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Analysis of People's Perceptions of Turtle Conservation Effectiveness for the Magdalena River Turtle *Podocnemis lewyana* and the Colombian Slider *Trachemys callirostris* in Northern Colombia: An Ethnozoological Approach

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Abstract

The endemic species *Podocnemis lewyana*, the Magdalena River turtle, is listed worldwide as one of the turtle species at highest risk of extinction, and *Trachemys callirostris*, the Colombian slider, is the most trafficked turtle species in Colombia. An ethnozoological approach was used to analyze people's attitudes and perceptions on the effectiveness of conservation programs for these species and to identify conservation measures that would contribute to turtle population sustainability. Available statistics on turtle trade were also used as complementary information. We interviewed local residents who were exposed ($n = 50$) and not exposed ($n = 50$) to turtle conservation initiatives. When evaluating the two focal turtle species, we found differences in direct use between people exposed and not exposed to conservation programs, where people exposed to conservation initiatives made less direct use of these focal species. However, when other sympatric turtle species were considered, there were no significant differences in levels of turtle exploitation between people exposed and not exposed to conservation programs. Thus, successfully reducing the consumption of a focal turtle species might lead to an increased use of other local turtle species. Almost all interviewed locals were aware of turtle population declines, with the perceived most serious risk to turtle species reported being habitat loss and degradation followed by human consumption. Regarding turtle trade, we did not find significant differences between the two groups. Illegal trade levels in 2010 were 6.5 greater compared to 2016. We propose several new directions for turtle management and conservation of these species.

Keywords

Testudinae, endemic species, freshwater turtles, local knowledge, turtle hotspot, turtle conservation

Introduction

An increased number of studies have attempted to evaluate the impact of different types of conservation programs directed at freshwater turtles from South America (Campos-Silva, Peres, Antunes, Valsecchi, & Pezzuti, 2017; Cantarelli, Malvasio, & Verdade, 2014; Hernández & Espín, 2006; Miorando, Rebêlo, Pignati, & Pezzuti, 2013; Norris, Michalski, & Gibbs, 2018; Schneider, Ferrara, Vogt, & Burger, 2011). The methodologies and conclusions of these studies vary enormously, even when analyzing the results from the same programs (Mogollones, Rodríguez, Hernández, & Barreto, 2010; Peñaloza, Hernández, & Espín, 2015). However, in the particular case of Colombia, no studies have been published to date that have attempted to measure whether conservation efforts there have or have not reversed trends of declining populations.

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Presently, 37% of freshwater and terrestrial turtle species in Colombia are listed as threatened (Morales-Betancourt, Lasso, Páez, & Bock, 2015), despite the fact that since 1964 legislation has existed to protect these species (Resolution No. 0219-1964 of the Ministry of Agriculture). The main causes of declines in Colombia are overexploited for human consumption, habitat loss or degradation, and the construction of hydroelectric power plants (Morales-Betancourt, Lasso, Trujillo, De La Ossa, Forero, and Páez, (2012), Morales-Betancourt, Lasso, Páez, Trujillo, Vargas-Ramírez, Forero-Medina, Hernández, and Trujullo (2012)). Recently, two species from northern Colombia were identified as high priorities for conservation (Forero-Medina et al., 2016; Morales-Betancourt, Lasso, et al., 2015, Morales-Betancourt, Páez, and Lasso, 2015). One is *Podocnemis lewyana* (Duméril, 1852), the Magdalena River Turtle. This endemic and critically endangered species is listed among the 25 tortoise and freshwater turtle species at highest risk of extinction in the world (Turtle Conservation Coalition [TCC], 2018). The other priority species is *Trachemys callirostris* (Gray, 1856), the Colombian slider. It is a species found only in northern Colombia and around Lake Maracaibo in northwest Venezuela (Bock et al., 2015). Nesting females experience intense hunting pressure in most areas of its distribution, and the species also suffers from habitat loss and degradation (Bock et al., 2012; MAVDT, 2009). In terms of the distributional ranges of *P. lewyana* and *T. callirostris* in Colombia, only 1.4% and 0.99%, respectively, of these areas lie within some form of protected natural areas (Forero-Medina, Yusti-Muñoz, & Castaño-Mora, 2014).

The primary literature on the biology of both of these species has been reviewed recently (Bock et al., 2012; Páez, Morales-Betancourt, Lasso, Castaño-Mora, & Bock, 2012). In addition, several action plans that include these species have been elaborated (Gallego-García & Forero-Medina, 2014; MAVDT, 2009; MMA, 2002), and different organizations also have produced educational materials as part of their conservation initiatives (MAVDT, 2012; Urrá, 2016). However, none of this body of literature focuses specifically on evidence that supports (or refutes) the effectiveness of the different management efforts that have been attempted.

