Availability of Microtrash Materials and Selectivity by California Condors

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By

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Abstract

California condors consume non-food items, including anthropogenic waste, and provision it to their young. Consuming “microtrash” can cause mortality, especially in nestlings. There are several hypotheses explaining why condors might consume microtrash. These hypotheses assume condors exhibit a preference for the type of material. Therefore, we test the assumption that when California condors take microtrash, they display material selectivity. We did this by sampling microtrash from roadside pullouts in the Los Padres National Forest. Those samples were compared to condor necropsy and nest microtrash data, categorized by material type: glass, plastic, metal, and other. We find that in our analysis condors exhibit a preference for plastics and an avoidance of “other” materials (primarily ceramic).

Introduction

California Condors (*Gymnogyps californianus*) are critically endangered scavengers, endemic to North America. With a wingspan of 9 feet, they are the largest bird on the continent (Walters et al., 2008). Their diet consists of carcasses from large mammals, from which they predominantly consume muscle tissue and internal organs, or viscera, from within the body cavity (Houston et al., 2007). Their massive size, efficient flight, and use of thermals and strong winds allow for a large individual home range size, sometimes reaching up to 180 km in radius (Meretsky and Snyder, 1992, Rivers et. al., 2014).

California condors are a prehistoric species, alive during the Pleistocene period (2.58 million years to 0.012 million years ago) alongside mastodons, giant ground sloths and saber tooth tigers (Emslie, 1987; Snyder and Snyder, 2000). At that time, their range extended from Canada to Mexico and reached across the southern and eastern portions of the United States (Emslie, 1987; Snyder and Snyder, 2000). Following the Pleistocene extinction, megafaunal species no longer existed, causing the species' first major population decline. The range size decreased to the west coast of North America (British Columbia to Baja California) (National Park Service). Their range stabilized until European settlement began in North America (Koford 1953, Wilbur 1978). With increased human presence, their range and population size began to fluctuate, but for different reasons. As humans began to affect condor populations, the threats consisted of shooting birds, egg collection from the wild, and capturing of birds (National Park Service, CA Department of Fish & Wildlife). Lead poisoning, cyanide poisoning, negative DDT effects on egg shell thickness, and power line collisions were more threats that developed as human society advanced further (National Park Service, CA Department of Fish & Wildlife). By the late 1930's, California condors were only present in California (National Park Service) and by the later 1900's they were only living in the mountains of Southern California (Koford, 1953; Wilbur, 1978; Snyder and Snyder, 2000). Condors were listed as federally endangered in 1967. By 1982, only 22 birds were alive in the wild. After much consideration, the decision was made by U.S. Fish & Wildlife to begin a captive breeding program in 1983. By 1987, each remaining bird was in captivity (National Park Service).

The life cycle of a condor is exceptionally long. Birds reach sexual maturity when they are about six years of age and once mated, females typically lay one egg every 1-2 years (National Park Service). During the captive breeding program, removal of eggs from nests was a method used to trigger another egg-laying (National Park Service), increasing the population size much more rapidly than what would have happened otherwise. Condor releases back into the wild began in California in 1992 (National Park Service). Birds have been released in Arizona and Mexico as well (National Park Service). After facing this rapid population decline in the late 1900s (Koford, 1953; Wilbur, 1978; Snyder and Snyder, 2000) and being released back into the wild, California condors currently face obstacles that were unforeseen when the recovery efforts began in the 1980s.

Unanticipated "bad" behaviors of released birds are proving to be severely counterproductive for increasing the overall population size (Walters et. al., 2008). Additionally, these behaviors are resulting in a continued need for human intervention. This includes 1) provisioning calf carcasses to ensure the birds don't eat carcasses containing lead, 2) monitoring of behavior to remediate their physical ailments, specifically lead poisoning, before they result in death, and 3) occasional emergency surgeries performed on nestlings to remove blockages or build-up of harmful materials, particularly microtrash (Walters et. al., 2010). Herein I focus on microtrash.

