Colegio de Postgraduados

Water supply in artificial troughs: a strategy to mitigate the impacts of climate change in the Maya forest

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ABSTRACT

Objective: To verify the functionality of drinking troughs based on fauna record.
Design/Methodology/Approach: Most of the approximately 70 artificial drinking troughs were installed inside the core zones of the Calakmul Biosphere Reserve (CBR). The remaining troughs were installed in communities and left under the protection and supervision of beekeepers. A camera-trap station was associated with each of the drinking troughs installed.
Results: Ninety-one wildlife species that drink water from the artificial troughs have been identified, including 30 mammals, 53 birds, 5 reptiles, and three amphibians. Jaguars, tapirs, and other endangered species are some of the most frequent visitors to these sites, especially during the dry season.
Study Limitations/Implications: The use of artificial water troughs is an adequate alternative to guarantee water availability in the Calakmul region. The high diversity of species that constantly visit the drinking troughs during the dry season makes evident the functionality of the water supply strategy with artificial drinking troughs.
Findings/Conclusions: The drinking troughs can be a tool for various objectives in the region. It arose from the need to respond to emergency climatological events (*i.e.*, droughts), but it has been adapted to the regional needs and other activities. It has been considered a successful management strategy in the face of climate change.

Keywords: Drinking troughs, camera-trapping, mammals, drought, climate change.

INTRODUCTION

Climate change is characterized by long-term changes in temperature and climate patterns (Kardol *et al.*, 2010). The hydrological cycle has been one of the main axes of study, given the possible increase in flood and drought risks (Chou *et al.*, 2013).

Water availability is a habitat-specific resource that can influence the spatial distribution of wildlife (Rich *et al.*, 2019), especially in sites where precipitation has been compressed. However, some animals meet their water demand with their food (Nagy and Gruchacz, 1994). Although most species depend on surface water (Moro-Ríos *et al.*, 2008), they adjust their behavior in the face of scarcity (Hofmann *et al.*, 2015).

In places where water has been identified as a limiting resource, rainfall can have a major impact, since it influences many of the animals' movements (Bello *et al.*, 2001).

Artificial water sources (*i.e.*, artificial ponds, dams, reservoirs, and drinking troughs) have historically been used to counteract the impacts of prolonged droughts in Mexico (Villarreal, 2006). This measure contributes to the enrichment of the habitat and the maintenance of wildlife populations (Bello *et al.* 2001). In particular, the implementation of drinking troughs for wildlife has been reported as a successful strategy to mitigate the consequences of the lack of water in times of drought, mainly in places where water is the limiting resource (Mandujano-Rodríguez and Hernández, 2019; Borges-Zapata *et al.*, 2020).

The use of these artificial water sources is part of various strategies, some of which aim to maintain wildlife populations within sites with better conditions, such as protected natural areas (PNA). These strategies would prevent the death of animals when they explore new sites (Borges-Zapata *et al.*, 2020). Filling drinking troughs with water is conceived as a measure that can contribute to the short-term maintenance of wildlife populations, since it allows animals to have access to water during the dry season (Borges-Zapata *et al.*, 2020).

Mardero *et al.* (2018) have documented increasingly extreme temperatures in the Yucatan Peninsula in recent years, with more severe and longer temperature events, which force wildlife to resort to water as a thermo-regulation factor. The Maya Forest, particularly the Calakmul region (in southeastern Mexico), lacks fast-flowing rivers or extensive surface water bodies (García-Gil *et al.*, 2002). The mismatch in precipitation patterns that has been recorded in recent years (Mardero *et al.*, 2018) has prevented the aguadas, natural water reservoirs found in the region (Reyna-Hurtado *et al.*, 2022), from capturing enough water to remain full during the dry season.

Given the imminent need for surface water in the Maya Forest that will be the consequence of global climate change, the Calakmul Biosphere Reserve, in collaboration with non-governmental organizations (NGOs), has established a water supply strategy for wild fauna, through a network of drinking troughs. Discussing that experience is the focus of this article.

MATERIALS AND METHODS

The Calakmul Biosphere Reserve (CBR) is located within the Yucatan Peninsula, to the southeast of the state of Campeche. It is part of the Greater Calakmul Region, which includes the Maya Biosphere Reserve in Guatemala and the Río Bravo Dos Milpas conservation area in Belize. It has an area of 723,185.12 ha (Reyna-Hurtado *et al.*, 2022).

The CBR has a warm and subhumid climate (Aw), with an average annual temperature of 24.6 °C. The maximum height is found on the Champerico hill (390 m.a.s.l.), while the minimum height varies from 100 to 150 m. The dominant vegetation types are medium sub-evergreen forests, medium sub-deciduous forests, and low sub-deciduous forests (Martínez and Galindo, 2002; Martínez-Kú *et al.*, 2008).

