Food Webs 21 (2019) e00127

Contents lists available at ScienceDirect

Food Webs

journal homepage: www.journals.elsevier.com/food-webs

Short communication

Relationship between vegetation cover and feeding areas of jaguars (*Panthera onca*) on sea turtles in Santa Rosa National Park, Costa Rica

Brayan H. Morera-Chacón *, Ana C. Posadas-García, José Manuel Mora-Benavides, Eduardo Carrillo

Instituto Internacional en Conservación y Manejo de Vida Silvestre, Universidad Nacional, Heredia, Costa Rica

ARTICLE INFO

Article history:
Received 18 May 2019
Accepted 15 October 2019

Keywords:
Nancite beach
Olive ridley sea turtle
Carcasses density
Dense vegetation

ABSTRACT

Several factors determine the distribution of areas in which jaguars feed on sea turtles. Different studies have evaluated the relationship of feeding sites with the distribution of human activity on the beach, distribution of nesting female turtles, interactions and territorial behaviors among jaguars and scavenger's presence. However, no study has evaluated the relationship of jaguar feeding areas with vegetation cover. We calculate de density of sea turtle's carcasses in plots demarked in Nancite beach at Santa Rosa National Park, Costa Rica. The average of carcasses density was 33.79/ha (CI 95% = 19.12–48.46) and the average percentage of vegetation cover was 55.62% (CI 95% = 41.84–69.41). We found a positive relationship between density of carcasses and percentage of vegetation cover. The variation in the density of carcasses was explained in a 21.4% by the vegetation cover. The vegetation cover contributes to the complex nature of food webs, and describing the relationships of this with food webs can provide relevant information for the design of future studies, wildlife management and conservation.

The jaguar (*Panthera onca*) is considered an opportunistic predator that can subsist with a wide variety of prey, but prefer medium and large size ones (López-González and Miller, 2002). Sea turtles are part of the jaguar's diet where it predates on five species: green (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), and leatherback (*Dermochelys coriacea*) turtles (Arroyo-Arce et al., 2017; Autar, 1994; Carrillo et al., 1994; Fretey, 1977). In Santa Rosa National Park (SRNP) in northwestern Costa Rica, the jaguar preys on green sea turtle and olive ridley sea turtle (Carrillo et al., 1994), these species are an important food source for the jaguar because they are easy to hunt and they have a high biomass (Alfaro et al., 2016). Additionally, in Nancite beach in the SRNP, thousands of olive ridleys sea turtles nest massively during “arribadas” on some months but also lonely throughout the year (Cornelius, 1986), being an abundant food source for jaguars.

Factors such as distribution of human activity, distribution of nesting female turtles, interactions and territorial behaviors among jaguars, scavengers presence in, determine the feeding areas of jaguars on sea turtles (Alfaro et al., 2016; Arroyo-Arce and Salom-Pérez, 2015; Escobar-Lasso et al., 2017, 2016b; Verissimo et al., 2012). Escobar-Lasso et al. (2017) described that on the Nancite beach, on SRNP, human activity and the distribution of nesting turtles influence synergistically to determine two feeding hotspots at the north and south extremes of the beach. Also, after killing sea turtles, jaguars dragged the carcasses into dense vegetation near to the beach to hide them from scavengers (Guilder et al., 2015). At Nancite, there was reported 12 species scavenging on sea turtle carcasses, including several jaguars (Escobar-Lasso et al., 2016b, 2016a). Vultures took more days to find turtle carcasses when the jaguars dragged them more distance and jaguars fed on sea turtles carcasses for more days when vultures took more days to find turtle carcasses (Escobar-Lasso et al., 2016b).

Another factor that could influence the feeding areas of jaguars on sea turtles is the vegetation cover. Escobar-Lasso et al. (2017) raised the possible relationship between drag distance and vegetal cover, where a less dense cover demands a greater distance to hide the carcasses. We evaluated the relationship between the density of marine turtle carcasses predated by jaguars and the vegetation cover at Nancite beach, SRNP. Specifically, we investigated whether the density of carcasses of sea turtle preyed by jaguars varies according to the canopy cover.

