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The plight of camels eating plastic waste

Marcus Eriksen[a,b]* *Amy Lusher*[c], *Mia Nixon*[a], *Ulrich Wernery*[d]

[a] 5 Gyres Institute, 5792 W Jefferson Blvd, Los Angeles, CA 90016, USA

[b] Leap Lab, 2122 S. Spaulding Ave. Los Angeles, 90016, USA

[c] Norwegian Institute for Water Research (NIVA), Oslo, Norway

[d] Central Veterinary Research Laboratory. Dubai - United Arab Emirates

*Corresponding author

Email address: marcus@5gyres.org (Marcus Eriksen)

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Plastic Pollution, UAE, Arabian Peninsula, camel, bezoar, polybezoar

Abstract

Ecological impacts of plastic pollution are widespread, in all biomes and geographies. Here, we report the ingestion of anthropogenic waste, primarily plastic bags and rope by dromedary camels (*Camelus dromedarius*) in the United Arab Emirates (UAE) and across the Arabian Peninsula, which has led to a regional mortality rate of 1%. We define the ingested waste as a polybezoar, a collection of tightly packed indigestible materials which can include plastics, ropes, other litter and salt deposits trapped in the stomach or digestive tract forming a large stone-like mass. In the Central Veterinary Research Laboratory (CVRL) in Dubai, UAE, of the more than 30,000 camels evaluated from the region since 2008, there have been 300 camels observed post-mortem with polybezoars in the stomach, from both camels in the CRVL or recovered from desiccated skeletons found in the desert. Here, we analyze a subset of five polybezoars extracted from camel carcasses found in the desert, ranging from 6.2-63.6 kg. Polybeozars lead to gastrointestinal blockages, sepsis from increased populations of gut bacteria, dehydration and malnutrition. Due to high winds and the open desert environment, plastic bags and other film packaging escape open waste bins and landfills, traveling long distances, therefore we suggest improved waste management and alternative systems to package and deliver goods throughout the region.

Main findings of this manuscript:

Camels residing in the UAE are experiencing regional harm at an estimated 1% mortality rate from ingesting plastic pollution. The term “polybezoar” is introduced here to define the tightly packed collection of indigestible materials, which can include plastics, ropes other litter and salt deposits, that is trapped in the stomach or digestive tract, forming a large stone-like mass. The prefix “poly” refers to a synthetic substance, and “bezoar” refers to a small stony concretion that may form in the stomachs of certain animals, especially ruminants. Camels are a culturally significant animal to the region, further justifying the rationale to implement alternative materials and/or systems to package and deliver goods, other than plastic film.

Introduction

Plastic pollution poses significant environmental problems around the world. Plastic pollution of the global environment has been dominated by reports of ecological impacts on marine organisms, including evidence of entanglement and ingestion in over 637 species that interacted with plastic pollution (Kühn et al., 2015). Yet, emissions of plastic to the terrestrial environment may be 4-23 times higher than inputs to the marine environment (Horton et al. 2017). Plastics in terrestrial ecosystems are therefore available to wildlife, although population and ecosystem effects are currently lacking in the literature. There are sporadic, yet increasing, references to the ingestion of plastic as a foreign body in different terrestrial animal groups including scavenging birds (Houston et al. 2007) and ruminants.

Plastics have been observed in digestive tracts of cattle (Singh 2005; Jebessa et al. 2018), sheep and goats (Tiruneh and Yesuwork 2010), Arabian oryx (Anajariyya et al. 2008), camel calves (Ahmed 2011), and adult camels (Wernery et al. 2014). Most of the ingested items were plastic bags and film. Plastic materials cannot be digested and may take a long time to pass through the digestive tract or be retained indefinitely when caught in complex digestive tracts. Consequences of plastic ingestion include ruminal impaction, where indigestible plastic foreign bodies accumulate in the rumen, which leads to indigestion, the formation of bezoars containing primarily synthetic materials, traumas, poor body condition, immune suppression, reduced health status, and mortality (Hailat et al. 1997; Jebessa et al. 2018; Priyanka and Dey 2018). The term "polybezoar" is introduced here to define bezoars containing primarily synthetic materials, with the prefix "poly" refers to the synthetic material, and "bezoar" refers to a small stony concretion that may form in the stomachs of certain animals, especially ruminants.