Consumption of microtrash can lead to many negative outcomes. Examples include inflammation and pressure within the crop and gizzard which reduces function, prevention of adequate nutritional uptake from provisioned food, and potentially death (Walters et. al., 2008). Metal microtrash can also result in lead exposure (Finkelstein et. al., 2015). There are very little data about original causes of population decline, though most speculate that it was due to lead poisoning. There is essentially no analysis regarding microtrash, so it is difficult to determine if microtrash was a *major* contributor to population decline before reintroduction (Rideout et. al., 2012). We do, however, know that microtrash was present in nests prior to captivity and subsequent reintroductions, with a significantly smaller size, mass and frequency (Walters et. al., 2008).

There are many hypotheses for why large scavenger bird species, including California condors, pick up microtrash and bring it to nesting areas. Cape Vultures (*Gyps coprotheres*) appear to pick up and consume microtrash as a calcium source (Richardson et. al., 1986), which was the first hypothesis for condor microtrash behavior. However, they have been shown to exhibit bone deformities (osteodystrophy) when they fail to consume *actual* calcium sources (bone fragments). Because the condor diet consists of muscle and viscera, there are very few bones in their diet that are small enough for the birds to consume as a calcium source. This may not be detrimental to all adult birds. However, before and during egg-laying seasons, females need a surplus of calcium to lay eggs with an adequate shell thickness for hatchling survival as well as to ensure sufficient bone development in nestlings (Houston et. al., 2007). California condors have been thought to exhibit signs of diminished feather development when they are calcium deficient (Mee et. al., 2007a). However, this physical change can be associated with many issues like crop blockages and other nutritional deficiencies (Mee et. al., 2007a). As a result, it is difficult to show the direct link of microtrash consumption for calcium supplementation, as shown for cape vultures. Therefore, it is not definitively known why condors pick up microtrash, but it is known that microtrash picked up by parent birds can be either placed within their nesting area or directly fed to nestlings (Mee et. al., 2007a). A secondary hypothesis that researchers have developed is that microtrash is provided as a substitute digestive aid (Houston et al., 2007, Benson et. al., 2004). If microtrash is more readily available, more conveniently located, or simply easier to carry than small sticks and stones normally provided to nestlings as digestive aids, then it could be likely that parents are more inclined to use the microtrash. A third hypothesis is that microtrash consumption is an adaptive behavior in food-stressed individuals (Benson et. al., 2004). In environments where meat is not as available, behavior might be modified to seek out bone and microtrash as food sources. A final hypothesis is that microtrash can replace fibrous materials readily available to free-flying birds as a binding material to form pellets (Mee et. al., 2007a). Microtrash tends to not be effective in binding to indigestible material, so it remains within the body of a nestling. This makes it a particularly harmful material to nestlings, but less so to adult birds who have access to better pellet-forming materials outside of the nesting area.

Dr. Mee and other authors attempted to document how microtrash present within a nesting area and/or nestling affected the adult condor's nest success via nestling mortality in "Junk ingestion and nestling mortality in a reintroduced population of CA condors *Gymnogyps californianus*." This study was conducted in the Los Padres National Forest. California condors do not carry microtrash in their bills or with their feet; instead, it is always swallowed. Therefore, when regurgitated, the trash commonly has some amount of cattle hair attached to it because condors in California frequently consume provisioned cattle carcasses. Of 10 nests sorted through by Mee et al. (2007a), seven contained some amount of microtrash. In addition, Mee et al. (2007a) performed necropsies on dead nestlings to determine cause of death and assess the prevalence of microtrash within the body. Their results showed that of all the eight birds assessed, 37.5% had trash materials as the cause of death or cause for removal from nest for emergency care. Importantly, all but one of the eight necropsied nestlings had microtrash within the gizzard and were exhibiting negative consequences of microtrash ingestion (zinc toxicity, retarded feather development, distention). In total, there were 650 pieces of microtrash retrieved from nests and nestlings. 34.8% were plastic, 34.3% were glass, 22.8% were metallic and 8.1% were deemed "other." Considering there has only been one successful fledging from 2001 to 2005 in southern California out of 13 total breeding attempts in the wild, the conclusion was made that microtrash is, in fact, playing a very major and detrimental role in nest failure of California Condors.

