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ANIMAL SCIENCE

A novel approach to urban turtle sampling: Assessing Hookless Fishing with clip and two conventional methods

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Abstract: To address urban turtle sampling challenges, we presented Hookless fishing with clip, a cost-effective method for sampling this important group. Effectiveness, biases and potential advantages were analysed in comparison to two commonly used methods (funnel trap and hand capture). Fieldwork was conducted between August and November/2021 in four areas in Brazil, using the three methods simultaneously. A total of 195 turtles from four species (*Phrynops geoffroanus*, *Hydromedusa tectifera*, *Trachemys dorbigni* and *T. scripta elegans*) were captured. Funnel trap demonstrate a significantly higher capture than hand capture, while Hookless fishing showed no significant difference in captures compared to funnel trap. The highest catch per unit effort values were observed for the new method (0.37) and the funnel trap (0.34). Despite being widely used, funnel traps were the only method to exhibit male bias. Our findings revealed that Hookless fishing with clip exhibited remarkable capture efficiency, cost-effectiveness, and ease of transport and utilization; however, it requires operator presence. Nevertheless, the proposed method, both as the primary or auxiliary approach, appears efficient in enhancing captures and reducing costs and risks. This innovative method has the potential to assist researchers studying omnivorous and carnivores freshwater turtles in environments worldwide, especially in human settlements.

Key words: Anthropic environment, aquatic environments, cost-effectiveness, freshwater biodiversity, sex ratio, turtle trapping method comparison.

INTRODUCTION

Different trapping methods for freshwater turtles have been described, which are generally subdivided in two types: direct and indirect (Vogt 1980). Direct capture involves active collecting by hands or hand nets (e.g. dip net, seining net), while indirect capture requires the use of trammel nets and traps, as baited hoop trap (e.g. funnel trap), pitfall trap, and basking traps (Vogt 1980, Lovich 2012). Most of the last studies with turtles developed in South America used either nets (i.e. fyke and dip nets) and/or traps (i.e. funnel trap) to capture turtles (Caputo & Vogt 2008, Silveira et al. 2019, Santos et al. 2020, Schiavetti et al. 2021); as well as the association of nets (i.e. net seining)/traps (i.e. baited hoop trap) and hand capture (Böhm 2013, Portelinha et al. 2014), and only few of them used only hand capture (e.g. Restrepo et al. 2014).

To choose the most suitable method requires to consider some factors such as environmental and target species features, as well as funding to purchase equipment (Vogt 1980, Semeñiuk et al. 2017). Weather and environmental conditions, such as water deep, turbidity, substrate (Semeñiuk et al. 2017), and also water quality are important variables that should be taken into account. In polluted water bodies for example, some trapping methods are discarded, such as hand capture with snorkelling and diving,

as well as the dragging net/net seining due to the presence of many submerged branches and trash. Moreover, in urban areas there is one more variable that should be considered when choosing the best sampling method: the accessibility of local people, and consequently the risk of devices theft.

Mainly in developing countries, such as Brazil, the risk of theft increases the difficulty for finding an adequate method to sample urban freshwater turtles. Therefore, we aimed to describe a novel turtle trapping method (i.e. hookless fishing with clip), to provide a useful technique for sampling turtle assemblage in urban environments, and to compare it effectiveness and potential advantages in relation to two other techniques (funnel trap and hand capture).

MATERIALS AND METHODS

Fieldwork was carried out between August and November 2021 in four artificial lakes in Maringá city, southern Brazil. Two of these lakes are located at public parks and the other two at private areas: Parque do Ingá (23°25'40.60"S, 51°55'48.56"W, WGS84), Parque Alfredo Werner Niffeler (23°24'41.12"S, 51°55'5.42"W, WGS84), Horto Florestal Dr. Luiz Teixeira Mendes (23°26'9.09"S, 51°58'5.09"W, WGS84), and in the experimental farm of the University Unicesumar - BIOTEC (23°20'38.73"S, 51°52'5.78"W, WGS84), respectively. They are surrounded by a riparian vegetation of Atlantic Rainforest, over different degrees of anthropized ground. The lakes sampled belong to Ivaí and Pirapó hydrographic basin, tributaries of the Paraná River (SEMA 2010). The most common species of turtles inhabiting this area are the native *Phrynops geoffroanus* (Schweigger, 1812) and two introduced species *Trachemys scripta* elegans (Wied, 1838) and *T. dorbigni* (Duméril and Bibron, 1835). Although less abundant, *Hydromedusa tectifera* Cope, 1870 also occurs in Maringá (C.E.V. Grou, unpublished data).