For this reason, the goal of this study was to use an ethnozoological approach to analyze people's attitudes and perceptions regarding the effectiveness of turtle conservation management initiatives (TCMIs) in northern Colombia, especially those directed specifically toward *P. lewyana* or *T. callirostris*. We contrasted two groups of local people: those who had been exposed to and those who had not been exposed to TCMIs and evaluated the following questions: (a) According to people's perceptions, do turtle populations continue to decline irrespective of whether TCMIs have been attempted locally or not? (b) Are there significant differences in the levels of direct use of turtle species related to whether local people have been exposed or not to TCMIs? (c) Do local people believe habitat loss and degradation constitutes the greatest threat to local turtle populations (rather than overexploitation by themselves)? We hope that the results of this study will provide a baseline reference against which measures of the effectiveness of future conservation efforts may be compared.

Methods

Study Area

The study was conducted from April 2017 to October 2017 in northern Colombia (Figure 1). We conducted interviews in 37 sites located in the following departments and municipalities: Antioquia Department (Puerto Triunfo, Nechí, El Bagre, Zaragoza, Tarazá, Caucasia); Córdoba Department (Santa Cruz de Lorica, Purísima de la Concepción, Montería, Moñitos, San Bernardo del Viento, Planeta Rica, Pueblo Nuevo, Ciénaga de Oro, La Apartada); Sucre Department (Sincelejo); Bolívar Department (Magangué, Santa Cruz de Mompox, Bodega); and Cesar Department (La Jagua de Ibirico, Becerril, Curumaní, El Paso, Valledupar). The areas surveyed comprised localities where TCMIs were implemented ($n = 17$), in order to be contrasted with other sites where no conservation actions were carried out ($n = 20$). These contrasting locations were chosen to facilitate inspection of differences in local peoples' attitudes toward turtles and their perceptions concerning whether turtle populations were recovering, or at least were stable, in areas where TCMIs had been conducted. Thus, we used three criteria for selecting the studied localities: (a) sites that maintained populations of both focal turtle species, (b) sites where TCMIs had been carried out, and (c) other sites where no turtle conservation actions had been reported. All sites were located in northern Colombian in the Magdalena, Cauca, Nechí, Tarazá, San Jorge, and Sinú river drainages. The locations selected were georeferenced (datum = WGS84) by using a GPS Garmin Etrex 10 and then classified into two categories (local residents who were exposed and not exposed to TCMIs). In addition, each category was associated with a focal turtle species.

Data Collection

We used three different sources of information: (a) interviews of local residents in sites that had been exposed to TCMIs ($n = 50$) or sites not exposed to TCMIs ($n = 50$). Of these 100 people, 66 were men and 34 were women, made up of students aged 18 years or older (3%), teachers (11%), professionals (13%), fishermen (25%), housewives (17%), and other local people with nonprofessional occupations (31%); (b) information on the conservation

