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SHORT COMMUNICATION

Differential detectability of rodents and birds in scats of ocelots, *Leopardus pardalis* (Mammalia: Felidae)

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ABSTRACT. Scat analysis is a valuable tool for the description and quantification of mammal diets. However, estimating the number of prey eaten using prey remains found in feces is difficult mainly due to differential digestibility of prey. In this context, we performed feeding trials with captive ocelots, *Leopardus pardalis* (Linnaeus, 1785), to evaluate the time needed until complete elimination in feces of different prey such as rodents and birds. Rodents took up to five days and birds two days until complete elimination. Our results are consistent in showing that elimination time differs for different prey and some prey may take a long time to be expelled, inducing errors in dietary studies.

KEYWORDS. Captive; diet; feeding trial; prey.

Dietary studies are essential to predict the viability of a given species in its habitat. Scat analysis is a valuable tool for the description and quantification of mammal diets, since it is a non-invasive technique that allows recovering dietary information of secretive species such as mammalian carnivores (Weaver & Hoffman 1979, Putman 1984).

Felids, as top predators, play an important role in structuring communities, (Dirzo & Miranda 1991, Terborgh 1992). For this reason, it is important that the number of prey captured and biomass consumed are accurately reported in felid dietary surveys (Ackerman 1984). However, estimating the number of prey eaten using prey remains found in scats is a difficult task (Putman 1984). The selective consumption of prey parts and differential digestion of prey components may induce errors when estimating the number of prey eaten (Gamberg & Atkinson 1988). Moreover, the detectability of a given prey may depend on how much of its remains are undigested (Weaver 1993).

Different studies have dealt with the potential sources of bias in scat analysis in different ways. For instance, when the same prey species was found in separate scats, authors such as Emmons (1987) and De Villa Meza *et al.* (2002) considered it to represent independent captures, assuming that small prey are consumed in one meal. By contrast, others have suggested the use of correction factors based on prey biomass per scat produced, which provides better estimates of consumed biomass for each species (Ackerman 1984).

In the present study, we address the problem of using prey remains recovered from fecal samples to estimate the number of prey consumed by predators. We performed feeding trials using captive ocelots, *Leopardus pardalis* (Linnaeus, 1758), the largest American small felid (mean body weight <20 kg), in an attempt to answer the following questions: (i) How long does it take for different prey items such as mammals and birds to be completely eliminated in feces? (ii) Do different prey differ in the time it takes to be eliminated (herein called "elimination time")? (iii) And finally, how do the differences detected in (ii) affect dietary studies? These questions, however simple, are very relevant, because if different prey species are eliminated at different times, their role in the predators' diet can be overestimated or underestimated.

This study was carried out at the "Centro para Conservação de Felinos Neotropicais/Associação Mata Ciliar", Jundiaí, São Paulo (southeastern Brazil), where ocelot subjects were confined in outdoor enclosures with indoor holding areas. Ten adult ocelots (*L. pardalis*), five males and five females, were studied. Subjects were kept as follows: three couples were kept in separated enclosures, and four individuals (two males and two females) were maintained separated in individual spaces.

Ocelots favor prey under 1.0 kg (Emmons 1987, De Villa Meza *et al.* 2002, Wang 2002), eliminating an average number of prey per scat between 1.30 to 2.85 (Bisbal 1986, Emmons 1987, Chinchilla-Romero 1997, De Villa Meza *et al.* 2002). Small ro-

dents between 150 and 550 g predominate in their diet (frequency of occurrence: 45 to 100%), followed by birds (3 to 20%) and reptiles (0 to 32%) (De Villa Meza *et al.* 2002, Abreu *et al.* 2008).

In order to emulate the ocelot's field diet, we performed two feeding trials. The first feeding trial consisted of an experimental meal of two (based on the average number of prey per scat) dead white rats, *Rattus norvegicus* (Berkenhout, 1769). Two days after the first feeding trial ended, we started a second feeding trial where the experimental meal was composed of two Japanese quail, *Coturnix japonica* Temminck & Schlegel, 1849. To reduce the effects of previous meals, the ocelots were fed chicken (neck and limbs, no feathers) for two days prior to each feeding trial. The starting point of each feeding trial consisted of a single experimental meal of rats or quail. In the following days ocelots received only chicken (after the rat feeding trial) or rat (after the quail feeding trial) meals until the target prey failed to be detected in the scats for two consecutive days. We expected larger elimination time for rats than for quail, because rats have a larger proportion of indigestible matter. Although diet in the field may be more complex with many different prey, we assumed that rats and quail have approximately the same percentage of indigestible matter as do natural prey such as small mammals and birds, and thus that the performed feeding trials do not significantly deviate from the rate of passage of food in wild ocelots. Again, we chose this design to simulate what a researcher would find in field studies: feces that often contain different items such as birds and mammals.

The ocelots were kept at the holding area until all the food, offered daily between 4:00 and 4:30 p.m., was eaten. Couples sharing the same enclosure were fed separately, and blue dye was injected in the food given to one of the ocelots but not the other. This allowed us to easily recognize feces from each individual while including both individuals in the experiment. During the trials, we inspected and cleaned the enclosures after the feeding time, removing all leftovers from previous meals. In preliminary trials, performed with rat and quail meals, we rarely found leftovers prior to the beginning of the experiment, suggesting that ingestion was not selective.