Unfortunately, the consequences of plastic pollution in regions with minimal or non-existent waste management systems may be greater than other countries due to factors including, but not limited to: low environmental standards, poor waste handling systems, less public awareness of the consequences of plastic pollution, and poor enforcement of waste disposal regulations (Adane and Muleta 2011). When plastic waste is not managed, it can lead to accumulation in not only local urban areas but also remote open grounds due to transport by wind or waterways. It can also accumulate in low shrub vegetation and grassy locations (Ramaswamy and Sharma 2011) as well as acacia trees, which dominate in the region surrounding the Persian Gulf. Consequently, grazing and scavenging animals such as ruminants, will feed indiscriminately on plastic pollution in the environment. Animals ingest plastic waste due to erratic feeding behavior, and confusing plastic with food when trying to eat leftover feed materials in plastic wrappings (Priyanka and Dey 2018). Plastic waste accumulated in the rumen may release dioxins, phthalates, polychlorinated biphenyls (Vanitha, Chandra and Nambi 2010), and heavy metals (Osuga et al. 2013). Ingested plastic materials in the rumen slowly release chemicals to the rumen fluid, which may enter the food chain through milk and meat products (Kunisue et al. 2004).

In the region surrounding the Persian Gulf, camels are the dominant foraging ruminants, with wild populations existing in all countries bordering the gulf. In the UAE alone, populations of camels have been estimated at over 390,000 individuals. Globally, there are estimated to be over 35 million camels (FAO 2019), both wild and domesticated. Camels are browsing animals with up to 37% of their time in a 24-hour period spent grazing (Iqbal and Khan 2001). This feeding behaviour predisposes them to plastic pollution ingestion. Although camels have been identified as versatile animals, capable of surviving and performing in arid and semiarid regions (Iqbal and Khan 2001), as individuals, they are not able to cope with ingested plastic pollution. Plastic pollution in the form of thin film products and packaging, like balloons and plastic bags, is increasingly abundant in deserts worldwide (Zylstra 2013) (Figure 1).

Adverse effects on camels (*Camelus dromdarius*) due to the ingestion of anthropogenic material, consisting of primarily plastic bags, but also ropes and textiles, has been widely observed. Of 156 camels evaluated post-mortem in Jordan, foreign-body accumulation within the first and second stomach compartments was the predominant gastrointestinal disease of slaughtered adult camels (22%), including plastic (65%), rope and leather (23.5%), or all three (11.5%) (Al-Rawashdeh et al. 2000). A recent study of eight juvenile camels sent to a veterinary clinic in Saudia Arabia with obstructions of the esophagus caused by plastic bags (75%) and pieces of cloth (25%) (Shawaf et al. 2017), and an earlier study in the same region found six juvenile camels with obstructions in the esophagus due to plastics bags in five and cloth in one (Ahmed 2011).

Figure 1. Two camels (*Camelus dromedarius*) foraging on plastic waste in the desert near Dubai, UAE. Photo: Ulrich Wernery

The Central Veterinary Research Laboratory (CVRL) in Dubai, UAE has evaluated over 30,000 camels since 2008, both in the laboratory and in the field. CVRL has documented 300 cases of mortality due to ingesting anthropogenic waste that form polybezoars, ranging in weight from 1kg to 50kg, and primarily plastic bags and ropes (Wernery et al. 2014). They have been observed to die for several reasons :

- Sudden death caused by complete obstruction of the intestine by a plastic bag, or incomplete obstruction accompanied by a secondary clostridial enterotoxemia, a bacterial infection, due to plastic ingestion. In the later cases, lesions are observed and toxin-producing anaerobes are abundant and isolated where the plastic mass nears the tissues.
- Death within two to three weeks due to organ failure. In these cases, the ingested plastic rubbish releases toxins into the circulatory system, which causes the liver values (glutamate oxalaetate transaminase - GOT [AST], gamma-glutamyl transferase [y-GT],

glutamate-pyrovate-transminase- GPT [ALT]) and kidney values (blood urea nitrogen-BUN, creatine) to increase steadily, culminating in organ failure (Wernery et al. 2014).

- Slow death due to starvation. Plastic bags, parts of plastic bottles and caps, plastic ropes used to hold hay bales together, and other plastic utensils accumulate, most probably over weeks, months, and years, in camels' stomach compartments. When in the stomach, they start to calcify, forming a solid plastic mass, which may fill and take the shape of the first compartment in the stomach. This plastic mass, or polybezoar, can affect feeding behavior, resulting in camels eating less until they stop eating completely, as the camel always feels full, resulting in a false sense of satiation.