Because there were varying proportions of material types (plastic, glass, metal, and other) found in nests and nestlings from data by Mee et al. (2007a), it is possible that California condors may have a preference for the material type they consume and bring to the nest areas or nestlings. Preference would be demonstrated if, for example, some material type was rare in the field but common in nests. Therefore, we attempted to determine the prevalence of microtrash types available in the Los Padres National Forest. Specifically, we compared proportions of material types found in dirt road pullouts of the Los Padres National Forest to the proportions found by Mee et al. (2007a) to determine if there was a difference in proportions or if the birds were only providing materials based on availability. If there was a difference in proportions, it would suggest that condors are selecting for particular material types. Without a difference, I would conclude that microtrash selection is effectively random. I found that when California condors take microtrash back to their nests and nestlings, they do have a preference for material type.

Materials and Methods

Hi Mountain Lookout is a fire lookout located within the Los Padres National Forest, a 1.75 million acre area spanning from Ventura to Monterey (https://www.fs.usda.gov/main/lpnf/about-forest). More specifically, the area of LPNF where Hi Mountain Lookout stands is the Santa Lucia Wilderness Area within San Luis Obispo County, inland from San Luis Obispo and Arroyo Grande as well as southwest of Pozo (Figure 1). This specific region is dominated by chaparral, riparian, and oak woodland (Desideri, 2016).

All roads leading to Hi Mountain Lookout are unpaved and mostly available to the public. Hi-Mountain Lookout Road travels along the ridge of the Santa Lucia Mountain Range and pullouts are subsequently located on outcrops of the ridge (Figure 1).

The pullouts were chosen based on criteria of California condor use. Each one had little foliage within, ensuring that if a condor was present, enough wind would move through the area to propel the bird skyward. The pullout size was also considered; we estimated that it needed to be large enough for an adult bird to spread its wings fully while still on the ground (at least 9 feet long or wide).

The pullout sampling process required quart-sized plastic bags, three quadrant squares (1m by 1m), and a Sharpie to label the plastic bags. The pullouts sampled were labeled “A” through “E” and each bag was labeled one through six. However, it’s important to note that because our data collected all the microtrash into different categories, these labels became unimportant. Once at a selected pullout, our three quadrat squares were randomly tossed within the pullout, each one thrown twice. Within the 1m by 1m square, microtrash contained within the loose soil was collected by hand. This totaled six bags at each of the five pullouts.

With 30 samples collected, a categorical sorting was performed to match those in Mee et. al.’s “Junk ingestion and nestling mortality in a reintroduced population of California Condors *Gymnogyps californianus*.” The four categories were Glass, Plastic, Metal and Other.

Data Analysis

We performed a chi-square analysis https://www.socscistatistics.com/tests/chisquare2/default2.aspx comparing the proportional data of the four categories – glass, plastic, metal and other - collected from the roadside pullouts to those from nestling/nesting area data from the publication (see above). Results were considered significant if the P-value < 0.05.

Results

The total number of microtrash pieces collected from five turnouts in the Los Padres National Forest was 383 pieces. The total sample from nestlings and nesting areas by Mee et al. was 650 pieces. Table 1 displays the amount and proportion of microtrash material types from Mee et. al. (2007a) and from roadside pullouts along Hi Mountain Lookout Rd. While there was no breakdown of the materials in category “Other” in Mee et. al.’s (2007a) publication, a subcategory sorting of “Other” was conducted for this report, displayed in Table 2. Figure 2 displays examples of microtrash collected from pullouts.

I used a chi-squared data analysis to test the null hypothesis that the proportion of material types collected from nests and nestlings is not significantly different from the proportion of material types available from pullouts in the Los Padres National Forest. The chi-square test had a p-value of < 0.00001 and a chi-square statistic of 57.636. Therefore, I reject the null hypothesis. This suggests that what condors collect is not representative of what is available in their surrounding environment, thereby suggesting that condors have a preference for specific microtrash materials.

Discussion

I infer that when California condors take microtrash back to their nests and nestlings, they do have a preference for material type. Specifically, I found that the proportion of material types found in nests and nestlings, and thus collected by Mee et al. (2007a), is significantly different from the proportion of material types available from pullouts in the Los Padres. The statistically significant p-value means that there is a relationship between microtrash types available to the birds and what they bring to their nesting areas and nestlings. Essentially, material type *does* matter. The samples collected from pullouts represent what is available to the birds and the data from Mee et. al. (2007a) represents what the birds actually *choose* to consume and regurgitate for their nests and nestlings. The largest discrepancy seems to be with plastics: 20.6% of what is available for the birds is plastic, but plastic makes up 34.8% of what is brought to their nesting area. This suggests that the birds exhibit a strong preference for plastic microtrash and could potentially seek it out from all available microtrash. Furthermore, 23% of what is available in the Los Padres is in category "other", but according to Mee et. al. (2007a) only 8.1% of materials brought back to the nest are actually in the "other" category. These proportion differences show a strong selection against "other" material. I note here that this category is primarily composed of ceramic objects. The proportion comparisons of glass and metal do not show a deviation from expected to actual proportions.