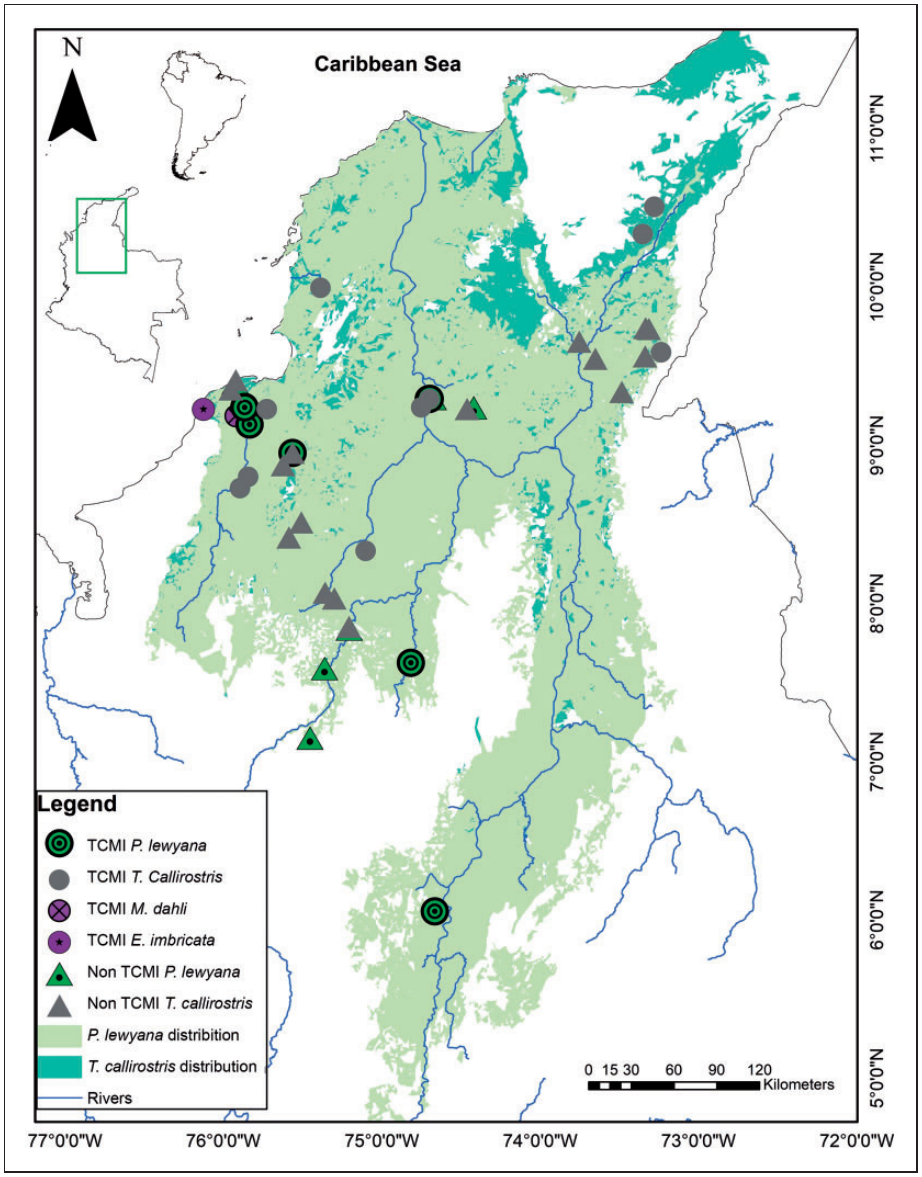

Figure 1. Survey area locations in a turtle hotspot situated in northern Colombia. Circles represent sites where local people had been exposed to turtle conservation management initiatives (TCMIs), and triangles symbolize sites where residents were not exposed. Differences in types of circles and triangles denote sites related to focal turtle species: *Podocnemis lewyana, Trachemys callirostris, Mesoclemmys dahlia*, and *Eretmochelys imbricata*.

strategies implemented in the former type of sites; and (c) data on confiscations provided by environmental authorities (Appendix A). Confiscation rates are imperfect indicators, which cannot be used to directly demonstrate the magnitude of trafficking, but they do indicate the presence of a problem; and when evaluated with additional information, they have the potential to provide insights into conservation problems that threaten the survival of turtle populations (United Nations Office on Drugs and Crime, 2016).

The interviews we employed were semistructured and focused on knowledge, use, relationships with turtles, and conservation actions. There was a different type of questionnaire for each source of information: local people ($N = 100$), conservation organization representatives ($N = 17$), and environmental authorities ($N = 12$). The questionnaires were conducted after having obtained a previous oral consent, guaranteeing voluntary participation and confidentiality about personal information. In addition, we also explained the purpose of the study in a written communication to those local people who inquired and to all organizations that have implemented TCMIs. We also sent a letter to all regional environmental authorities to formally request information regarding illegal turtle trade and about turtle conservation actions in their jurisdictions.

Data Analysis

Our qualitative analyses were basically descriptive. Our inquiry centered on responses about turtle declines, the main perceived threats, and the effectiveness of conservation programs (Appendix B. Information obtained through surveys was consolidated in terms of percentages and frequencies). Using Fisher's exact tests (Table 1), we determined whether factors such as exposure to TCMIs led to significant differences in rates of turtle exploitation, both by considering differences over time in (a) direct use of turtle species that were the focus of the local conservation programs and (b) direct use of other sympatric turtle species that had not been the focus of conservation projects. Statistical analyses were performed in R, Version 3.4.1 (R Development Core Team). Local authorities provided data for the period 2006 to 2017 on numbers of confiscated turtles, from which percentages and frequencies were calculated. Exploratory charts were used to establish patterns based on these annual confiscation data, and the results were associated with the ethnozoological data obtained in our interviews and with information reported in the literature.

Results

Perceptions of Population Declines and Threats

From an overall perspective, locals (93%) were aware of turtle population declines, with the perceived most serious risk to turtle species reported being habitat loss and degradation (46%) followed by human consumption (27%), and natural predators (4%); another 23% of respondents did not acknowledge a threat or did not know its cause. Despite the opinion that turtles in general had declined, 72% of the people exposed to conservation programs also thought that populations of the focal turtle species had experienced a possible recovery, or at least demographic stability. Also, 84% of this same group perceived that the TCMI had a positive impact in the community, because people had changed with regard to the focal turtle species by reducing its consumption personally, refraining from hunting it, or from selling (Figure 3). In the cases where the conservation program included headstaring, ex-situ egg incubation and captive rearing of hatchlings for variable periods of time before their release, 6% of the interviewers stated that hatchlings were easily observed close to the release areas (implying they do not disperse following release), while normal adult turtles preferred to inhabit more remote areas. However, people exposed to TCMIs also said that in the same sites where focal species had benefited, populations of other nonfocal turtle species had been almost extirpated; in fact, 14% of the interviewees who were people who promoted focal turtle species conservation admitted that at the same time, they continued capturing or consuming other turtle species.

Differences in Direct Use Depending on Exposure to TCMIs

A Fisher's exact test revealed that the consumption of turtles varied significantly between men and women ($p < .001$), with women consuming turtles less often than

Table 1. Questions to Inspect for Differences in Local Peoples' Attitudes Toward Turtles and Their Perceptions Concerning Turtle Population Declines.