Turtles were sampled by three distinct techniques, with each method being operated by two different researchers: I) funnel trap (FT) with double-mouth, 100 cm in length, 50 cm diameter, 25 cm mouth width, and 2 cm mesh, baited with gizzard and canned sardines in oil; the traps were tied to shrubs on the edge of the water body, leaving the trap submerged but partially out of water. We used five devices 10 m apart, and they were reviewed every 4 h; II) hand capture (HC), based on active search where investigators walked around the water body with binoculars, looking for turtles basking on longs, rocks and on the surface of the water, and capture the animals by hand or with hand dip net 2 cm mesh without entering the water; III) hookless fishing with clip (HF), the novel method similar to traditional fishing but without causing injury to the animals (Figure 1); the device consists of three main parts: a clip baited, fishing line, and one operator. At one extremity, a 4 cm specific clip is positioned. This apparatus, known as "fishing snaps" or "clip de pesca" (in Portuguese), is readily available at fishing supply stores (Figure 2a). On this clip is attached a bait (i.e. gizzard) and it is tied to a fishing line (i.e. n. 0.80) around 10 meters long. A buoy, weighting around 20 g, is affixed to this line (Figure 2b), with the specific distance between the buoy and the clip determined by the depth of the water body and mainly by the target species behavior. Since the turtle assemblage studied is composed by species with different feeding behaviors, two different distances from the clip to the float was set: two devices with 20 cm distant and two with 100 cm (Figure 1e). The opposite end of the line is fastened to a small log/wood tablet (Figure 2c) and placed near the operator, solely to provide weight at

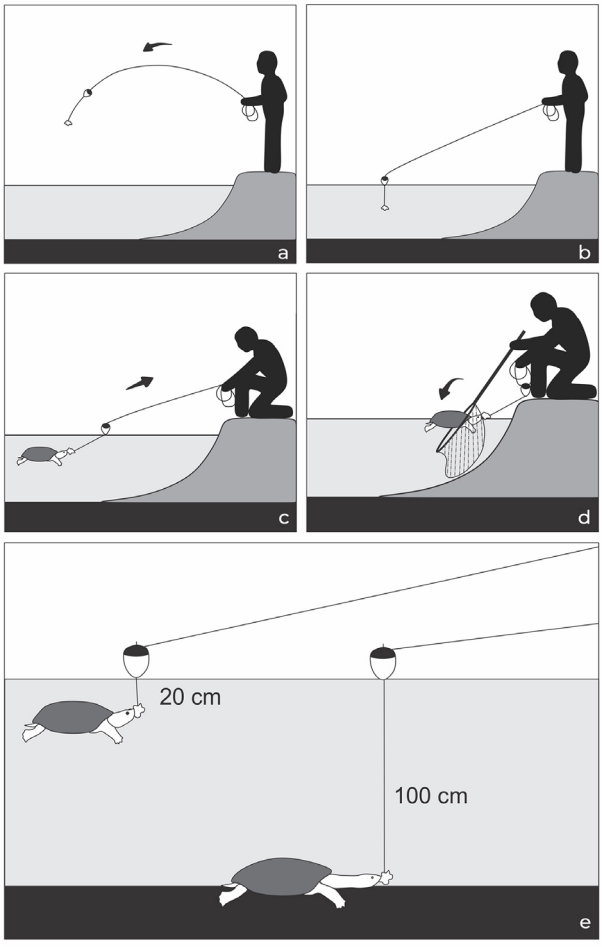

Figure 1. Schematic illustration of hookless fishing operation with a clip device. a) and b) Throw the line into the water, with the clip baited, with movements similar to a traditional fishing; c) As the trap moves, squat down and use subtle movements to bring the clip closer; d) with the other hand, take the hand dip net and capture the turtle; e) different distances to set up the float, depending on the target species.

the line's end, thus preventing equipment loss. This enables the operator to move between different devices, allowing a single researcher to manage two or more HF simultaneously. As soon as the device moves, the clip is brought close to the operator and the turtle is captured with the aid of a hand dip net, without the investigator entering the water (Figure 3). We used four HF devices, spaced 10 m apart.