We collected scats daily between 10:00 a.m. and 3:00 p.m. and stored them in tagged paper bags. Although it was not possible to determine the exact time each individual defecated, we kept the same interval (24 hours) between daily collections. We took samples to the laboratory and stored them for two days in 70% ethanol (90%) and 10% formalin (5%). For analysis, scats were broken up, washed with water over a fine mesh, and dried. We separated bones and hair (or feathers) from the prey, predator hair, and plant matter. Predator and prey hair were easy to distinguish because hair from white rats formed tufts in the ocelot scats. Finally, we recorded, for each trial, the number of days each individual took until complete elimination of prey remains, and how the abundance of remains varied during the trial. Abundance was estimated visually by comparison with the first samples after the experimental meal. We did not use quantitative measurements such as volume or mass for two reasons. First, although we were able to readily recognize prey hair, it was not possible for us to be sure that there was no ocelot hair mixed within prey hair tufts. The presence of the latter could introduce error in our estimates. Second, even after washing and separating materials, fecal matter might still remain entangled in prey hair tufts. Therefore, we opted for visual comparisons, which we believe was sufficient for our purposes.

Our results showed remarkable regularity among individuals. Rats took in general four days and up to five days until elimination, whereas quail were completely expelled from the tract in two days. In the rat feeding trial, 70% of the scats had more bone fragments in the second collecting day after the beginning of the experiment. Not all bones and teeth were recovered, and there was individual variation in the fragmentation of bones, suggesting that bone digestion may vary among individuals. Prey hair was more abundant in the second day (80% of the individuals), decreasing after the third day. In the second feeding trial (Japanese quails), feather rachis and small bone fragments were only found in the two consecutive days after ocelots were fed. Both items were more abundant in the second day for all ocelots.

Most dietary studies use statistics such as the frequency of occurrence (percentage of total scats in which a given prey was found) to describe diet composition (Ackerman 1984, Korschgen 1987, De Villa Meza *et al.* 2002, Wang 2002). An additional statistic, the percent of occurrence, provides an estimate of the minimum number of consumed individuals by counting claws, teeth, mandibles, and other prey parts in each fecal sample (Wang 2002, Abreu *et al.* 2008). In both cases, prey parts identified from separate scats are assumed to represent independent captures (Emmons 1987, Garla *et al.* 2001). Nevertheless, as our results show, this procedure may lead to an overestimation of small mammalian prey, especially if prey identification is based on hair, since hairs keep showing in feces for many days after being consumed. On the other hand, avian prey may be underestimated because remains are poorly represented, especially if the scat contains mammalian prey vestiges.

The rate of passage of the digest through the intestine is affected by factors such as prey size, meal size and composition, and by the frequency of prey ingestion (Helm 1984). These factors also affect the degree to which bones and teeth will be digested (Kelly & Garton 1997). Furthermore, our results showed that digestion of teeth and bones may also vary from one individual to another, which makes these items unreliable for prey detection in scat. Alternatively, it has been suggested that prey hair identification provides a good basis for diet reconstruction (Liberg 1982, Gamberg & Atkinson 1988, Kelly & Garton 1997), because hair is more difficult to digest (Leprince *et al.* 1980). Stahl *et al.* (1992) also advocated the use of prey hair for

estimating the proportion of rodents in the diet of wildcats. In their, results hairs yielded more accurate estimates when compared with the alternative method being tested, the number of molars recovered in scats. In this sense, we agree with Weaver & Hoffman (1979) that, when bones and teeth are absent from scats, prey should be recorded as more than one only when different species or individuals are identified through their hairs. Otherwise, it should be assumed that the same individual prey has been found in more than one scat, since predators as the ocelot can roam large distances in a day and it is difficult to determine when feces were deposited.

An alternative for minimizing errors when estimating the number of individual prey represented in each sample is the use of correction factors that make estimates using the relationship between ingested and recovered biomass for each prey (Meriwether & Johnson 1980, Ackerman *et al*. 1984, Weaver 1993, Kelly & Garton 1997). The drawback of this useful tool is that it is time consuming, since feeding trials using the different prey consumed and combinations between preys are needed for accurate results.

In spite of our limited number of treatments regarding meal size and composition, which undoubtedly affect gut passage time, our results have consistently shown that elimination time differs for different prey and some prey may take a long time to be expelled, inducing errors in dietary surveys. Both the differences in the proportion of indigestible matter and differences in bone or hair/feather structure among prey seem to affect prey detectability. Therefore we recommend caution when using these items to estimate carnivore diets, especially when dealing with small mammalian prey. All methods of diet determination, for instance stomach content and fecal analysis, are subject to errors, since digestion is a destructive process that does not preserve all the desired information. Yet, dietary knowledge is essential to the development of conservation and management programs (Korschgen 1987). Although we recognize the difficulties in devising realistic correction factors, they might still be the best tools to improve the interpretation of field dietary data. In this sense, feeding trials using captive individuals as performed here, combined with studies aiming to understand the rate of food passage and the digestive physiology of predators, would certainly help in this task.

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