Question	Answer	TCMI[a] n	TCMI[a] %	No TCMI[b] n	No TCMI[b] %	Fisher's exact test p
Do locals use focal turtle species as food?	Yes	5	10	27	54	<.001
Do locals use sympatric turtle species as food?	Yes	17	34	27	54	<.01
Have you had a change in focal turtle species consumption habits?	Yes	18	36	3	6	<.001
Did you used to eat other turtle species?	Yes	8	16	3	6	NS
Do locals hunt turtles?	Yes	8	16	15	30	NS
Do locals buy turtles?	Yes	7	14	8	16	NS
Do locals sell turtles?	Yes	2	4	8	16	NS
Do you believe that turtles have aphrodisiac, curative or magic properties?	No	46	100	50	100	NS
Do you keep *T. callirostris* or *P. lewyana* as pets?	No	50	100	50	100	NS
Can local people explain turtle's ecological role?	Yes	17	34	3	6	<.001
Have turtle populations declined?	Yes	49	98	44	88	NS

Note. TCMIs = turtle conservation management initiatives; NS = not significant.
[a] $n = 50$ (28% males and 72% females). [b] $n = 50$ (20% males and 30% females).

men. Of all interviewed people, 44% reported using turtles directly as a food resource (39% of these consumers were people exposed to a TCMI and 61% were not exposed). When evaluating the focal turtle species, we found significant differences (Fisher's exact test, $p < .001$) in turtle direct use rates between people exposed and not exposed to TCMIs. People exposed to conservation initiatives claimed to have reduced their direct use of them. However, when other sympatric turtle species were considered, there were no significant differences (Fisher's exact test, $p = .069$) in the levels of turtle exploitation between people exposed and not exposed to a TCMI (Table 1). Regarding turtle trade, we did not find significant differences between the two groups (Table 1), with 23% of the people admitting to being turtle hunters (Fisher's exact test, $p = .153$), 15% admitting having purchased turtles, (Fisher's exact test, $p = 1$), and 10% admitting having sold turtles (Fisher's exact test, $p = .091$). Colombian Sliders were mainly persecuted for meat consumption, but in the case of the Magdalena River Turtle, both eggs and meat were avidly consumed. According to the locals who had consumed several different turtle species, the most preferred species based on its meat was *P. lewyana*.

For only 4% of the interviewed people, turtle meat or eggs were considered as aphrodisiacs. None of the interviewed people had kept *T. callirostris* or *P. lewyana* as pets. Nevertheless, we observed that tortoise species (mainly *Chelonoidis carbonarius*) were commonly held as pets. Hunting effort was strongly influenced by the nesting season, although capturing during incidental encounters with adult turtles during the entire year was confirmed in all localities for all turtle species (sea turtles, freshwater turtles, and tortoises). Religious traditions highly influenced turtle consumption, with the highest demand occurring each year during lent, which coincides with the reproductive season for both focal species.

Locals' Perception of Turtle Trade Decline and Its Causes

Locals (15%) considered that turtle trade had declined for two reasons: prices had increased and so had surveillance by local authorities. Local people stated that higher prices were related to turtle scarcity, with capture effort increasing every year. According to 70% of turtle hunters, the perceived increase in capture effort for 2017 could be estimated as 28 times greater than in the late 1990s (Δ turtles/hunter/h = 6.75), translating into increased sale prices (US$14/adult turtle and US$0.69/egg). In addition, 9% of hunters preferred to sell turtles rather than to keep them for household consumption and 22% thought that turtle traffic also had decreased because it had become a risky activity for poachers due to increased law enforcement efforts. Because of this, many captured turtles were no longer transported alive but were sacrificed and butchered before shipment of their meat. In addition, in some localities, turtle shipments were hidden under fish meat to help avoid detection and confiscation during transport to markets.

Results Obtained From Organizations That Have Implemented TCMIs

Overall, most of the initiatives (59%) that were considered in this study focused on *P. lewyana* conservation, followed by *T. callirostris* (29%) and other sympatric species (12%). The majority of the initiatives (65%) included head-starting programs as the main conservation action. In situ conservation actions (12%) involved community agreements to protect turtle species habitats, strategies regarding fighting illegal wildlife trade such as turtle confiscations, campaigns and control operatives (12%), and environmental education programs in schools (6%). Most of the TCMIs were located in the Cordoba Department (41%; Table 2). According to interviewees, 100% of these programs retained turtles for up to 2 months after they had hatched, so hatchlings can reach a size which makes them less vulnerable to predation (Figure 4). One of the interviewed observed hatchling disorientation when turtles were retained for more than 2 or 3 months. Only 27% of the initiatives returned juveniles to their natural nesting site locations for release. Eggs employed in these head-starting projects were obtained via (a) rescue by TCMI team members, (b) donated by locals, (c) extracted by hunters from harvested gravid females, and (d) purchased by TCMIs from local hunters (US$0.51/egg). Based on the perspective of conservation initiative project managers, experiences such as observing hatching turtles, or returning them to their habitat, had produced significant changes in people's attitudes toward turtle conservation, even in the case of dedicated turtle hunters.