Harm to individual ruminants from plastic ingestion can be straightforward, such as mechanical obstructions, perforations of the intestinal tract, and abscessed or ulcerated intestinal linings (Ahmed, 2011). These impacts can lead to stomach volume displacement, false-satiation and slow malnourishment, dehydration and toxification from leached compounds from the plastics themselves or sepsis from high bacterial loads living in the folds of plastic film (Priyanka and day, 2018). This vulnerability may contribute to immuno-suppression, liver damage, and clostridium (Wernery and Kaaden, 2002). These observations show clear harm to individual animals, but the extent of harm to entire populations has not been fully explored yet.

Therefore, the aim of this study is to document the occurrence, abundance, and composition of ingested anthropogenic matter in the stomachs of camels, introduce polybezoar as a distinct nomenclature to describe these observations, and suggest mitigations to address the problem.

Materials and Methods

Between 2008 and 2017, five bezoars of anthropogenic material (Figure 2 and 3) were recovered post-mortem from desiccated skeletons of camels found near Dubai, UAE in a distance no more than 100km south and 50km east to the foothills of the Al-Hajar mountains (Figure 4). The polybezoars were brought to the Central Veterinary Research Laboratory (CVRL) in Dubai, whereby they were brushed and shaken to dislodge loose sediment, and were suspended outside the laboratory facility until gathered for this study.

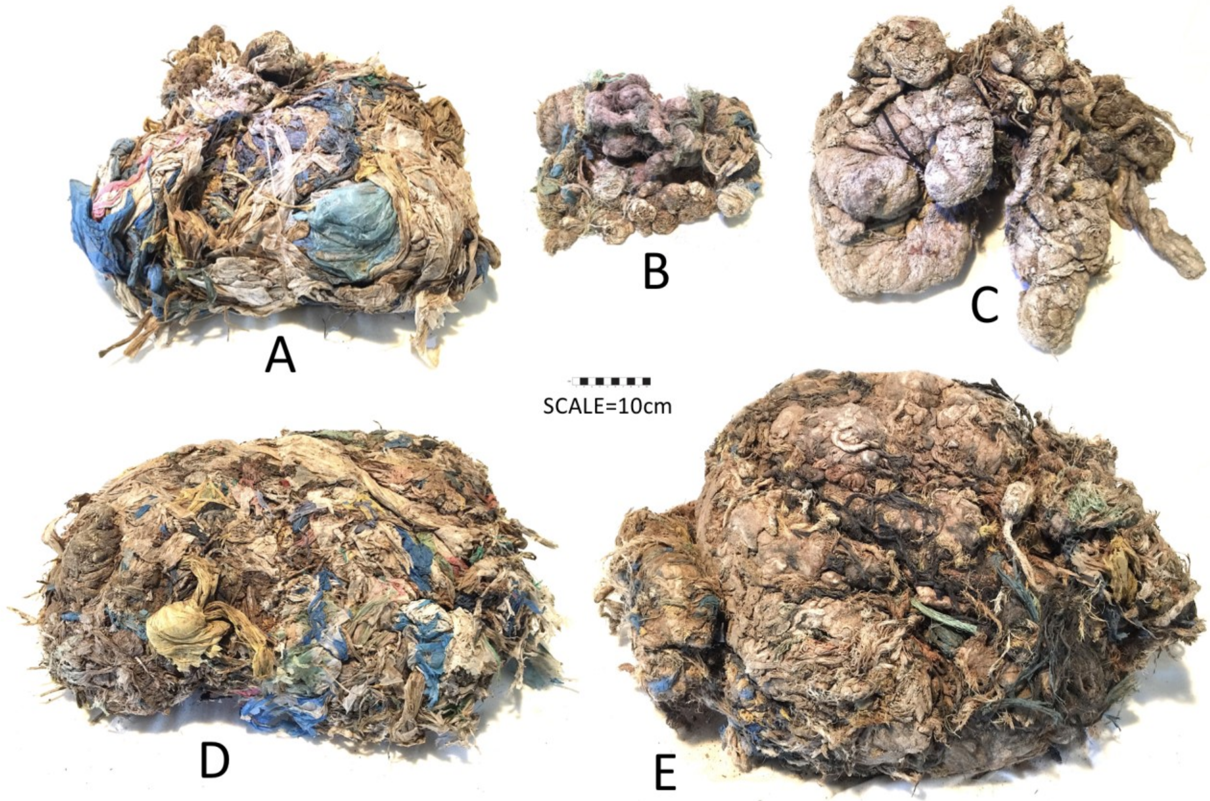


Figure 2. Five polybezoars collected from camel skeletons discovered within 150km of Dubai, United Arab Emirates.