Installation of drinking troughs

As part of the efforts of the CBR, in collaboration with the GEF project for species at risk and WWF Mexico, to counteract the impacts of climate change in the region, approximately 70 artificial drinking troughs were installed in a water supply network. Most of them were located within the core zones of the PNA, while the rest were established in communities under the protection and supervision of beekeepers. The drinking troughs that were set up in the CBR consisted of 300 L black Rotoplas® plastic structures (Figure 3). The troughs were distributed along the CBR access road (Figure 1), with a minimum distance of 2 km between stations (troughs). At the beginning of the dry season (Figure 4), water was usually supplied twice a month (every 15 days); however, as the dry season marched on and became harsher, sometimes water had to be supplied every 7 days.

Data from camera traps

To verify if the strategy was functional for the purposes of the CBR, the biological monitoring protocol in drinking troughs was created in 2018, based mainly on the recording of wildlife with camera traps (Borges-Zapata *et al.*, 2020; Contreras-Moreno *et al.*, 2020).

RESULTS AND DISCUSSION

Currently, 91 wildlife species that drink water from the troughs have been identified: 30 mammals, 53 birds, 5 reptiles, and 3 amphibians (Table 1). Twenty-nine of these species are classified in one of the risk categories established by the NOM-059-SEMARNAT-2010

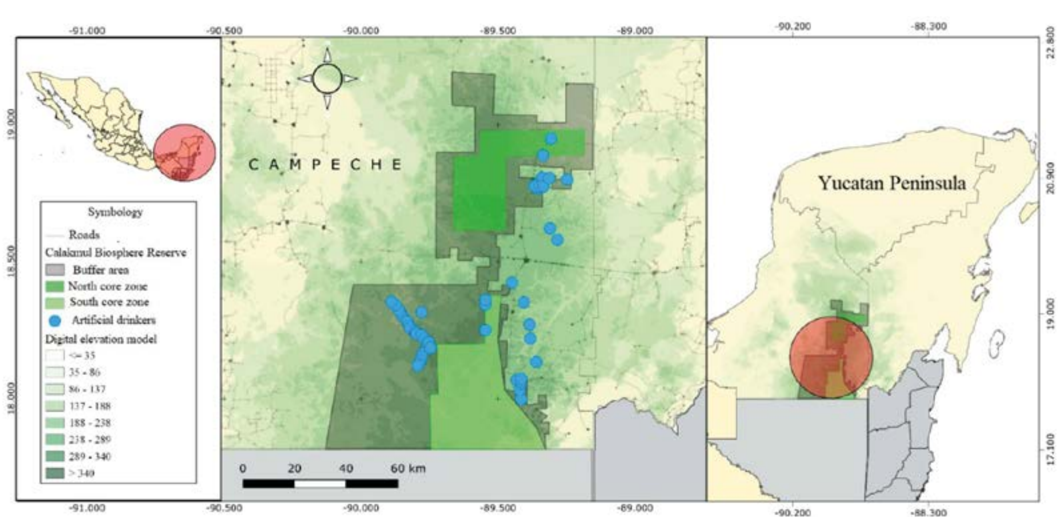

Figure 1. The position of the drinking troughs in the Calakmul Biosphere Reserve and neighboring ejidos in southeastern Mexico are shown in blue circles.

Table 1. Species recorded in drinking troughs.

Group	Family	Taxonomy	Risk category	
			NOM-059	UICN
Anfibios	Hylidae	*Dendropsophus microcephalus*	-	LC
		Scinax staufferi	-	LC
		Smilisca baudinii	-	LC
Reptiles	Anolidae	*Anolis sagrei*	-	LC
	Colubridae	*Drymobius margaritiferus*	-	LC
	Kinosternidae	*Kinosternon creaseri*	-	LC
	Phrynosomatidae	*Sceloporus chrysostictus*	-	LC
	Teiidae	*Holcosus gaigeae*	-	LC
Aves	Accipitridae	*Buteo plagiatus*	-	LC
		Buteogallus anthracinus	Pr	LC
		Chondrohierax uncinatus	Pr	LC
		Leptodon cayanensis	Pr	LC
		Rupornis magnirostris	-	LC
		Spizaetus ornatus	P	NT
	Aramidae	*Aramus guarauna*	A	LC
	Cardinalidae	*Cyanocompsa cyanoides*	-	LC
		Cyanocompsa parellina	-	LC
		Cyanoloxia cyanoides	-	LC
		Passerina ciris	Pr	LC
		Piranga rubra	-	LC
	Cathartidae	*Cathartes aura*	-	LC
	Columbidae	*Claravis pretiosa*	-	LC
		Geotrygon montana	-	LC
		Patagioenas flavirostris	-	LC
		Patagioenas nigrirostris	Pr	LC
		Patagioenas speciosa	Pr	LC
	Corvidae	*Psilorhinus morio*	-	LC
		Cyanocorax yucatanicus	-	LC
	Cracidae	*Crax rubra*	A	VU
		Ortalis vetula	-	LC
		Penelope purpurascens	A	LC
	Cuculidae	*Piaya cayana*	-	LC
	Falconidae	*Micrastur ruficollis*	Pr	LC
		Micrastur semitorquatus	Pr	LC
	Furnariidae	*Dendrocincla homochroa*	-	LC
	Icteridae	*Quiscalus mexicanus*	-	LC
	Mimidae	*Dumetella carolinensis*	-	LC
		Melanoptila glabrirostris	Pr	NT
	Momotidae	*Eumomota superciliosa*	-	LC
	Parulidae	*Geothlypis formosa*	-	LC
		Mniotilta varia	-	LC
		Setophaga citrina	-	LC
		Setophaga ruticilla	-	LC
	Phasianidae	*Meleagris ocellata*	A	NT
	Picidae	*Dryocopus lineatus*	-	LC
	Rallidae	*Aramides albiventris*	-	LC