Results Obtained From Environmental Authorities

An insight about the scale and dynamics of illegal turtle trade in Colombia was obtained from information provided by 33% of all the Colombian regional environmental authorities contacted. Reports included both records on turtle confiscations and on turtles that had been voluntarily surrendered to them. We requested only information that had been obtained during the current decade (since 2010). Nevertheless, 9% of the organizations also provided data they had obtained since 2006, but only 12% had available information for 2017. In total, 54,294 freshwater turtle and tortoises were reported in this database; 5,313 of them were confiscated from 2006 to 2009 and 48,643 from 2010 to 2016 (with 338 reports for the first half of 2017). Comparing 2010 and 2016 (the years with the highest and lowest confiscation rates), the number of turtles reported for 2010 was 6.5 times greater

Table 2. Turtle Conservation Management Initiatives Found in the Study Area.

Focal turtle species[a]	Common name[b]	Global IUCN conservation status[c]	Colombian IUCN status[d]	Department[e]	*n*	%	Main conservation action[f]	*n*	%
P. lewyana	Magdalena river turtle	CR	CR	Antioquia	5	29	Head-starting	11	65
T. callirostris	Colombian slider	NE	VU	Bolívar	3	18	In situ conservation	2	12
Mesoclemmys dahli	Dahl's Toad-headed turtle	CR	EN	Córdoba	7	41	Illegal wildlife trade	3	18
Eretmochelys imbricata	Hawksbill sea turtle	CR	CR	Sucre	1	6	Environmental education	1	6
				César	1	6			

Note. IUCN = International Union for Conservation of Nature.
[a]Focal turtle species conservation. [b]Focal turtle species common name. [c]Global IUCN Red list category (Rhodin et al., 2017): critically endangered (CR), endangered (EN), vulnerable (VU) and not evaluated (NE). [d]Colombian IUCN Red list category (Morales-Betancourt, Lasso, et al., 2015). [e]Department. [f]Main conservation action.

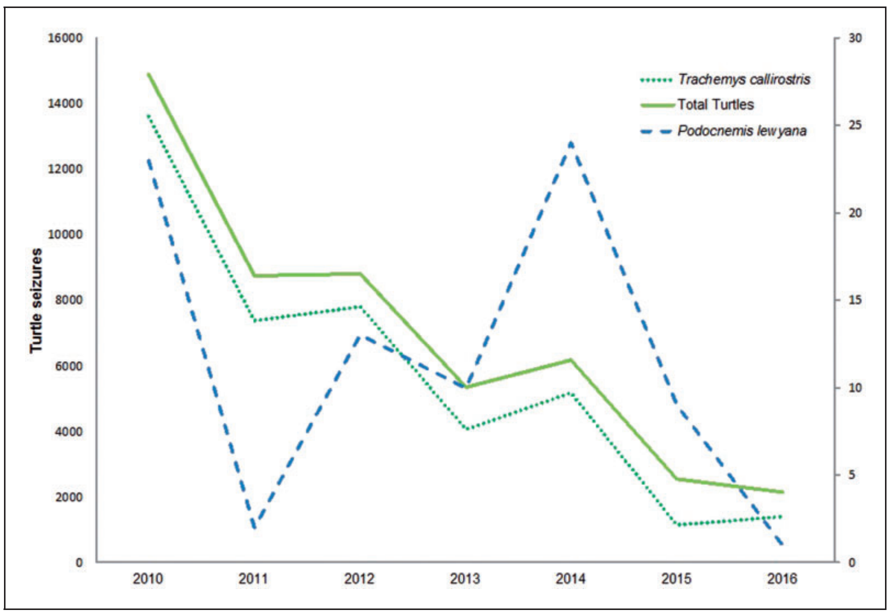

Figure 2. Scale and dynamics of illegal turtle trade in Colombia. Source: 33.36% of Regional Autonomous Corporations which had available data. Reports correspond to turtle record on confiscations and animals voluntarily surrendered by people who had maintained turtles as pets. Lines represent number of registers of *Podocnemis lewyana, Trachemys callirostris*, and the total number of native Testudinae reported between 2010 and 2016.

than the number of turtles reported for 2016 (Figure 2). Over the final 6-year period, 0.15% and 84.5% of the registers were individuals of *P. lewyana* and *T. callirostris*, respectively. Among the fates for confiscated/surrendered turtles were incubation of eggs, liberation of juveniles or adults, euthanasia, and captive rearing in ex-situ conservation centers. Environmental authorities in Colombia reported that they had supported head-starting programs and wetland protection and restoration projects for *T. callirostris, P. lewyana*, and *Podocnemis unifilis*. Information regarding international trade of Colombian turtles was not available.

