteristics calculated from the number of macroinvertebrate families observed at each creek where *Kinosternon leucostomum* was captured (* indicates that the minimum and maximum values are reported when there were 2+ sampling sites; n = number of sampling sites at each creek).

Variable	Barrio Nuevo (n = 2)	Puente Tierra (n = 1)	Totumo (n = 4)	Vega (n = 3)
Water velocity, m/s (range)	0.09 (0–0.19)	0.06 (0.04–0.07)	0.08 (0–0.25)	0.25 (0.21–0.30)
Water depth, cm (range)	29.4 (8–50)	34.5 (21–48)	100.6 (29–184)	53.5 (24–104)
Transparency, % (range)	23 (8–40)	84 (79–95)	36.3 (13–100)	44 (16–100)
Water temperature, °C (range)	24.5	23.3 (24–22.5)	23.2 (23–24)	23.2 (21.5–26)
Number of macroinvertebrate families	1–2*	12	5–10*	6–11*
BMWP index	10–11*	84	32–67*	40–76*
Water quality	Heavily contaminated	Slightly polluted	Slightly to moderately polluted	Slightly to moderately polluted

We cleaned, weighed (g), measured, and marked turtles by notching the carapace (Cagle, 1939). We also photographed them with a digital camera (Nikon Coolpix P510) set on a tripod to confirm identification when recaptured. We took linear and curved measurements of the carapace and plastron along the medial axis with a Brown & Sharpe 30 cm (12 inch) digital caliper (Hexagon Manufacturing Intelligence, North Kingstown, Rhode Island, U.S.A.) to the nearest 0.01 mm and with a metric tape to the nearest 1 mm, respectively.

Diet.—As a defensive mechanism, turtles usually defecate when being manipulated; therefore, feces were collected directly from the cloacal orifice or from the plastic containers in which they were temporally housed for 1–3 h. Each collected sample was preserved in 70% ethanol to examine dietary content. All fecal samples were refrigerated until their arrival at the Escuela de Veterinaria at the Universidad de Antioquia. Once in the Parasitology Lab, feces were separated into five categories: plant material (leaves, stems, seeds), gastropods (snails), insects, algae, and unidentified items. Individuals of Gastropoda were identified to the species level by a specialist from the Programa de Estudio y Control de Enfermedades Tropicales (PECET) at the Universidad de Antioquia, and insects were identified to the family level following the taxonomic key of a guide to the macroinvertebrates of Antioquia (Roldán-Pérez, 1988). Algae were identified by a specialist from the herbarium of the Universidad de Antioquia.

Data Analyses.—Morphological data were normally distributed except for body weight and linear carapace width of females. To test for sexual dimorphism and morphological differences associated with habitat quality, we used an analysis of variance (ANOVA) for data that were normally distributed and a Kruskal-Wallis test for data not normally distributed. To test for differences in the diet associated to the habitat of origin, we used the overall sex ratio as the null hypothesis. Pairwise comparisons were tested using a Bonferroni-corrected alpha ($0.05/6 = 0.0083$). To test for differences in linear carapace length (LCL) and body weight (BW) distributions of males and females, we used a Kolmogorov-Smirnov test. All data analyses were completed with R 3.1.1 software (R Core Team, 2014).

RESULTS

Turtle Habitats.—All four creeks were perennial streams and their channels were shallow and slow moving ($\leq$1.8 m deep, $\leq$0.3 m/s); however, during the rainy season the water volume may increase drastically and form temporary waterfalls which may flood nearby cattle pastures. We estimated physical parameters (Table 1) and a water contamination index based on the identified macroinvertebrate families (Appendix 1) for each creek.

Barrio Nuevo Creek takes its name from a human settlement along the creek and a railroad line; residents use this creek for sewage disposal. Accordingly, the biological monitoring working party (BMWP) scores (Appendix 1) indicated this creek to be heavily polluted, the worst water quality of all four creeks. Puente Tierra Creek was the shortest of the four study creeks, originating in a small gallery forest and draining into Vega Creek; we set up only one trap because the creek was too shallow. The BMWP score in this creek suggested a slightly polluted water quality. Totumo Creek was surrounded by open areas of cattle pasture and fed a small pond that was densely covered by a patch of gallery forest. The BMWP index suggested a slightly polluted to very polluted water quality. Finally, Vega Creek also was surrounded by cattle pastures and had the fastest water velocity of all the creeks. The BMWP index suggested the water quality of this creek was slightly to moderately polluted.