Ceramic material – more specifically fragments of clay pigeons – made up the largest percentage of the "other" category. However, because the "other" category was so small overall in Mee et al., there appears to be a strong selection against the ceramic material. This has the potential to debunk the hypothesis that condors consume microtrash that resembles bone fragments as a calcium source. White ceramic (almost 40% of the "other" category collected from the pullouts) is the material that most resembles bone fragments, but the results obtained here suggest that in regards to white ceramics, condors just don't seem to be picking it up. This is the same finding as Mee et al. 2007a; they found that white items even vaguely resembling bone made up a very small percentage of the microtrash found in nestlings and nesting areas.

Furthermore, another study found that white ceramic even remotely resembling bone fragments made up only 15% of the entire microtrash collection (Mee et al., 2007b).

The lack of a subcategorization of the “other” category in Mee et al.’s (2007a) publication creates the possibility of a discrepancy between their sample set and mine. Without any definition of what their “other” consists of, it is difficult to determine what materials they collected from nests and nestlings. My “other” category, though overall a small proportion of the materials collected, specifically sub-categorizes what materials were included, and the category displays a high proportion of ceramic fragments. Therefore, it’s impossible to tell whether ceramic material was properly identified in Mee et. al.’s (2007a) publication. Based on texture and appearance, I would assume that it’s difficult to confuse plastic and clay microtrash, so I believe it’s unlikely that Mee et. al. (2007a) incorrectly identified materials. However, if they did so, their proportions would be skewed, resulting in an invalid chi-square test comparing the two sets of proportions.

I acknowledge that samples from the Los Padres National Forest may not be entirely representative of what is available to condors. The pullouts sampled were only on Hi Mountain Lookout Road within close proximity to the Hi Mountain Lookout, while the entire forest spans 2,969 square miles. Because of this, there most likely is a larger amount of microtrash along my survey route than would be the average across the entire forest. People are highly likely to frequent this area in particular (due to somewhat easier access), much more so than other locations with more limited access. However, the representation (or lack thereof) of the entire forest is easy to test. A repeated survey can be conducted elsewhere within the National Forest, potentially surveying multiple roads, farther from the lookout. Such a study should compare the proportion of materials discovered to this study *and* to the Mee et al. study. That way we will know how representative my sample is, while also discovering how general my result is.

A valuable caveat to identify is that the Los Padres National Forest is located within California. The birds residing here have very different microtrash behaviors than birds in Arizona (Woods et. al., 2007). There are also different maintenance processes in protected areas to mitigate bad behavior. For example, in Southern California, there are provisioning sites to provide condors with calf carcasses as a main food source. The consistent placement of this food source at the same location has caused the birds to essentially cease natural foraging behaviors (Mee et al., 2007b) and become almost entirely focused on specific location(s) (Mee et al., 2007a). In this regard, microtrash collection might be much more concentrated in a small area, which can have implications on the types of microtrash available and how one might conduct a study such as mine. However, this consistent provisioning of food has had some benefits. Condor populations in California face a much lower rate of lead toxicity because their food sources are confirmed to be safe for consumption. Arizona birds forage for their own food and locate carcasses that aren't necessarily safe for them to eat. As a result, they face a higher rate of lead toxicity. Nest-to-provisioning-site distance is also dramatically different between California and Arizona populations. Condors in California tend to nest within close proximity to provisioning sites, typically between 2.5 and 12 km. With less dependency on provisioning areas, Arizona condors are estimated to nest ~80 km away from food provisioning sites (Mee et al., 2007a).

There is even a difference in behavior between the Central California populations and Southern California. Southern California birds exhibit more microtrash consumption than birds in Central California. According to Walter et al. (2008), it is possible this is due to the increased prevalence of oil drilling sites near nesting areas along with an overall increase in roadside trash in Southern California. Another potential reason is simply the larger human population present in Southern California. With a decreased area of untouched environment, it’s possible the residing condor population has no other option than to nest near humans, resulting in easier access to trash that is inappropriately discarded.

