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Núcleo de Teoria e Pesquisa do Comportamento
Programa de Pós-Graduação em Neurociências e Comportamento - PPGNC
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Limites de percepção olfativa do urubu-de-cabeça-preta (*Coragyps atratus*)

Larissa Hasnah Queiroz dos Santos

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Dissertação apresentada ao Programa de Pós-Graduação e Neurociência e Comportamento, do Núcleo de Teoria e Pesquisa da Universidade Federal do Pará, como parte dos requisitos para obtenção do título de Mestre em Neurociências e Comportamento.

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RESUMO

A família Cathartidae é amplamente estudada devido ao seu poder olfativo, visto que as espécies do gênero *Cathartes* são capazes de localizar alimento através do olfato, sem pistas visuais e em lugares de pouco alcance, além de possuírem aparato olfativo bem desenvolvido. Em contraste, tem sido assumido que o urubu-de-cabeça-preta (*Coragyps atratus*) não possui olfato ou não o utiliza durante o forrageio, porque dispõe de aparato olfativo menos desenvolvido. No entanto, poucas evidências suportam esta ideia, nenhuma do estudo experimental. Dessa forma, nós conduzimos um experimento de campo, em que apresentamos duas opções para os urubus-de-cabeça-preta, uma sacola plástica contendo peixe pútrido e outra sacola contendo areia, servindo como controle. Os indivíduos escolheram a sacola de peixe 81% de vezes em que se aproximaram das sacolas plásticas. A aproximação às sacolas ocorreu com mais frequência quando colocadas em distâncias menores e mostraram pouca reação em 40 e 50 metros. Os urubus-de-cabeça-preta reagiram mais ao peixe com elevado grau de decomposição (7 dias). Os resultados mostram que, provavelmente, o urubu-de-cabeça-preta utiliza o senso olfativo para identificar sacolas plásticas escondidas contendo alimento, que caracteriza o ambiente de forrageio da espécie em áreas urbanas.

Palavras-chave: Forrageio, aterro, olfato, necrófago, ecologia, urubu-de-cabeça-vermelha

ABSTRACT

New World vultures have been considerably studied regarding their sense of smell. *Cathartes* species present a remarkable development of their olfactory apparatus, and experiments conducted with the turkey vulture (*Cathartes aura*) demonstrated that they can locate carrion exclusively by smell at considerable distances. Black vultures (*Coragyps atratus*), because of their less developed olfactory apparatus, have been compared with the turkey vulture as a phylogenetically related species lacking the sense of smell. However, little evidence and no experimental studies support the lack of olfaction of black vultures. We conducted a field experiment where we presented urban black vultures a binary choice of decaying fish and sand (serving as control) inside plastic bags. Birds chose the fish bait in 81% of the times they approached the plastic bags. They also approached fish more often when plastic bags were placed at closer distances, but showed little reaction at 40-50 m away. Furthermore, birds clearly reacted more when the fish presented higher decaying time (seven compared to three days). These results show that olfaction is not only used by black vultures but is probably the most relevant sense when they search for food hidden in plastic bags and in piles of unsorted waste, which is the most common foraging environment for this species in urban areas where they are hyperabundant.

Keywords: Foraging, landfills, olfaction, scavenging, sensory ecology, turkey vulture

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INTRODUÇÃO GERAL

A perspectiva acerca da funcionalidade olfativa das aves mudou ao longo dos anos. Inicialmente, buscava-se responder, principalmente, se as aves eram capazes de perceber odores (Strong, 1911). As primeiras investigações sobre o uso do olfato levaram à conclusão de que as aves não seriam possuidoras de um senso olfativo funcional (Wenzel, 1971.). A ideia difundiu-se principalmente a partir de experimentos sem padronização, com as variáveis pouco controladas e com metodologia pouco elaborada, frequentemente testando visão e olfato de forma não independente (Strong, 1911; Wenzel, 1971). Após importantes análises morfológicas, sobretudo a partir dos anos 60, as particularidades do aparato olfativo das aves foram desvendadas (Bang, 1960 ; Bang & Cobb, 1968). A identificação dos diferentes tipos de bulbo olfativo em diversos grupos, levou a sugestiva relação entre tamanho do órgão olfativo e funcionalidade do olfato (Bang & Cobb, 1968; Grigg *et al*., 2017; Zelenitsky *et al*., 2011). Posteriormente, o desenvolvimento de estudos comportamentais agregou evidências sobre as diferenças de uso do olfato entre as aves.

Os grupos com maiores aparatos olfativos são Apterygiformes (kiwi) e Procellariformes (aves marinhas) (Bang & Cobb, 1968). Pesquisas que buscaram analisar o uso do olfato nestes grupos, mostraram que Kiwis utilizam o olfato para identificação de parceiros (Castro *et al*., 2010). Em Procellariiformes, o senso olfativo é particularmente importante para a orientação, navegação, identificação de ninhos e parceiros em tocas (Bonadonna, 2007; Gagliardo, 2013). Outro grupo que utiliza o olfato para navegação é o dos Columbiformes (pombos) (Gagliardo, 2013). Os pombos percebem odores dispersos ao longo das rotas percorridas, para poder retornar ao seu ponto de origem. Pombos que não são expostos aos odores naturais ao longo da rota ficam desorientados e não retornam ao ponto de origem (Gagliardo *et al*., 2011).