Population Structure and Sex Ratio.—We recaptured 12 of the total 80 turtles. Most of the time turtles were captured in traps ($n = 79$, 85.9%), but several were opportunistically captured by hand ($n = 13$, 14.1%). Totumo Creek was the site with the highest number of turtles captured ($n = 35$, with 8 recaptures) followed by Barrio Nuevo ($n = 21$, with 1 recapture), Vega ($n = 18$, with 1 recapture), and Puente Tierra ($n = 6$, with 2 recaptures). We opportunistically captured turtles by hand in Barrio Nuevo and Vega ($n = 6$ and 7, respectively) but none in the other two creeks. The capture success (number of turtles captured per trap per day) was 0.67, 0.58, 028, and 0.46 for Totumo, Barrio Nuevo, Vega, and Puente Tierra, respectively.

TABLE 2. Abundance and sex distribution of *Kinosternon leucostomum* in San José del Nus, Antioquia, Colombia. Abbreviation: NA = not applicable due to low sample size.

Creek	Males	Females	Total	Male-biased structure?
Barrio Nuevo	16	5	21	Yes ($\chi^2 = 5.7619$, df = 1, $P = 0.0163$)
Puente Tierra	4	2	6	NA
Totumo	24	10	35	Yes ($\chi^2 = 4.8286$, df = 1, $P = 0.0279$)
Vega	11	5	18	No ($\chi^2 = 2.25$, df = 1, $P = 0.1336$)
Total	55	22	80	Yes ($\chi^2 = 13.254$, df = 1, $P = 0.0002$)

TABLE 3. Sexual dimorphism of *Kinosternon leucostomum* in San José del Nus, Antioquia, Colombia. Abbreviations: BW = Body weight (g), LCL = Linear carapace length (mm), LCW = linear carapace width (mm), LPL = linear plastron length (mm), CCL = curved carapace length (mm), CCW = curved carapace width (mm). Sexual dimorphism was significantly male biased in all variables ($P < 0.001$).

	Females (n = 23)				Males (n = 54)				
Variable	Mean	Min	Max	SD	Mean	Min	Max	SD	Male-biased sexual size dimorphism
BW	201.4	100.0	382.6	60.2	285.5	125.0	475.0	83.5	29.5% heavier
LCL	118.2	105.2	136.2	7.6	132.8	105.0	156.0	12.1	11% longer
LCW	75.8	67.6	95.5	7.0	83.4	66.0	117.1	8.6	9.1% wider
LPL	104.9	94.2	119.0	6.1	113.0	92.0	132.3	8.1	7.2% longer
CCL	132.0	118.0	148.0	8.9	154.1	117.0	188.0	14.6	14.4% longer
CCW	115.5	96.0	140.0	10.3	125.9	93.0	152.0	12.7	8.3% longer

The overall observed sex ratio (28 male : 11 female) was 2.5 : 1, which deviated significantly from an expectation of 1 : 1. This highly masculinized sex ratio was observed overall and at two creeks, Barrio Nuevo and Totumo (Table 2). The small number of turtles captured at Puente Tierra precluded analysis of the sex ratio at that site.

Turtle Morphology.—Body measurements of adult turtles are summarized in Table 3. The smallest individual was a neonate captured by hand on the beach of Vega Creek on June 11, 2013. It had an LCL = 35.3 mm, linear carapace width (LCW) = 25.8 mm, linear plastron length (LPL) = 27.5 mm, and it weighed 6.4 g.

We found significant sexual size dimorphism with males being heavier, longer, and wider than females (Table 3). The LCL and BW distributions of males and females differed significantly ($P < 0.001$ for LCL and $P < 0.001$ for BW; Fig. 2). Most males measured between 120–150 mm of LCL while most females measured between 110–130 mm.