We marked 18 plots on Nancite beach, SRNP on 17 August 2018 (Fig. 1) to estimate density of turtle carcasses. Twelve plots had an area of 0.04 ha, 3 had 0.024 ha and 3 had 0.02 ha for a total of 0.612 ha. The size of the plots varied to adjust them to the strip of vegetation that exists between the beach and the edge of the mangrove forest. In each plot we counted the carcasses to estimate the density of turtles predated (number of carcasses/ha), assuming that all were predated by jaguars (Fig. 2). In each plot we took 2 pictures of the canopy to calculate the average percentage of vegetation cover. The

* Corresponding author.
E-mail address: morera.b91@gmail.com (B.H. Morera-Chacón).

https://doi.org/10.1016/j.fooweb.2019.e00127
2352-2496/

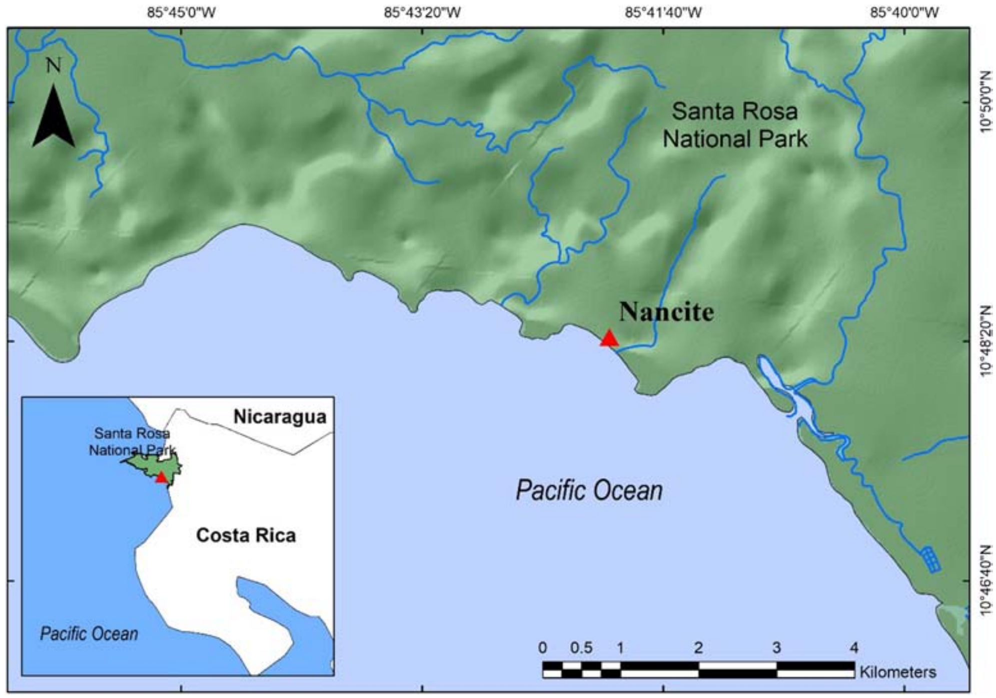

Fig. 1. Nancite beach, Santa Rosa National Park, northwestern Costa Rica.

photographs were analyzed with ImageJ software (Schneider et al., 2012). We performed a linear regression between the response variable (carcass density) and the explanatory variable (percentage of vegetation cover).