We applied the three methods simultaneously at each area for 8 h/d, between 8:00-12:00 and 13:00-17:00 h. We sampled each area once a week, with intervals ranging from seven to 15 days between each sampling session. After four months, each lake was sampled seven times. The total sampling effort for FT amounted to 280 hours, for HC it was 212 hours, and for HF it was 224 hours. Once trapped, the turtles were identified (Rueda-Almonacid et al. 2007; Bujes 2010), sexed, weighed, and released at the same point they were captured.

On the R statistical computing environment (R Core Team 2022) we used chi-square test for each method applied to verify whether sex ratio differed from 1:1. To test if there were differences in the number of individuals trapped among the three methods, the number of individuals trapped variable was fitted to a Generalized Linear Mixed Model using the glmmTMB function (GLMMTMB, package glmmTMB21) and a Poisson distribution and identity link function. The categorical variable type of method (i.e. HF, FT, HC) was used as explanatory variables, and, "day" of sampling was included as a random factor. We previously checked the model for overdispersion and distribution fitting using function simulateResiduals (package DHARMa22, simulations = 999). Finally, to test if there were differences in the number of different species trapped per each method we run three more models, one for each method where the number of individuals trapped was fitted to GLMMTMB and a Poisson distribution and identity link function, with species (i.e. *H. tectifera, P. geoffroanus, T. dorbigni, T. scripta elegans*) as explanatory variables, and, "day" of sampling was included as a random factor.

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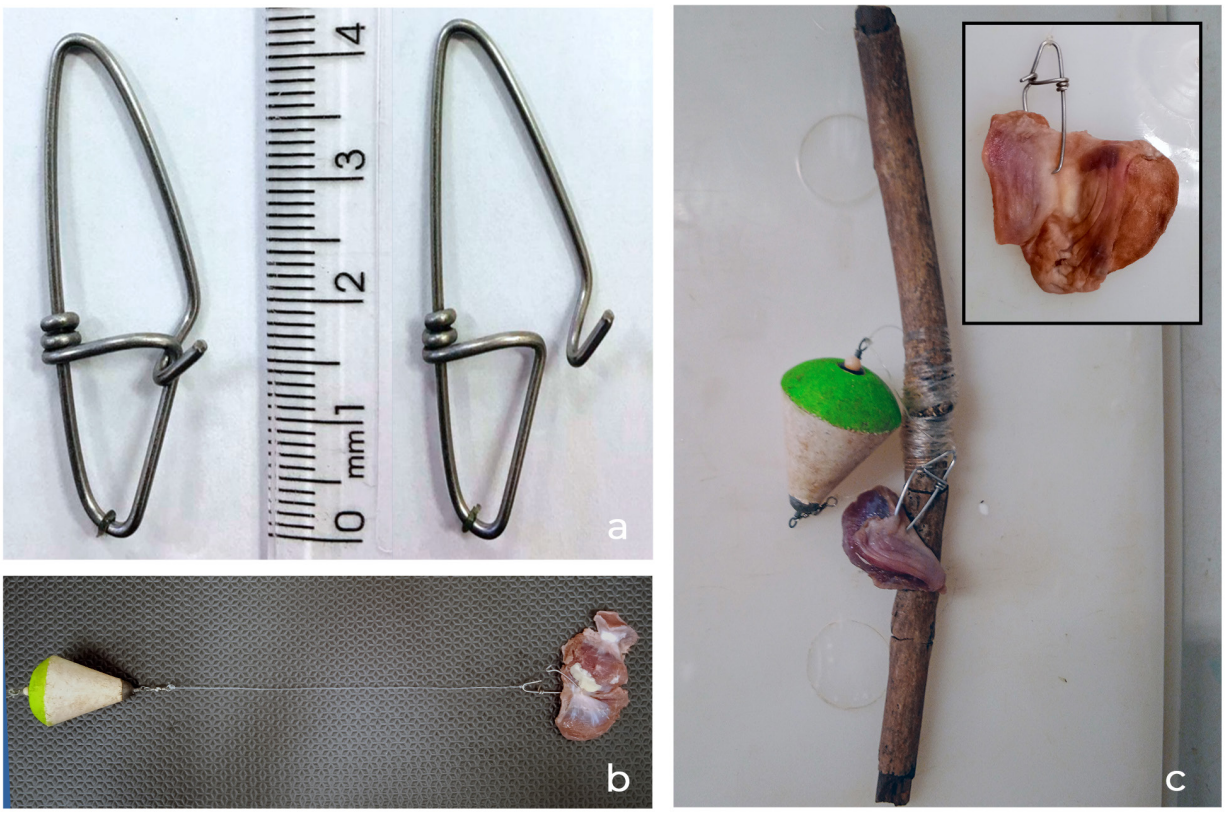