Given the habitat differences among the four creeks, we tested for morphological differences related to the creek of origin. Overall, turtles from Barrio Nuevo were heavier, longer, and wider than were turtles from Totumo Creek (Table 4). This was interesting given that aquatic macroinvertebrates found in Barrio Nuevo Creek categorized it as heavily contaminated, yet the turtles were the largest. On the other hand, Totumo Creek was the site with the highest number of captures (see below) but the turtles were the smallest.

Diet.—Of the 80 turtles captured, we collected a fecal sample from 40 individuals. From this total, 65% had consumed plant material (seeds, leaves, roots, or flower parts), 50% consumed insects, 35% consumed snails, 17.5% consumed algae, and 17.5% consumed unidentified or animal material (e.g., shed skin,

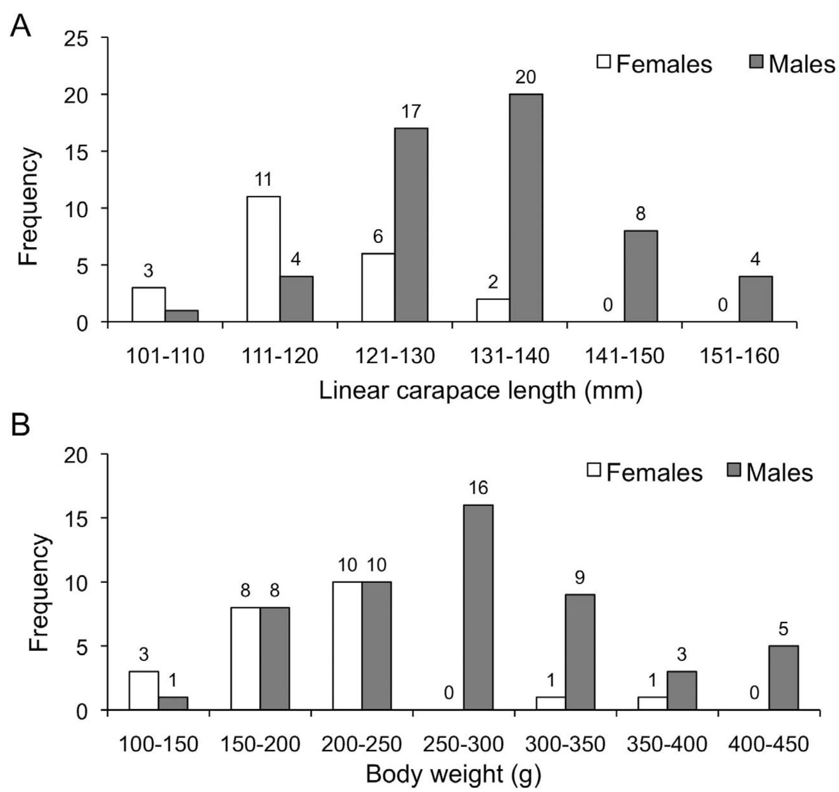

FIG. 2. Size class (A) and body weight (B) distributions of a population of *Kinosternon leucostomum postinguinale* in San José del Nus, Antioquia, Colombia.

TABLE 4. Geographic differences in the morphometrics of *Kinosternon leucostomum* in four creeks in San José del Nus, Antioquia, Colombia. Significant geographic differences were found in all variables.

	Group means					
Variable	Barrio Nuevo (BN) ($n = 21$)	Puente Tierra (PT) ($n = 6$)	Totumo (T) ($n = 34$)	Vega (V) ($n = 16$)	Geographic differences	Pairwise comparisons
BW	331.0	240.0	221.0	263.0	($P < 0.001$)	BN > T ($P < 0.001$)
LCL	138.3	122.4	124.8	126.3	($P < 0.001$)	BN > T ($P = 0.0001$), BN > V ($P = 0.0061$)
LCW	87.0	77.3	79.3	79.4	($P = 0.0041$)	BN > T ($P = 0.0063$)
LPL	116.6	106.1	104.8	110.4	($P = 0.0193$)	None
CCL	157.6	140.0	143.1	148.1	($P = 0.0071$)	BN > T ($P = 0.0064$)
CCW	130.2	115.7	118.1	126.7	($P = 0.0009$)	BN > T ($P = 0.0017$)