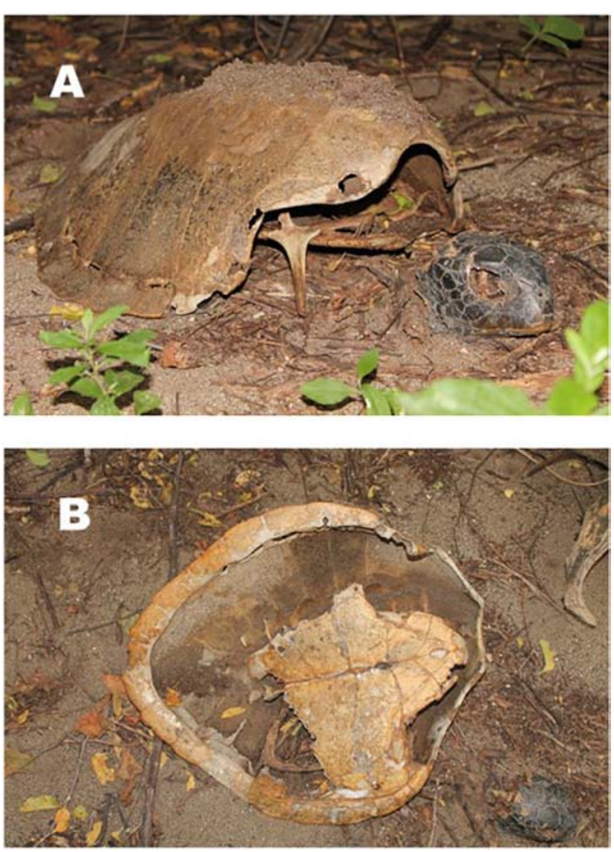

Fig. 2. Olive ridley sea turtle carcasses preyed by jaguar.

We found a total of 18 carcasses, all belonging to olive ridley sea turtles. The average of density carcasses for the study area was 33.79 carcasses/ha (CI 95% = 19.12–48.46). The average percentage of vegetation cover in the plots was 55.62% (CI 95% = 41.84–69.41). We found a positive relationship between density of carcasses and percentage of vegetation cover, the density increased significantly on 0.53 carcasses/ha per each percent of vegetation cover ($Z = 0.53$, $df = 16$, $P < 0.05$) (Fig. 3). The variation in the density of carcasses was explained in a 21.4% (R2) by the vegetation cover.

Our results show how vegetation cover is an important factor that influences the distribution of jaguar feeding areas. According to Guilder et al. (2015), the jaguars drag the carcasses into dense vegetation to hide them from the scavengers. Our results support this fact showing a positive relationship between the density of carcasses and the percentage of vegetation cover: jaguars dragged more turtles towards denser vegetation. Vegetation at Nancite possibly is denser at higher distances from the beach. This could explain in a more direct way the fact that vultures took more days to find carcasses when jaguars dragged them a greater distance, and when jaguars fed on sea turtles

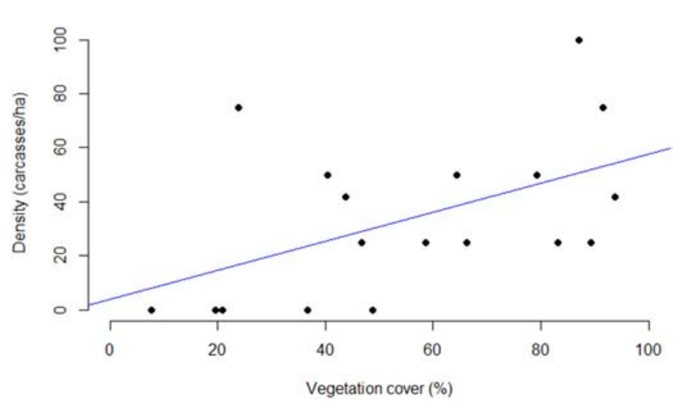

Fig. 3. Density of carcasses and vegetation cover relationship. Nancite beach, Santa Rosa National Park, Costa Rica.

carcasses for more days when vultures took more days to find it as reported by Escobar-Lasso et al. (2016b).

The vegetation cover contributes to the complex nature of food webs. The jaguar has a very high ecological value as a top predator, flag, umbrella and keystone species, and also provide carcasses to scavengers (Escobar-Lasso et al., 2016b). However, vegetation also plays a very important role in the food web influencing the distribution of jaguar feeding areas and regulating scavenging. Describing the relationships between vegetation and food webs can provide relevant information for the design of future studies, wildlife management and conservation.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

None.