Figures

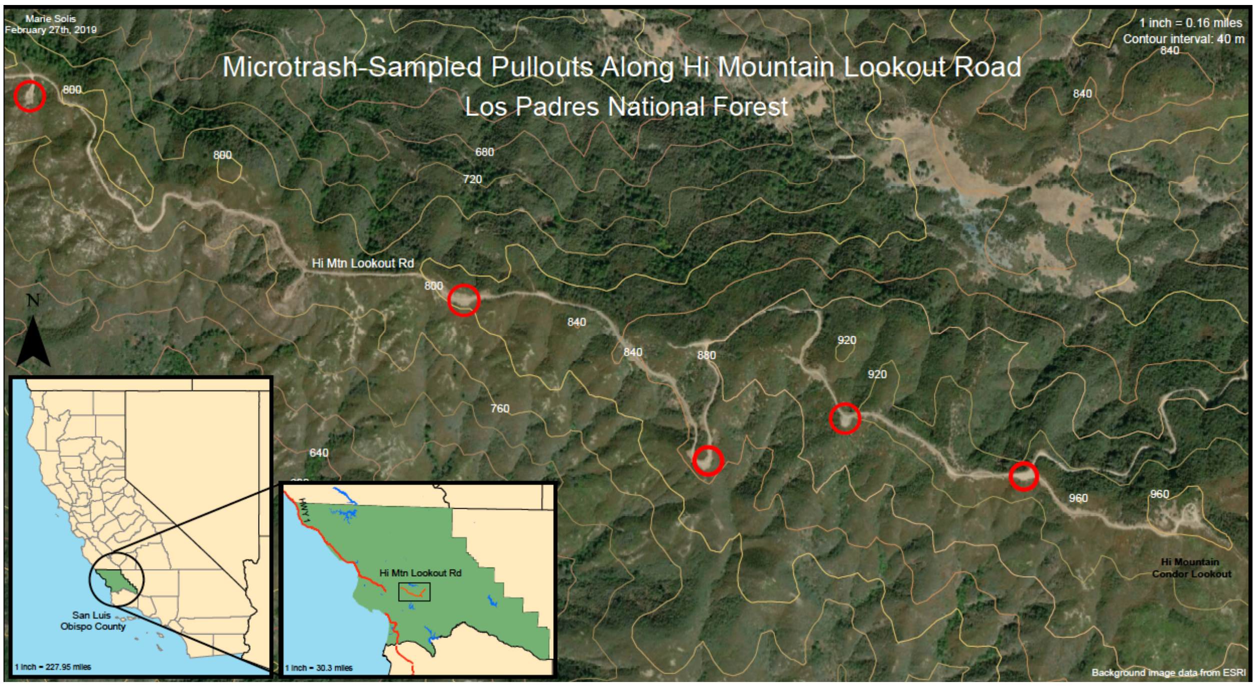

Figure 1. Hi Mountain Lookout Road with pullouts sampled in red dots. Topographic lines have a 40 meter contour interval. Insert maps display Hi Mountain Lookout Road within San Luis Obispo County as well as San Luis Obispo County within California.

Figure 2. Microtrash surveyed at pullouts with 4 categories (plastic, metal, glass, other) displayed.

Table 1. Count and proportions of four microtrash categories from Mee et al. (2007a) and from Hi Mountain dirt road pull-outs.

		Plastic	Metal	Glass	Other	Total
Count	Mee et al.	226	148	223	53	650
	Hi Mt.	79	72	144	88	383
Proportion	Mee et al.	34.8%	22.8%	34.3%	8.1%	100%
	Hi Mt.	20.63%	18.80%	37.6%	22.98%	100%

Table 2. Count and proportion of microtrash Subcategories describing the breakdown of the 88 samples from Hi Mountain categorized as "other" in table 1.

	Rubber	Ceramic (black)	Ceramic (white)	Cerami c (grey)	Ceramic (blue)	Plastic and metal casing	Total
Number	3	47	35	1	1	1	88
Proportion	3.41%	53.41%	39.77%	1.14%	1.14%	1.14%	100%

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