unidentified muscle tissue). Specifically, we identified six insects: leafcutter ants *Atta* sp. ($n = 15$ turtles) as well as individuals, or parts, of Gyrinidae ($n = 3$), Gerridae ($n = 1$), Gryllidae ($n = 1$), Odonata ($n = 1$), and Hebridae ($n = 1$). Snail (Gastropoda) shells were barely digested, so we identified them to the species level: *Melanoides tuberculata* ($n = 12$), *Pomacea palmeri* ($n = 4$), *Subulina octona* ($n = 1$), *Aroapyrgus* sp. ($n = 1$), and *Marisa cornuarietis* ($n = 1$). The only green alga identified was *Spirogyra* sp. ($n = 4$).

To account for the observed strong male-biased sex ratio, we tested for diet differences associated with sex and the habitat of origin. We did not find sexual differences in the consumption of plant material ($n_{\text{males}} = 22$, $n_{\text{females}} = 4$, $\chi^2 = 2.11$, $P = 0.146$), insects ($n_{\text{males}} = 14$, $n_{\text{females}} = 6$, $\chi^2 = 0.031$, $P = 0.858$), snails ($n_{\text{males}} = 10$, $n_{\text{females}} = 4$, $\chi^2 < 0.001$, $P = 0.976$), or algae ($n_{\text{males}} = 3$, $n_{\text{females}} = 3$, $\chi^2 = 0.34$, $P = 0.559$). To test for geographic differences, our null hypothesis tested the overall frequency of the five food types (proportions of each category out of all 74 food items found in all creeks: 0.35 plant material, 0.27 insects, 0.19 snails, 0.095 algae, and 0.095 unidentified items). The analysis was repeated for each creek. Food type occurrence in Barrio Nuevo ($\chi^2 = 22.58$, df = 4, $P = 0.0001$), Puente Tierra ($\chi^2 = 86.87$, df = 4, $P < 0.0001$), and Vega ($\chi^2 = 58.47$, df = 4, $P < 0.001$) differed from the overall percentages, but not those in Totumo Creek ($\chi^2 = 4.85$, df = 4, $P = 0.30$). In Barrio Nuevo, snails were consumed almost twice (35%) as much as overall (Fig. 3). In Puente Tierra, algae were consumed more than three times (33%) as much as overall, and no snails were found. In Vega, the main food type was plant material (56%) and no algae were found.

DISCUSSION

The habitat of *K. l. postinguinale* in northern Colombia was highly variable. This turtle can live in heavily contaminated environments that receive wastewater and garbage from rural human settlements but also in muddy habitats, cleaner water with abundant vegetation shading the stream, or in creeks with rocks and fast-flowing water. Interestingly in this region, this turtle also persists where waterfalls with a strong current form during the rainy seasons, and these relatively small turtles manage not to be washed away, as suggested from our recaptures (6.7%). A similar habitat with cascades was reported for this same subspecies in Costa Rica (Acuña-Mesén, 1993).

Body size was smaller than in other populations of the same subspecies and of the species overall. For example, on average we found an LCL of 132.8 and 118.2 mm for males and females, but *K. l. postinguinale* in Costa Rica is larger, measuring 174 and 158 mm, respectively (Acuña-Mesén, 1993). Similarly, maximum LCL for males and females was 156 mm and 136 mm, respectively, while the maximum LCL reported for the species