References

Alfaro, L., Montalvo, V., Guimaraes, F., Saenz, C., Cruz, J., Morazan, F., Carrillo, E., 2016. Characterization of attack events on sea turtles (*Chelonia mydas* and *Lepidochelys olivacea*) by jaguar (*Panthera onca*) in Naranjo sector, Santa Rosa National Park, Costa Rica. Int. J. Conserv. Sci. 7, 101–108.

Arroyo-Arce, S., Salom-Pérez, R., 2015. Impact of jaguar *Panthera onca* (Carnívora: Felidae) predation on marine turtle populations in Tortuguero, Caribbean coast of Costa Rica. Rev. Biol. Trop. 63, 815–825. https://doi.org/10.15517/rbt.v63i3.16537.

Arroyo-Arce, S., Thomson, I., Harrison, E., Wilmott, S., Baker, G., 2017. First record of jaguar (*Panthera onca*) predation on a loggerhead sea turtle (*Caretta caretta*) in Tortuguero National. Herpetol. Notes 10, 17–18.

Autar, L., 1994. Sea turtles attacked and killed by jaguars in Suriname. Mar. Turt. Newsl. 67, 11–12.

Carrillo, E., Morera-Avila, R., Wong-Reyes, G., 1994. Depredación de tortuga lora (*Lepidochelys olivacea*) y de tortuga verde (*Chelonia mydas*) por el jaguar (*Panthera onca*). Vida Silvestre Neotropical 3, 48–49.

Cornelius, S., 1986. The Sea Turtles of Santa Rosa National Park. Fundación de Parques Nacionales, San José.

Escobar-Lasso, S., Gil-Fernández, M., Herrera, H., Fonseca, L., Carrillo, E., Sáenz, J., Wong, G., 2016a. Scavenging on sea turtle carcasses by multiple jaguars in northwestern Costa Rica. Therya 7, 231–239. https://doi.org/10.12933/therya-16-380.

Escobar-Lasso, S., Gil-Fernández, M., Saenz, J., Carrillo, E., Wong, G., Fonseca, L., 2016b. Inter-trophic food provisioning between sea and land: the jaguar (*Panthera onca*) as provider of sea turtle carcases to terrestrial scavengers. Int. J. Conserv. Sci. 7, 1081–1094.

Escobar-Lasso, S., Gil-fernández, M., Sáenz, J., Carrillo-jiménez, E., Wong, G., Fonseca, L., Gómez-Hoyos, D., 2017. Distribution and hotspots of the feeding areas of jaguars on sea turtles at a national park in Costa Rica. Neotropical Biology and Conservation 12, 2–11. https://doi.org/10.4013/nbc.2017.121.01.

Fretey, J., 1977. Cuases de motalite des tortues luth adults (*Dermochelys coriacea*) sur le littoral guayanais. Courrier de la Nature 52, 257–266.

Guilder, J., Barca, B., Arroyo-Arce, S., Gramajo, R., Salom-Pérez, R., 2015. Jaguars (*Panthera onca*) increase kill utilization rates and share prey in response to seasonal fluctuations in nesting green turtle (*Chelonia mydas mydas*) abundance in Tortuguero National Park, Costa Rica. Mamm. Biol. 80, 65–72. https://doi.org/10.1016/j.mambio.2014.11.005.

López-González, C.A., Miller, B.J., 2002. Do jaguars (*Panthera onca*) depend on large prey? West. N. Am. Nat. 62, 218–222.

Schneider, C.A., Rasband, W.S., Eliceiri, K.W., 2012. NIH image to ImageJ: 25 years of image analysis. Nat. Methods 9, 671–675.

Verissimo, D., Jones, D., Chaverri, R., Meyer, S., 2012. Jaguar *Panthera onca* predation of marine turtles: conflict between flagship species in Tortuguero, Costa Rica. Ory 46, 340–347. https://doi.org/10.1017/S0030605311001487.