Table 1. Continues...

Group	Family	Taxonomy	Risk category	
			NOM-059	UICN
Aves	Ramphastidae	*Ramphastos sulfuratus*	A	LC
		Pteroglossus torquatus	Pr	LC
	Strigidae	*Glaucidium brasilianum*	-	LC
		Strix virgata	-	LC
	Thraupidae	*Thraupis episcopus*	-	LC
	Tinamidae	*Tinamus mayor*	A	NT
		Crypturellus cinnamomeus	Pr	LC
	Trochilidae	*Amazilia yucatanensis*	-	LC
	Turdidae	*Catharus ustulatus*	-	LC
		Hylocichla mustelina	-	LC
		Turdus grayi	-	LC
	Tyrannidae	*Pachyramphus aglaiae*	-	LC
		Pitangus sulphuratus	-	LC
		Pyrocephalus rubinus	-	LC
Mamíferos	Atelidae	*Ateles geoffroyii*	P	EN
	Canidae	*Canis latrans*	-	LC
		Urocyon cinereoargenteus	-	LC
	Cervidae	*Mazama pandora*	-	VU
		Mazama temama	-	DD
		Odocoileus virginianus	-	LC
	Cuniculidae	*Cuniculus paca*	-	LC
	Dasypodidae	*Dasypus novemcinctus*	-	LC
	Dasyproctidae	*Dasyprocta punctata*	-	LC
	Didelphidae	*Didelphis marsupialis*	-	LC
		Didelphis virginiana	-	LC
		Philander opossum	A	LC
		Tlacuatzin canescens	-	LC
	Felidae	*Herpailurus yagouaroundi*	A	LC
		Leopardus pardalis	P	LC
		Leopardus wiedii	P	NT
		Panthera onca	P	NT
		Puma concolor	-	LC
	Mephitidae	*Conepatus semistriatus*	-	LC
		Spilogale angustifrons	-	LC
	Mustelidae	*Eira barbara*	P	LC
	Myrmecophagidae	*Tamandua mexicana*	P	LC
	Phyllostomidae	*Desmodus rotundus*	-	LC
	Procyonidae	*Nasua narica*	-	LC
		Procyon lotor	-	LC
	Sciuridae	*Sciurus deppei*	-	LC
		Sciurus yucatanensis	-	LC
	Sigmodontinae	*Sigmodon toltecus*	-	LC
	Tapiridae	*Tapirus bairdii*	P	EN
	Tayassuidae	*Pecari tajacu*	-	LC
		Tayassu pecari	P	VU

official Mexican standard: 11 as subject to special protection (Pr), 8 as threatened (A), and 9 in danger of extinction (P).

The mammals that frequently visit the drinking troughs include both predators (*i.e.*, jaguars and pumas; Figure 2a and 2b) and herbivores (Figure 2c and 2d). Females with young have been likewise observed. Photographs taken in the troughs help to identify the species and their body state, and intra and interspecies interactions, as well as little-known behaviors (Figures 3a-3d).

The presence of key species that constantly use drinking troughs in the Maya Forest region makes it clear that this strategy is ecologically functional for the conservation of high-priority species in terrestrial ecosystems. Therefore, this method partially addresses one of the multiple threats that these species face.

Birds also constantly use the troughs. The most striking specimes belong to the regional birds of prey (*e.g.*, ornate hawk-eagles), tropical forest species (*e.g.*, toucans), and endemic species (*e.g.*, ocellated turkeys) (Figure 4 a,b,c, d).