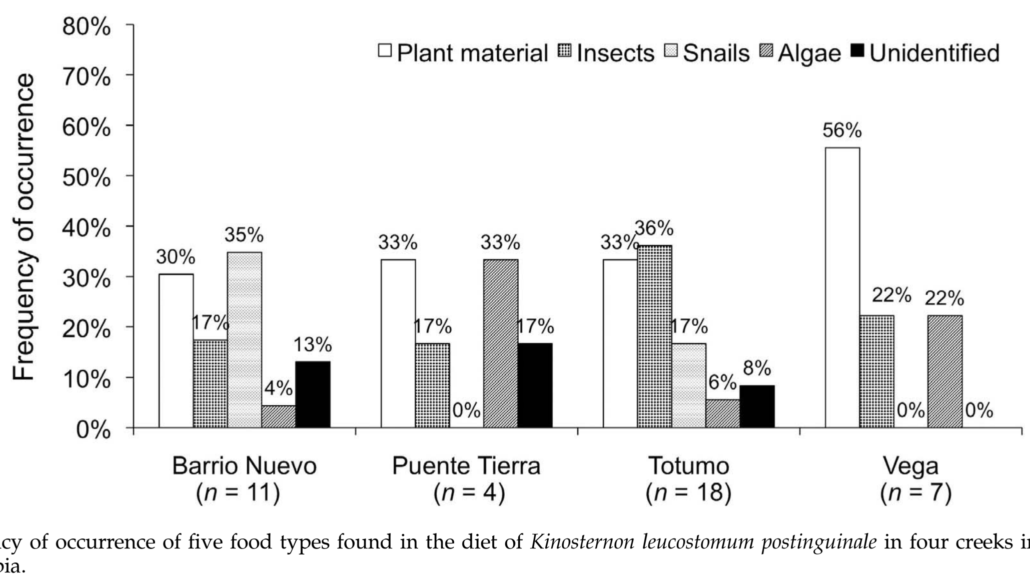

FIG. 3. Frequency of occurrence of five food types found in the diet of *Kinosternon leucostomum postinguinale* in four creeks in San José del Nus, Antioquia, Colombia.

is larger (175 mm and 165 mm, respectively; Berry and Iverson, 2001). Body size can vary with genetics, but also with the diet, which in turn depends on food availability (Vogt and Guzman, 1988; Moll, 1990). Indeed, the larger individuals in our study came from Barrio Nuevo Creek, the most-heavily contaminated habitat; however, the main component of the diet at this stream was snails, which are higher in protein than are insects and plant material (mean nitrogen contents of *Melanoides tuberculata* and freshwater angiosperms = 9% and 2.4% dry weight, respectively; Duarte, 1992; Mehler and Acharya, 2014). In addition, the smaller and lighter individuals came from Totumo Creek, where plant material and insects constituted 70% of the diet.

Our findings agree with other studies that reported *K. l. leucostomum* as an omnivorous generalist (i.e., they consume insects, snails, fish, seeds, fruits, leaves, and even carrion in México, northern Belize, and Costa Rica; Moll and Legler, 1971; Vogt and Guzman, 1988; Moll, 1990; Acuña-Mesén, 1993). Other authors have suggested that this species is primarily carnivorous and eats plant material when meat is not available (Medem, 1962). We did not find sexual differences in diet, suggesting both sexes are similarly generalists or opportunists. Finding aquatic snails and algae in their diet suggests they eat in the water, as suggested by Medem (1962) and Moll and Legler (1971). We also found terrestrial leafcutter ants in the diet, however, and given the opportunistic nature of this species and that it frequently moves on land (Moll and Legler, 1971; Morales-Verdeja and Vogt, 1997), it may feed on land as well (Acuña-Mesén, 1993).

We found a strong male-biased sex ratio (55 : 22) overall as well as locally at the two sites with the most turtles trapped: Barrio Nuevo (16 : 5) and Totumo (24 : 10). Factors that may help explain the observed male-biased sex ratio of this population include differential mortality, differential migration, biased primary sex ratios, and even sexual size dimorphism of the species (Gibbons, 1990; Girondot and Pieau, 1993; Lovich et al., 2014). Regardless of the reason, the situation is of critical concern as it suggests a serious risk of population extirpation. And there is precedent for this concern: A population of *Clemmys insculpta* in the United States, monitored for 20 yr, revealed a reduction in the number of females and an increase in age associated with human development until the turtle population disappeared (Garber and Burger, 1995). We urge further monitoring of the demography and reproduction of this population, especially regarding the number of eggs and clutches produced and the specific mechanism of sex determination.