Discussion

Even though most people exposed to TCMIs felt that focal turtle populations were recovering or at least remaining stable, the perception of declines in nonfocal turtle species was shared by both people exposed and not exposed to conservation programs. Thus, the answer to our first question (according to people's perceptions, do turtle populations continue to decline irrespective of whether conservation actions have been attempted locally or not) was equivocal because the perception of population stability or recovery only applied to the focal species. Apparently, many TCMIs only attempt to increase

Figure 3. (a) *Podocnemis lewyana* nesting beaches loss due to grass covering, at Isla Grande, Bolivar. (b) Fishing activities at *P. lewyana* nesting site at El Bagre, Antioquia. (c) *P. lewyana* head-starting program, Santa Cruz de Lorica, Córdoba, Bolívar. (d) Hunting site for *Trachemys callirostris*, Becerril, Cesar.

awareness of the importance of protecting one of the two focal species considered in this study, with an unintended consequence of maintaining or even increasing the hunting pressures on other sympatric turtle species in the area. In this regard, this phenomenon is analogous to the phenomenon of replacement that results from increased scarcity of the most preferable species due to overexploitation of wildlife in general (Jerozolimski & Peres, 2003). People supported their claims that other turtle species were declining based on their perceptions that (a) formerly common nonfocal turtle species are now being considered as rare (*T. callirostris, C. carbonarius, Rhinoclemmys melanosterna, Kinosternon* spp., and *Eretmochelys imbricata*) or locally extinct (*P. lewyana*), (b) estimates of interviewed hunters were that capture efforts for *T. callirostris* had increased up to 28 times, and (c) price increases for turtles had risen due to the combination of low supply and continued high demand. For example, *P. lewyana* and *T. callirostris* currently may bring up to US$14, 1.6 times more than prices formerly reported for *P. lewyana* in central Colombia (González-Zárate, Montenegro, Castaño-Mora, & Vargas-Ramírez, 2014). Thus, in a region where the daily wage averages US$12, the use of turtles as a food source has become almost inaccessible. When we compared people exposed and not exposed to TCMIs, we found that people who had not participated in one maintained more utilitarian attitudes toward turtle species, consistent with other studies (López-del-toro, Andresen, Barraza, & Estrada, 2009). We found significant differences between the two groups in terms of consumption rates for the focal turtle species but not in terms of rates of exploitation of nonfocal turtle species (with both groups similar in terms of rates of hunting, purchasing, and selling these alternative turtle species). Thus, the answer to our second question (do levels of direct use of turtle species differ depending on whether local people have been exposed or not to TCMIs?) was also equivocal. It seems that people exposed to a TCMI valued the importance of protecting the focal turtle species, but continued, or even increased,

Figure 4. (a) *Podocnemis lewyana* hatchling, at Santa Cruz de Lorica, Córdoba. (b) *Trachemys callirostris* hatchling at Santa Cruz de Lorica, Córdoba. (c) *P. lewyana hábitat, Sinú* River, Cordoba. (d) *T. callirostris* hábitat, El Paso, Cesar.

their rates of hunting, consuming, and trading other local nonfocal turtle species, suggesting a negative role of conservation efforts directed toward focal species on other species that were not considered by the TCMI. It appears that focusing conservation efforts on only one turtle species may increase the threats to sympatric nonfocal turtle species. Unfortunately, as far as we know, there are no data available that rigorously document the impact of a TCMI on the actual demographic tendencies of either focal or other sympatric turtle species.

The answer to our third question was affirmative, since interviewees' perspectives were that habitat loss and degradation constituted the greatest threat for local turtle species (46%), followed by human consumption (27%). Although not necessarily in the same order, these two threats coincide with rankings of the top threats for turtles in publications focused at local, national, and global scales (Bello, Báez, Gómez, Orrego, & Nägele, 2014; Collen et al., 2014; Eisemberg et al., 2016; Jaramillo, Cortés-Duque, & Flórez-Ayala, 2016; Lasso, Gutiérrez, & Morales-B, 2014). If one considers either turtle species that have become extinct in modern times or those species listed as among the top 25 currently most threatened turtle species, both groups are characterized by having large body sizes and *slow* life histories (slow growth rates, late ages at sexual maturity, and high subadult and adult survivorship rates when not subjected to exploitation). These attributes are shared by many turtle species currently threatened by overexploitation (Heppell, 1998; Iverson, 1991; Rhodin et al., 2011). For example, studies of *P. lewyana* have shown populations to be healthier in areas with limited hunting pressure, even where habitat modification has been extensive (Páez et al., 2012). Even so, opinions of local people were congruent with studies that also have shown freshwater turtle abundances to be affected by wetland availability, water quality, and the presence of riparian vegetation (González-Zárate, Montenegro, & Castaño-Mora, 2011; Jaramillo, Cortés-Duque, & Flórez, 2015; Quesnelle, Fahrig, & Lindsay, 2013). According to locals, increases in northern Colombia in buffalo ranching, mining, draining wetlands, and the impacts of hydroelectric facilities on nesting habitat have all adversely affected turtle populations. Even populations of species within protected areas might be driven to extinction by these impacts in less than a century (Famelli, Piacentini, Souza, Chiaravalloti, & Bertoluci, 2012).