Figure 3. Polybezoar E discovered in situ inside a desiccated camel skeleton found in the desert south of Dubai, United Arab Emirates. Photo: Ulrich Wernery.

Figure 4. Regional map showing the region where the five camel polybezoars were collected near Dubai in the United Arab Emirates. Image courtesy of Google Maps.

The five polybezoars were brought into the CVRL and weighed using a digital scale to the nearest 10 grams. Volume was ascertained by putting the bezoar inside a vacuum sealed bag, filling a large bin with water and submerging the polybeozar beneath the water surface. The volume of displaced water was collected and measured to the nearest 0.1 liters.

Fourier Transform Infrared Spectroscopy (FT-IR) was used for polymer identification using two instruments with different libraries. In each polybezoar, the two largest items externally visible were sampled by cutting away a small fragment of the material. Each sample, two from each of the 5 polybezoars, (n=10) was analyzed on two different FT-IR instruments to get comparative results. The samples were cleaned with isopropanol to remove as much calcification and dirt as possible before analysis. First, plastic pieces were tested using an Agilent Cary 630 FT-IR spectrometer with a diamond ATR accessory followed by a Perkin Elmer

Spectrum Two FT-IR with a diamond ATR accessory. Separate library searchers were performed using the Agilent Polymers ATR library. Best matches were calculated based on the library software of each instrument. Each match reported was above 90%.

Results

The weight and volume of each of the five polybezoars are reported in Table 1. Plastic was clearly present in each polybezoar, with two dominated by rope fragments and the other three dominated by plastic bags, based on external evaluation. Polybezoar D was sawn in half to expose the center, which revealed plastic film throughout the entire mass, primarily plastic bags, with no calcification internally (Figure 5). External calcification on polybezoar D was minimal, unlike polybezoars B, C, and D, which showed calcification of the rope fragments into a hardened mass (Figure 2).

Bezoar	Volume (l)	Weight (kg)
A	29.5	8.61
B	4.5	2.81
C	18.4	15.15
D	47.0	14.29
E	65.5	63.60

Table 1. Analysis of five camel polybezoars by volume and weight.