Acknowledgments.—We thank our undergraduate students and the staff of the Estación Piscícola in San José del Nus, particularly O. Franco, for logistical support during fieldwork. J. F. Toro granted us access to the Experimental Station El Nus of Corpoica. We thank L. E. Velásquez from the PECET for gastropod identification and F. Cardona for algae identification. This study was sponsored by a research grant from Comité para el Desarrollo de la Investigación CODI-Regionalización 2012 to CC, and the Programa de Sostenibilidad 2013–2015 of the Universidad de Antioquia. This research was approved by the Comité de Ética para la Experimentación con Animales of the Universidad de Antioquia as stated in Act 85 of 2013 and research permit 135–0079 issued by the local government authority CORNARE in 2012.

Literature Cited

Acuña-Mesén, R. A. 1993. Las tortugas continentales de Costa Rica. ICER, Costa Rica.

Aguirre-Ramírez, N. J., and O. Caicedo-Quintero. 2013. Métodos de Campo y Laboratorio para Hidrobiología Sanitaria. Reimpresos, Universidad de Antioquia, Colombia.

Berry, J. F., and J. B. Iverson. 2001. *Kinosternon leucostomum* (Duméril and Bibrón) White-lipped Mud Turtle. Catalogue of American Amphibians and Reptiles 724:721–728.

Cagle, F. R. 1939. A system of marking turtles for future identification. Copeia 1939:170–173.

CORNARE. 2012. Evaluación y zonificación de riesgos por avenida torrencial, inundación y movimiento en masa y dimensionamiento de procesos erosivos en el municipio de San Roque. CORNARE, Colombia.

Duarte, C. M. 1992. Nutrient concentration of aquatic plants: patterns across species. Limnology and Oceanography 37:882–889.

Duméril, A. M. C., and A. H. A. Duméril. 1851. Catalogue Méthodique de la Collection des Reptiles (Muséum d'Histoire Naturelle de Paris). Gide and Baudry, France.

Ernst, C. H., R. G. M. Altenburg, and R. W. Barbour. 1997. Turtles of the World. World Biodiversity Database [Internet]. Available from: http://wbd.etibioinformatics.nl/bis/turtles.php. Accessed 16 February 2015.

Garber, S. D., and J. Burger. 1995. A 20-yr study documenting the relationship between turtle decline and human recreation. Ecological Applications 5:1151–1162.

Gibbons, J. W. 1990. Sex ratios and their significance among turtle populations. Pp. 171–182 in J. W. Gibbons (ed.), Life History and Ecology of the Slider Turtle. Smithsonian Institution Press, USA.

Giraldo, A., M. F. Garces-Restrepo, and J. L. Carr. 2012. *Kinosternon leucostomum*. Pp. 332–339 in V. P. Páez-Nieto, M. A. Morales-Betacourt, C. A. Lasso, O. V. Castaño-Mora, and B. Bock (eds.), V. Biología y Conservación de las Tortugas Continentales de Colombia. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH), Colombia.

Girondot, M., and C. Pieau. 1993. Effects of sexual differences of age at maturity and survival on population sex-ratio. Evolutionary Ecology 7:645–650.

IUCN. 2015. The IUCN Red List of Threatened Species. Version 105–3: an online reference. International Union for Conservation of Nature. Available from: http://www.iucnredlist.org. Accessed 14 October 2015.

Iverson, J. B., M. Le, and C. Ingram. 2013. Molecular phylogenetics of the mud and musk turtle family Kinosternidae. Molecular Phylogenetics and Evolution 69:929–939.

Lovich, J. E., J. W. Gibbons, and M. Agha. 2014. Does the timing of attainment of maturity influence sexual size dimorphism and adult sex ratio in turtles? Biological Journal of the Linnean Society 112:142–149.

Medem, F. 1962. La distribución geográfica y ecología de los Crocodylia y Testudinata en el Departamento del Chocó. Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales 11:279–303.

Mehler, K., and K. Acharya. 2014. Size distribution and nutrient excretion of *Melanoides tuberculata* in a southern Nevada spring ecosystem. Western North American Naturalist 74:386–395.

Moll, D. 1990. Population sizes and foraging ecology in a tropical freshwater stream turtle community. Journal of Herpetology 24:48–53.