Our study showed that 65% of the TCMIs examined included head-starting efforts as their main conservation activity, while only 27% of these initiatives returned hatchlings to their natural nesting site locations for release. In most cases, neonates were retained for up to 2 months before release, implying additional costs to these conservation efforts with no evidence that this practice actually improves long-term survival rates of these individuals. The opinion that the density of juveniles increases near the release locations could reflect an alteration caused by head-starting of their natural dispersal behaviors, as has been shown recently for head-started *Podocnemis expansa* in Brazil (Ferrara, Vogt, Sousa-lima, Tardio, & Campos, 2014; Vogt, R.C, personal communication, December 5th, 2014). Locals recognized that nest transfer, artificial incubation, and captive rearing may prevent contact between hatchling turtles and adult females (some of the interviewed locals believe *P. lewyana* adult females return to the nesting areas during the hatching season) and thereby disrupt development of normal migratory behaviors.

Contrary to the increase in confiscations reported for the period 2005 to 2009 by (Arroyave Bermudez, Romero Goyeneche, Bonilla Gómez, & Hurtado Heredia, 2014), our study indicated a decrease in confiscation rates over the same period, despite the report by local people who control efforts by local authorities had increased. The number of turtles reportedly confiscated in 2010 was 6.5 times greater than the number of turtles reported for 2016. This trend, evidenced both by the data and by the perceptions of interviewees that work for the environmental authorities, also support our first prediction. Similar to our findings, reduction in numbers of turtle trade was also documented for Asian turtles (Luiselli, Starita, Carpaneto, Segniagbeto, & Amori, 2016), suggesting a possible collapse of turtle populations or an increase of wildlife trade surveillance. As has been reported previously (Arroyave-Bermudez et al., 2014; Morales-Betancourt, Lasso, et al., 2015; Páez et al., 2012), the most heavily traded turtle species in Colombia is *T. callirostris* (84.5% of all turtle trade), even when inspecting data obtained from sites outside of its range of distribution (Aldana, Diaz, Feijoo, & Heimar, 2016).

Implications for Conservation

It is important for TCMIs in northern Colombia to include aspects of traditional culture into their conservation planning (Fagundes, Vogt, & De Marco, 2016) because in many cases, local knowledge has a great potential to be used in natural resources management (Morales-Betancourt, Lasso, et al., 2012). TCMIs also need to attempt to articulate both scientific and local knowledge into management programs (Gray, Phommachak, Vannachomchan, & Guegan, 2017; Lima, Lins Oliveira, de Nóbrega, & Lopes, 2017), by facilitating knowledge exchange between researchers and local people. In addition, environmental education programs directed toward school children have proven to be useful conservation measures (Forero-Medina & Mahecha, 2006). Our results suggest that such education programs should promote conservation of the local turtle community in general, rather than emphasizing a single focal species.

In the case of *P. lewyana*, the sites we surveyed were located in two of the three management units identified based on genetic analyses (Vargas-Ramírez, Stuckas, Castaño-Mora, & Fritz, 2012): (a) the Lower Magdalena + Lower Cauca + San Jorge river basins and (b) the Sinú River basin, and also at the Middle Magdalena River basin that corresponds to an important gateway for genetic exchange. The fact that one or more community-based conservation programs have been developed within each management unit is encouraging. Since most persons in charge of conservation programs for *P. lewyana* and *T. callirostris* lived in these remote areas and had limited English language skills, they often were not aware of relevant scientific publications on their focal species (Daza & Páez, 2007; Frazer, 1992; Gibbons, 1990; Páez, Lipman, Bock, & Heppell, 2015). Conversely, academic experts also have limited time and opportunities for contact with program managers or local actors. Socializing both scientific and locally based information on these turtle species, and in simpler and more innovative ways, poses a challenge for the future but will be necessary for a truly integrative management (Morales-Betancourt, Lasso, et al., 2012, Morales-Betancourt, Páez, et. al., 2015).

Successful conservation requires changing people's attitudes toward the focal species. For example, in sites where there is an ecotourism industry based on sea turtles, attitudes have been influenced by stressing the significance of the nonconsumptive value of these species (Cazabon-Mannette, Schuhmann, Hailey, & Horrocks, 2017; Rathnayake, 2016; Smith, Pedrini, & Ghilardi-Lopes, 2017) and stressing the importance of biological interactions that involve sea turtles (Griffin et al., 2017). Such education efforts have resulted in decreases in the number of individuals harvested, helping ensure the continued survival of these populations (Stewart, Norton, Tackes, & Mitchell, 2016). Such examples should be considered as models for generating alternative sources of income for local communities where freshwater turtle species currently are harvested, as a means to reverse declines for species such as *P. lewyana* and *T. callirostris*. In addition, mechanisms can be established to enable people to easily, anonymously, and safely report information about local wildlife trade to authorities through mobile technologies and also to promote citizen science for turtle species conservation (Cooney et al., 2017).