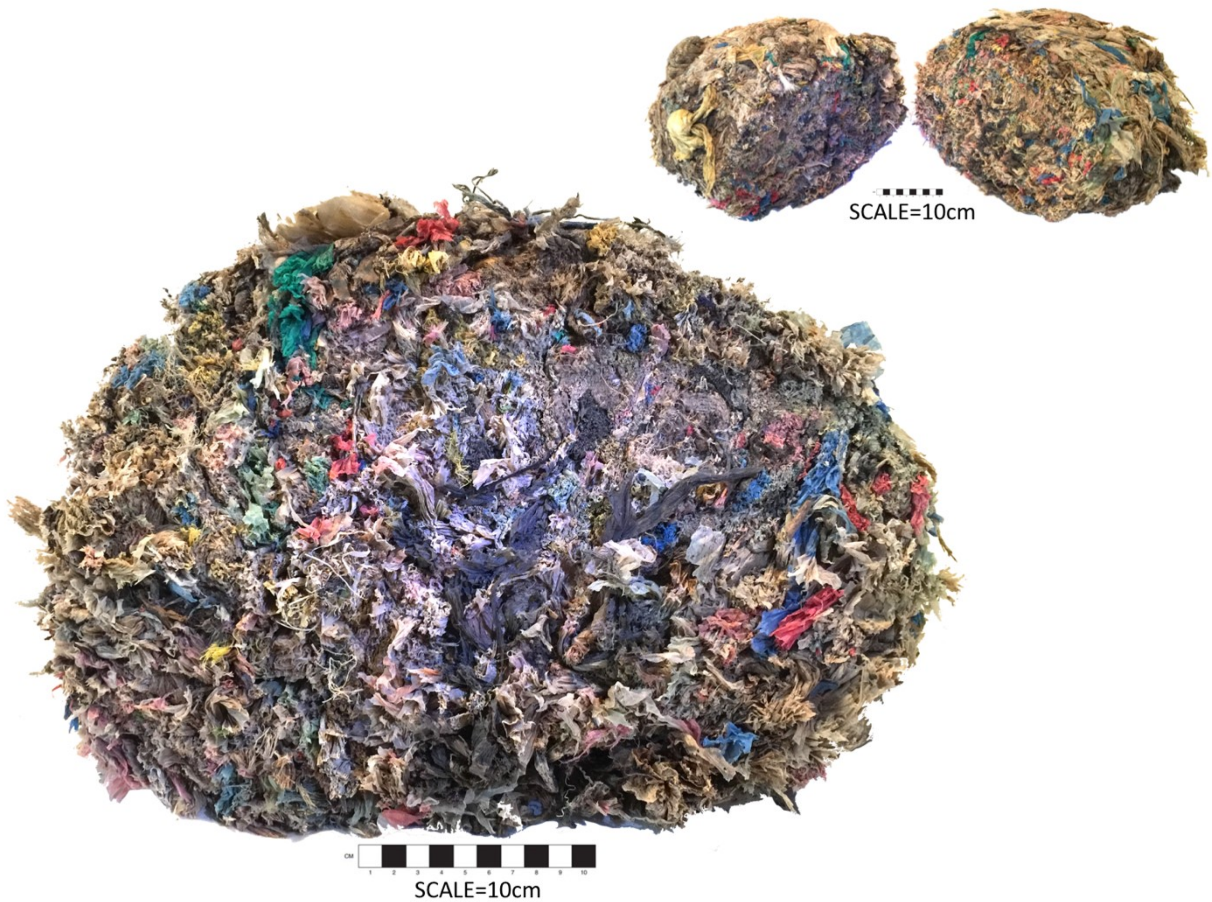


Figure 5. Bezoar D split to expose an interior of compacted plastic film.

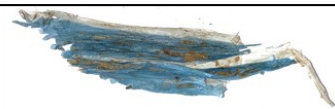
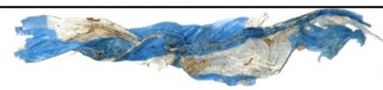
Sample	Description	Polymer	Fragment image
A1	Blue and white film, possible bag	Polyethylene (both colors)	
A2	White film, possible bag	Polyethylene co-polymer, co-polymer possibly triacetate	
B1	White and green rope	Polypropylene	
B2	Mixed ropes, lime, white, grey	All colors were polypropylene	
C1	Calcified green rope	Polypropylene	
C2	White rope	Polypropylene	
D1	Blue and white film, possible bag	Polyethylene (both colors)	
D2	White film, possible bag	Polyethylene	
E1	Blue film, possible bag	Polypropylene	
E2	Black rope	Ethylene vinyl acetate	

Table 2. FTIR analysis of 10 fragments of synthetic material, two from each of the five polybezoars.

Of these 10 samples removed from the five polybezoars, five were plastic film and five were fragments of rope, which were analyzed for polymer identification (Table 2). Polyethylene was the dominant polymer for the film samples (A1, A2, D1, D2), with one film sample identified as polypropylene (E1). Of the 5 fragments of rope, 4 were polypropylene (B1, B2, C1, C2) and one (E2) contained ethylene vinyl acetate.

Discussion

Of the 300 documented cases of mortality due to ingesting anthropogenic waste, both in the Central Veterinary Research Laboratory (CVRL) or collected from the desert, a subset of five polybezoars from desiccated skeletons in the field were evaluated in this study.

Using simple descriptive techniques to understand the weight and contents of each one, this study revealed the dominance of plastic film, primarily plastic bags made from polyethylene, and rope made primarily from polypropylene. Evidence of harm from plastic ingestion has been observed in hundreds of camels evaluated live and post-mortem by the CVRL and other veterinary clinics in the region over the past several decades. To mitigate the harm from anthropogenic plastic waste on camels, we must understand the significance of plastic waste impacts to individual animals, the exposure of animals to plastic waste in the region, and the types of mitigation strategies available to reduce exposure.

Population-level impact

The literature on harm caused by plastic ingestion or entanglement is dominated by studies of marine organisms, and is largely focused on field observations of individual organisms or laboratory studies showing impact. What is missing in the literature are studies of populations of organisms at ecologically relevant concentrations of plastic waste. While field studies of population-level effects are low, the perception is that population-level harm is high (Rochman et al. 2016).

In this study, we observed a 1% regional mortality rate. The total dromedary camel population in the UAE region is estimated to be roughly 390,000 animals. The CVRL has evaluated over 30,000 camels since 2008, both in the laboratory and in the field, with 300 documented deaths contributed to polybezoars in the stomach. Similarly, all the camels studied in the laboratory that had plastic waste extracted from their gut were also evaluated for toxicity, and were found with elevated levels of liver and kidney enzymes, indicating toxification (Wernery et al., 2014).