Diferente dos grupos anteriores, os urubus (Família Cathartidae) são os exemplos clássicos de uso do olfato para forrageio. O urubu-de-cabeça-vermelha (*Cathartes aura*), obteve grande destaque por possuir bulbo olfativo muito grande em relação ao tamanho do cérebro (Bang, 1960; Bang, 1964, Bang & Cobb, 1968; Grigg *et al.*, 2017). Pesquisas comparativas envolvendo urubu-de-cabeça-vermelha e urubu-de-cabeça-preta (*Coragyps atratus*) mostraram que a primeira espécie possui aparato olfativo quatro vezes maior em comparação com a segunda espécie e duas vezes mais células mitrais (principais neurônios do bulbo olfativo) (Grigg *et al*., 2017). De acordo com estas evidências

morfológicas, foi possível inferir que o urubu-de-cabeça-preta não apresenta eminente acuidade olfativa, podendo não ser o principal sentido utilizado durante o forrageio.

Importantes experimentos que reuniram as espécies da Família Cathartidae, em área de floresta, foram conduzidos para ilustrar a capacidade olfativa dos urubus (Houston, 1986; Houston, 1988; Wallace & Temple, 1987). Verificou-se um padrão de identificação das carcaças, em que o urubu-de-cabeça-vermelha, urubu-de-cabeça-amarela (*Cathartes burrovianus*) e urubu-da-mata (*Cathartes melambrotus*) são as primeiras espécies a encontrar fontes de alimento. Estes estudos concluíram que as espécies do gênero *Cathartes* possuem olfato bem desenvolvido, utilizando-o durante o forrageio (Gomez *et al*., 2008); Graves, 1992). Em contrapartida, o urubu-de-cabeça-preta não apresentou o mesmo desempenho, sendo, geralmente, a última espécie a comparecer aos locais de alimentação. Em área de floresta, verificou-se também que o urubu-de-cabeça-preta segue as espécies do gênero *Cathartes* até a carcaça (Houston, 1988, Wallace & Temple, 1987). Esses resultados levaram a ideia de que o urubu-de-cabeça-preta não possui senso olfativo ou que não utiliza o olfato durante o forrageio por se basear principalmente em pistas visuais. Esta conclusão continua sendo mencionada de maneira generalizada na literatura mais recente (Campbell, 2021; Stolen, 2000).

Para melhor identificar o uso do olfato pelo urubu-de-cabeça-preta, importantes características devem ser levadas em consideração. Como aves necrófagas obrigatórias, os urubus desempenham um papel ecológico fundamental, uma vez que consomem matéria orgânica em decomposição, tóxica para demais animais, contribuindo com a retirada destes compostos de áreas de floresta e zonas urbanas (DeVault *et al*., 2003). A colonização pós-colombiana pode ter favorecido o urubu-de-cabeça-preta a ocupar as cidades, pois, devido a intensa urbanização, houve grande disponibilidade de alimentos e aumento populacional da espécie (Sick et al., 1997). Consequentemente, os urubus-de-cabeça-preta possuem maior tolerância a ações antrópicas, que os permitem forragear em espaços com grande número de pessoas, como em feiras (Araújo *et al*., 2018; Novaes & Cintra, 2015; Moreno-Opo et al., 2020). Diferente das espécies do gênero *Cathartes*, o urubu-de-cabeça-preta é gregário, podendo formar ninhos comunitários com muitos indivíduos, e alcança fontes de alimento também em grupos (Campbell, 2021). Com base na ecologia da espécie e dos resultados das pesquisas mencionadas, é possível inferir que o uso do olfato pode ser secundário e que as habilidades olfativas da espécie são menos desenvolvidas se comparada com o gênero *Cathartes* (Bang, 1964; Houston, 1988; Grigg

et al., 2017). No entanto, poucas indagações sobre o assunto e metodologias adequadas para de fato identificar o uso do olfato pelo urubu-de-cabeça-preta foram realizadas deste então. Dessa forma, a busca para preencher as lacunas acerca do senso olfativo do urubu-de-cabeça-preta nos levou a seguinte pergunta: Qual é o nivel de sensibilidade olfativa desta espécie?