Figure 2. Detail of the hookless fishing with a clip device. a) Clip in open and closed position; b) Buoy attached to the fishing line, positioned around 20 cm away from the clip with bait; c) Equipment closed: a small log or wood tablet provides weight at the end of the line and facilitates rolling up the baited device (upper right corner: bait attached to the clip).

committee on the use of animals of University of Maringá (CEUA/UEM 1357120721).

RESULTS

A total of 195 turtles were captured, with FT as the method that captured most of them (n = 94; 48%), followed by HF (n = 83; 42.5%), and HC (n = 18; 9.2%). The FT method trapped significantly more individuals than the HC; however, there were no significant differences with the HF method (Table I). Furthermore, the captures per unit effort (CPUE) were slightly higher for HF (0.37) compared to FT (0.34), and lower for HC (0.16).

The FT was the unique to capture all four species. The most frequently captured species was *T. dorbigni* (n = 94), followed by *P. geoffroanus* (n = 52), *T. scripta elegans* (n = 45), and *H. tectifera* (n = 4). HC seems to capture more *P. geoffroanus*, while both FT and HF trapped more *T. dorbigni* (Figure 4). Regarding to the configurations between the clip and the float of the HF (i.e. 20 cm and 100 cm), both distances capture the three species similarly (*T. dorbigni, T. s. elegans, P. geoffroanus*).

All the three trapping methods captured both sexes and life stages over samples in Maringá (Supplementary Material - Table SI). In general, we captured similar number of males (n = 93; 47.6%) and females (n = 86; 44.10%), and immatures corresponded to 8.2% of captures (n = 16). Unlike FT that yielded 1:1.6 sex ratio favouring males (X^2 = 5.62, df = 1, p= 0.017), HF

Table I. Results of Generalized Linear Mixed Model using Template Model Builder (GLMTMB) to compare if there were differences in the number of individuals trapped among the three methods; note that intercept included funnel trap.

	Estimate	S.E.	*Z-value*	*p*
Intercept	-1.315	0.388	-3.39	0.0006
Hand Capture	-1.652	0.257	-6.425	<0.0001
Hookless Fishing	-0.124	0.1506	-0.826	0.408