Moll, E. O., and J. M. Legler. 1971. The life history of a Neotropical slider turtle, *Pseudemys scripta* (Schoepff) in Panama. Bulletin of the Los Angeles County Museum of Natural History Science 11:1–102.

Morales-Verdeja, S. A., and R. C. Vogt. 1997. Terrestrial movements in relation to aestivation and the annual reproductive cycle of *Kinosternon leucostomum*. Copeia 1997:123–130.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available from: http://www.R-project.org/

Roldán-Pérez, G. 1988. Guía para el Estudio de los Macroinvertebrados Acuáticos del Departamento de Antioquia. Fondo para la Protección del Medio Ambiente "José Celestino Mutis" (FEN Colombia) y COLCIENCIAS, Colombia.

Roldán-Pérez, G. 1999. Los macroinvertebrados y su valor como indicadores de la calidad del agua. Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales 23:375–387.

Spinks, P. Q., R. C. Thomson, M. Gidiş, and H. B. Shaffer. 2014. Multilocus phylogeny of the New-World mud turtles (Kinosternidae) supports the traditional classification of the group. Molecular Phylogenetics and Evolution 76:254–260.

van Dijk, P. P., J. B. Iverson, A. G. J. Rhodin, H. B. Shaffer, and R. Bour. 2014. Turtles of the world, 7th edition: annotated checklist of taxonomy, synonymy, distribution with maps, and conservation status. Chelonian Research Monographs 5:329–479.

Vogt, R. C., and S. G. Guzman. 1988. Food partitioning in a Neotropical freshwater turtle community. Copeia 1988:37–47.

Accepted: 5 January 2016.

Appendix 1. Aquatic macroinvertebrate families identified at each of the 10 trapping sites in Barrio Nuevo, Puente Tierra, Totumo, and Vega creeks and the BMWP scores (Roldán-Pérez, 1999) assigned to each family to estimate water quality of the creek.

	Barrio Nuevo		Puente Tierra	Totumo				Vega		
Macroinvertebrate	1	2	3	4	5	6	7	8	9	10
Aeshnidae	-	-	-	-	-	6	-	-	-	-
Belostomatidae	5	-	5	-	-	-	5	-	-	-
Calopterygidae	-	-	7	-	-	-	-	-	7	7
Coenagrionidae	-	-	-	-	7	7	-	-	-	7
Corixidae	-	-	7	-	-	-	-	-	7	-
Dytiscidae	-	-	-	-	9	-	-	-	-	-
Elmidae	-	-	-	6	-	-	-	6	-	-
Ephemerellidae	-	-	-	-	-	-	-	-	9	-
Gelastocoridae	-	-	-	-	-	-	-	5	5	5
Gerridae	-	-	8	-	8	8	8	8	8	-
Gomphidae	-	-	10	-	10	10	-	-	-	10
Gyrinidae	-	-	9	-	-	-	9	-	1	-
Hebridae	-	-	-	8	-	-	8	-	-	-
Hidrometridae	-	-	-	-	-	4	-	-	-	-
Hydropsychidae	-	-	7	-	-	-	-	-	-	-
Libellulidae	6	-	6	6	6	6	-	-	6	6
Mesovelidae	-	-	-	5	-	-	-	-	5	-
Naucoridae	-	-	7	-	7	7	-	-	-	-
Nepidae	-	-	-	-	-	-	-	-	5	5
Noteridae	-	-	4	-	-	4	-	-	-	-
Notonectidae	-	-	-	7	7	-	7	-	7	-
Planariidae	-	-	-	-	-	-	-	7	-	-
Pleidae	-	-	-	-	-	-	-	8	-	-
Ptylodactylidae	-	10	-	-	-	-	-	-	-	-
Saldidae	-	-	-	-	-	-	-	-	8	-
Scirtidae	-	-	-	-	7	7	-	-	-	-
Staphylinidae	-	-	6	-	-	-	6	-	-	-
Veliidae	-	-	8	-	-	8	8	8	-	-
Total BMWP	11	10	84	32	61	67	51	42	68	40
Water quality	Heavily polluted		Slightly polluted	Slightly to very polluted					Slightly to moderately polluted	