The number of drinking troughs installed in the CBR was doubled in 2019, as a response to the peak of an intense and prolonged drought recorded in the Calakmul region. In that same year, a high number of sightings of tapirs (*Tapirus bairdii*) in poor physical condition and with dehydration symptoms was registered near or within human settlements (Pérez-Flores *et al.*, 2021). However, it is likely that the impacts of 2019 were not only caused by the lack of water, but also by the increase in the number of fires in the area (Contreras-Moreno, personal communication).

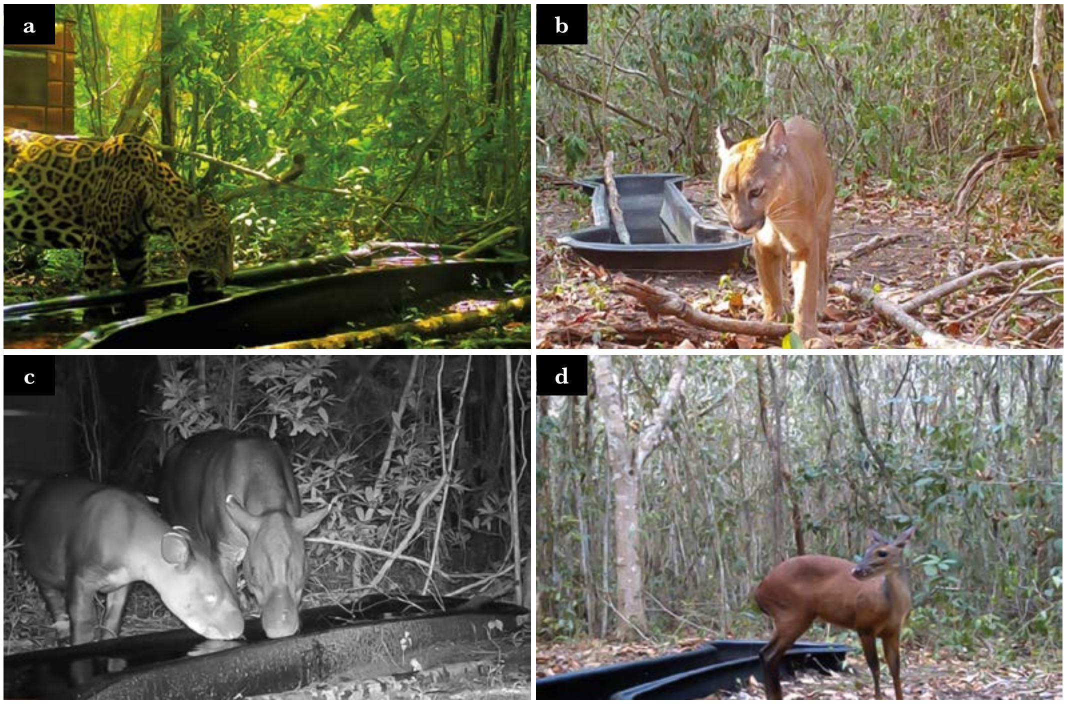

Figure 2. Jaguars (2a) and pumas (2b) are species of great importance for the Calakmul Biosphere Reserve, along with all herbivores such as tapirs (2c *Tapirus bairdii*), and red brocket deer (2d *Mazama temama*). All these species benefit from the water supply provided by the drinking troughs.

Figure 3. The photographic record helps to identify the intra and inter-species relationships of the animals that drink from the troughs. Figure 3a shows a coati (*Nasua narica*) and a great curassow (*Crax rubra*), while figure 3b shows a pair of Yucatan brown brockets (*Mazama pandora*). Species that rarely come down to the ground, such as the Geoffroy's spider monkey (*Ateles geoffroyi*), or curious carnivores such as the tayra (*Eira barbara*), have likewise been photographed (Figures 3c and 3d).

Figure 4. The jungle birds of the Calakmul region (*e.g.*, ornate hawk-eagles (4a) and eagles (4b)) also use artificial drinking troughs, not only for drinking but also as a bathtub. Likewise, tropical birds, such as the ocellated turkey (4c) and the toucan (4d), benefit from the throughs.

The impacts of climate change have likely increased the probability of negative interactions between some wildlife species and people (Abrahms *et al.* 2023). Therefore, supplying water to wildlife through drinking troughs could minimize these potential conflicts.

CONCLUSIONS

The use of drinking troughs is a good alternative to guarantee the availability of water in the Calakmul region. The high diversity of species that constantly visit the drinking troughs in the Maya Forest during the dry season makes evident the functionality of the water supply strategy using artificial drinking troughs. Drinking troughs provide individuals from diverse populations with access to water and enable their interaction. Therefore, throughs could be considered spaces for socialization, as shown by the photos of their interactions. The drinking troughs strategy helps to reduce conflict between various wildlife species and people.

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