Reducing Exposure to Plastic Waste

Plastic waste is abundant in the desert regions surrounding the Persian Gulf. In the case of camels in the UAE, animals are roaming the desert in small groups that forage in acacia forests, roadsides, and in landfills. Exposure to thin film plastic bags and packaging is common in these areas, as plastics escape waste bins or dumpsters, or are littered, resulting in wind-borne macroplastics traveling long distances. Recovering waste along roadsides and fences will reduce the likelihood of UV degradation and fragmentation of plastics, thereby reducing the exposure of wildlife to plastics, although the most economic mitigations happen before plastic waste escapes to the environment.

Desert recreation from campers, hunters, and falconers is responsible for significant loss of plastic waste. In a study of Arabian oryx in the fenced Mahazat as-Sayd Protected Area in Saudi Arabia, thirty oryx were captured and contained. Within one year, seven died of plastic waste ingestion, whereby roadside litter trapped against the fence was the primary exposure to waste that was eaten (Anajariyya et al. 2008). This prompted public education campaigns and waste management to recover plastic waste along the fence line.

Municipal solid waste (MSW) management is rapidly developing throughout countries surrounding the Persian Gulf. MSW management alternatives include landfilling, incineration, and recycling. The option of landfilling is declining in most developed countries as soil, water, and air contamination, increased potential for human health risks, and the scarcity of locations near urban developments increases (Paleologos et al. 2016). The MSW component of the General Waste stream in the UAE has increased from 1,523,822 tonnes in 2003 to 2,689,808 tonnes in 2011. According to the waste composition analysis conducted in 2012, 35% of the General Waste stream by weight was organic waste, 24% paper, and 24% plastic (Saifaie, 2013). A recent survey of public attitudes in the UAE shows a high level of interest in rapidly addressing plastic waste (Hammami et al. 2017).

In recent years, as the UAE and other countries surrounding the Persian Gulf experience a rise in GDP and population size, which correlate to increased consumption and waste generation, new models of waste management beyond landfilling have been considered. These countries are considering waste to energy as the dominant disposal option for the foreseeable future (Paleologos et al. 2016). In the cities of Dubai, Abu Dhabi, and Sharjah, large waste to energy facilities are currently operational or soon to become operational, meeting the goal of 75% diversion of MSW away from landfill by 2021 (United Arab Emirates 2019). Regardless of these mitigation strategies, including common devices called “BinStraps” used to secure lids on waste bins so the force of wind cannot open them, plastic film and bags continue to escape urban developments into the environment.

Plastic bag bans are increasing in municipalities across the globe (Xanthos and Walker 2017). The Dubai Municipality launched the "Say No to Plastic Bags" campaign in 2013, aimed to reduce plastic bag consumption by 20% in the first year, to tackle the annual 2.9 billion plastic bag consumption rate across the UAE (Pandy 2016). Today, efforts to eliminate plastic bags from the UAE are primarily conducted in the private sector, as shopping malls and grocery stores voluntarily eliminate plastic bags or charge a fee for bags to create disincentives for their use. While these actions are noteworthy, they will not curtail the loss of plastic waste to the environment.

Finally, in the absence of significant single-use plastic reduction measures, and the continued loss of plastic bags and film to the environment, it becomes the responsibility of animal husbandry to reduce exposure of animals to plastic waste. Good animal husbandry, by providing adequate feed, water, shelter and mineral supplements, as well as establishing grazing centers and water facilities will deter the straying of animals to roadsides and landfills in search of sustenance (Priyanka and Day 2018).

Conclusion

The camel is a culturally significant, charismatic megafauna that is of tremendous cultural value to nations surrounding the Persian Gulf, where the animals in this study were discovered. In the United Arab Emirates, camel racing has emerged as a means of cultural identity, giving meaning to Badu (Bedouin) poetic voice and its politico-cultural discourse (Khalaf 2000). Camels, while they are prized in competitive breeding, racing and are utilized in cultural events, such as weddings and political parades, are significantly harmed by the abundance of plastic waste, especially single-use plastics and bags blowing across deserts and escaping even the most efficiently designed waste management systems. Therefore, it is essential that careful consideration be placed on the role of single-use plastics, their current use, and eventual elimination from modern societies.

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