Our results suggest that the following directions should be pursued for turtle management and conservation: (a) prioritize protection of subadult and adult turtles by implementing community agreements to prohibit consumption of these classes (especially nesting females) for all turtle species in the area, not only for a focal species; (b) when head-starting programs are necessary (e.g., because of nest flooding by hydroelectric facilities), hatchlings should be released at their natural nesting site locations immediately after hatching; (c) promote maintaining connectivity of aquatic ecosystems and stress the importance of protecting water quality and of maintaining or replanting riparian vegetation that may represent an important food source for turtles; (d) establish a school-based turtle management and conservation network, prioritizing the enrollment of families that inhabit areas where focal turtle species are declining; (e) involve all actors (locals and academics) in basic long-term monitoring (Páez in prep) to document the demographic effects, if any, of conservation actions being employed; (f) conservation of turtles and of their fresh water ecosystems is an opportunity for school environmental projects, which are mandatory by law in Colombia; and (g) promote economic alternatives based on ecotourism and recreational tourism in strategic locations, such initiatives may be linked to tourist attractions that already exist, or create new ecotourism initiatives that involve not only turtles but also other charismatic species such as manatees, crocodiles, primates, and bird watching.

In our opinion, targeting actors who have the greatest impact on turtle populations (religious leaders and large land owners) and other local people (teachers and fishermen) in an effort to promote community empowerment and conservation could be a cost-efficient way to reduce pressures on adult turtles, gather more precise demographic information, and reduce exploitation rates. In the case of the focal species *P. lewyana* and *T. callirostris*, we considered, we highlight the importance of providing them natural protected areas, prohibiting exploitation of nesting females, and in general improving control of their unsustainable illegal trade, and also to promote participatory conservation actions that improve ecosystem connectivity and reduce landscape transformation.

Appendix A

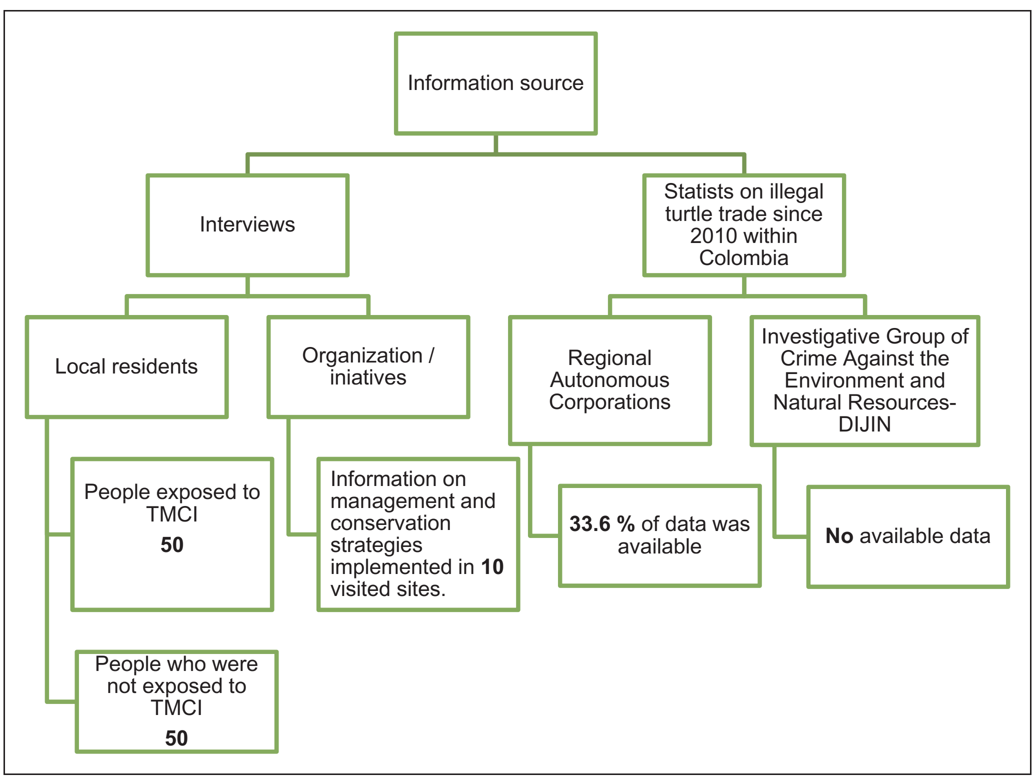

Figure A1. Information source regarding interviewed people exposed and not exposed to turtle conservation management initiatives and turtle confiscations in Colombia.

Appendix B

Table B1. Information Regarding Questionnaires by Source of Information.

Information source	Data
Local settler	1. Personal data on gender, age, and occupation. 2. Ability to identify turtle species. 3. Turtle's ecological role. 4. Direct use of turtles: egg and meat consumption, trade, pets, utilization for aphrodisiac, or curative purposes. 5. Turtle abundance, related to places with highest observation frequency, catch effort and main threats. 6. Perception on turtle conservation initiatives regarding impact, population recovery. 7. Perceived main threats to turtle populations.
Organization	1. Species and turtle age class targeted for conservation. 2. Conservation management actions and scientific research. 3. Monitoring, turtle abundance, and success indicators.
Environmental authorities	The following information was requested from 100% of the regional Colombian environmental authorities: 1. Strategies for management and conservation of Testudines. 2. Statistics on data on confiscations available since 2010. 3. Threats to turtles within each local jurisdiction. Information regarding national and international illegal turtle trade was requested from the Investigative Group on Environmental Crime, DIJIN.

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