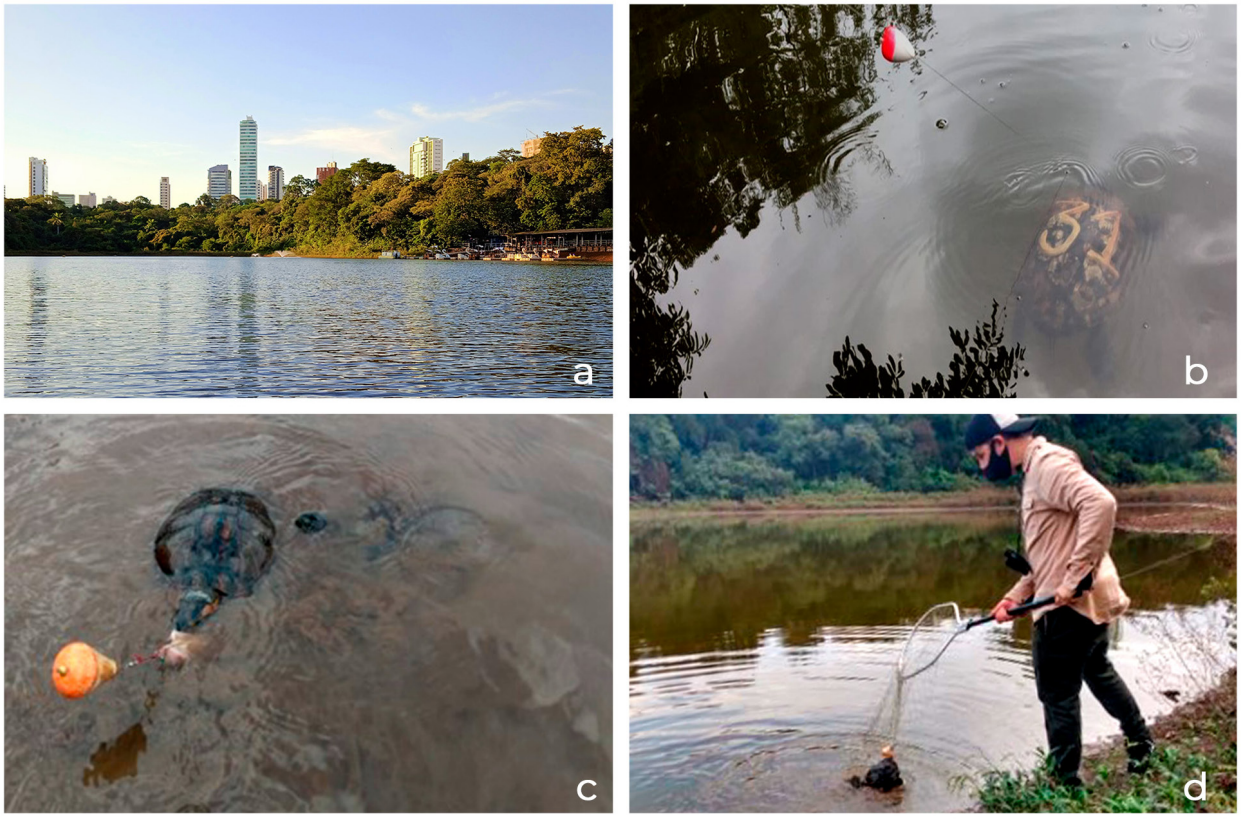

Figure 3. Utilization of hookless fishing with a clip device. a) Urban lake sampled; b) Attracting a marked turtle with bait; c) Drawing the clip closer to the operator; d) Capturing the turtle with the assistance of a hand dip net, requiring only a single person.

and HC produced an unbiased sex ratio of 1:1 when sampling this assemblage (X^2 = 1.75, df = 1, p = 0.18; X^2 = 0.81, df = 1, p = 0.36, respectively).

In terms of body size, we captured individuals ranging from 4 cm to 40 cm, with HC being responsible for capturing both size extremes. On average, this latter method recorded individuals with approximately 19 cm of carapace length (± 10.4), while FT yielded individuals with 20 cm (± 4.8; range 10.7 - 30 cm), and HF with 21 cm (± 4.7; range 10.7 - 33 cm).

DISCUSSION

Even hoop trap (i.e. FT) being well known as a very efficient to capture omnivorous and active-foraging freshwater turtles, as well as one of the most commonly used sampling tools, it presents potential biases of sampling due to

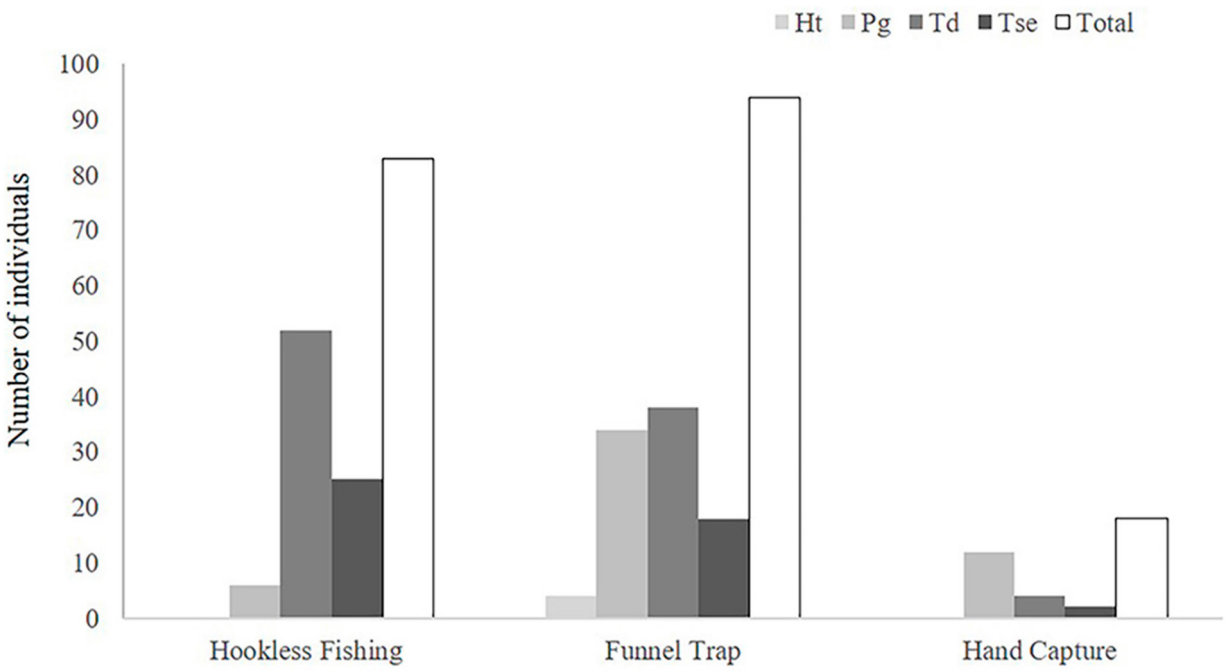

Figure 4. Number of individuals of freshwater turtle per species captured by each of three trapping methods over four months in Maringá city, Paraná state. Tse = *Trachemys scripta elegans;* Td = *T. dorbigni;* Pg = *Phrynops geoffroanus*; Ht = *Hydromedusa tectifera*.

escapes probability, and in sex ratio (Legler 1960, Thomas et al. 2008, Brown et al. 2011, Lovich 2012, Mali et al. 2014), as recorded in our study. Some researchers speculated that male bias of hoop net captures is linked to turtle body size; however, both trapping methods captured individuals of similar size. Alternatively, this bias has been attributed to the sex ratio of the population rather than the sampling method (Swannack & Rose 2003). However, a previous study conducted in the same area reported a sex ratio of turtle populations tending towards females for *P. geoffroanus* and *T. dorbigni*, an unbiased sex ratio for *T. scripta elegans*, while the population of *H. tectifera* was not assessed (Rocha et al. 2022).

Our results demonstrate that the new technique proposed offers great cost-benefit. In addition to the absence of bias, an important factor to be considered in measuring the effectiveness of a method (Sterrett et al. 2010), the HF exhibited the highest efficiency in turtle capture (i.e. CPUE) compare to other analysed methods. It depends on only one operator, who can easily manage more than one device, and the price to construct/buy it is six times cheaper (around US$5) than hoop trap (around US$30 each one). It is easily transported and safe to be used in polluted water bodies and urban areas. Conversely, hoop traps are not advisable for such sites considering the potential risk of equipment loss and subtraction of turtles captured (Alves et al. 2019). In this environments, an operator should necessarily be close to the device solely for equipment surveillance, requiring additional researchers and field time to capture a similar number of turtles.

The main drawbacks associated with the use of HF include the requirement for the operator to remain in close proximity, maintain silence, wear light-colored clothing, and minimize sudden movements to prevent

spook turtles. However, as advantage, staying close to the device also allows ease re-baiting whenever necessary. Furthermore, it increases the capturability, because allows to trap many individuals on the same day using one device. In addition, the presence of the operator also prevents the turtles from swallowing the bait, because as soon as the trap starts to move, the operator brings it closer to the lake shore. Therefore, most animals tend to bite small pieces of the bait and then follows the bait while it moves. When captured, few turtles had little time to swallow the entire bait and the clip, and if it happens, the process to remove it is straightforward and does not cause any harm to the animal.

Since 2013, our research team has successfully employed HF method in urban areas and it has undergone improvements during turtle assemblage inventory and monitoring (SEMA 2020, Rocha et al. 2022). Depending on the target species (e.g. *H. tectifera*) and the study objectives (e.g. diversity), hoop trap can be used associated to HF in urban areas; however, the possibility to trap-theft must be clearly considered. Finally, this study confirms that HF seems to be an efficient trapping method to overcome urban barriers, and it is appropriate to increase captures and decrease costs. This new method will help researchers to sample omnivorous freshwater turtles in different types of environments with human presence, in Brazil and other countries.

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SUPPLEMENTARY MATERIAL

Table SI.

How to cite

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Author contributions

All authors contributed to the study's conception and sampling design. The device design and data collection were performed by S.B.R. and C.E.V.G. The dada analysis were carried out by C.R. and S.B.R. The first draft of the manuscript was written by S.B.R., with input and revisions from the other two authors. The final manuscript was read and approved by all authors.