Buscamos responder esta questão a partir de um experimento de campo, investigando o comportamento dos urubus-de-cabeça-preta em áreas urbanas. A fim de testar as habilidades olfativas desta espécie, oferecemos aos urubus duas sacolas plásticas, uma contendo areia e outra contendo peixe pútrido, e as dispusemos em determinadas distâncias. Após o posicionamento das sacolas, observamos o comportamento dos urubus e contabilizamos as reações dos indivíduos até os sacos escolhidos. Com este experimento, visamos simular as condições de disponibilidade de alimento em áreas urbanas e analisar a habilidade de discernimento da espécie, diante das variadas opções disponíveis. Dessa forma, nosso objetivo geral consiste em determinar os limites de percepção olfativa do urubu-de-cabeça-preta. E como objetivos específicos: 1) determinar a influência da distância na percepção de alimentos putrefatos dos urubus e 2) determinar a influência do grau de putrefação dos alimentos na detecção olfativa dos urubus. Com este trabalho, pretendemos revigorar a discussão sobre as habilidades olfativas da espécie, que a longo período vem sendo negligenciada.

ARTIGO[1]

The limits of olfactory perception in black vultures: A field experiment

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1 Introduction

Avian olfaction was kept as a controversial topic until the 1960s when unequivocal evidence that birds rely on the sense of smell in multiple ecological contexts started to accumulate (Grubb, 1972; Papi et al., 1972; Snyder & Peterson, 1979; Stager, 1964; Wenzel, 1968; Wurdinger, 1979). New World vultures have been particularly studied regarding the ability to locate carrion by scent (Potier, 2020). The turkey vulture (*Cathartes aura*) has been used as a model in many experimental studies due to the remarkable adaptions of their olfactory apparatus, including an enlarged nasal cavity and a very large olfactory bulb compared to brain size (Bang & Cobb, 1968; Stager, 1964). Although the remaining *Cathartes* species (*C. burrovianus* and *C. melambrotus*) show similar adaptations (Stager, 1964).

Very often studies on olfaction capacity of turkey vultures draw contrasting comparisons with the black vulture (*Coragyps atratus*), a species of the same family, distributed nearly among the same range but presenting less obvious anatomical adaptations to the sense of smell (Bang, 1964; Houston, 1986; Stager, 1964). In experiments where carrion was placed under dense forest cover, turkey vultures typically arrived first but became rapidly outnumbered by black vultures and eventually displaced from the feeding sites (Byrne et al., 2019; Houston, 1986; Houston, 1988; Lemon, 1992). This suggests that while turkey vultures rely on the sense of smell and cover large areas to search for food, black vultures are opportunists, mostly tracking other scavengers to find food (Byrne et al., 2019). In addition, black vultures are typically observed in open habitats, suggesting that they mostly search for feeding opportunities through sight, while turkey vultures prefer to fly over forested areas, supposedly searching for odours of dead animals laying at the forest floor, where the competition with other scavengers is reduced (Holland et al., 2019; Houston, 1988; Novaes & Cintra, 2015). The different soaring behaviour of these two species also underline their contrasting foraging strategies. While black vultures tend to soar high using thermal uplift, from where they have a wide range of sight, turkey vultures are particularly prone to use contorted soaring, a low altitude soaring mode that relies on shear-induced turbulence (Mallon, 2015). These two species are hyperabundant in urban areas, particularly in the neotropics, where they mostly feed upon anthropogenic waste (Novaes & Cintra, 2015). Black vultures are particularly well adapted to this environment, commonly patrolling refuse containers and street markets and outnumbering turkey vultures by far in landfill sites (Araujo et al., 2018; Novaes & Cintra,

2015). While it becomes clear from the abundance of organic waste in urban areas of the neotropics that black vultures are not food limited as a species, one may presume that this environment presents foraging challenges that could favour particular coping styles among individuals (Reale et al., 2007). Among these challenges we highlight the ability to locate food inside piles of plastic bags that accumulate in refuse dumps. Using the sense of smell would be highly advantageous in such a context, allowing individuals to locate and ingest food before being displaced by other, potentially dominant, individuals.

Although many studies have assumed that black vultures lack the sense of smell (e.g. Buckley, 1996; Houston, 1986; Lisney et al., 2013; Novaes & Cintra, 2015; Sazima, 2007; Stager, 1964), to our best knowledge none have unequivocally proved this hypothesis. A recent experimental study has shown that southern caracaras (*Caracara plancus*), a species with equivalent development of olfactory apparatus to black vultures and similar ecology, were able to use olfaction although they gave preference to visual cues in the search of food (Potier et al., 2019).

In this study, we conducted a field experiment in order to quantify the olfactory sensitivity of black vultures to food hidden in plastic bags. In specific, we provided isolated black vultures in urban areas a binary choice between decomposing fish and sand (serving as control) inside plastic bags at distances ranging from 10 to 50 m. Bags were visible from the birds' locations, but were dropped in way to avoid calling their attention. Fish was aged for seven days in one set of experiments and for three days in another, intending to evaluate how the putrefaction level of the food would influence the behaviour of the birds. We drew three hypotheses: (1) birds will be attracted by the plastic bags containing fish more often than to the ones containing sand, which would prove that they use the sense of smell; (2) they will react more to the bags with fish placed at closer distances, and will stop reacting beyond a certain distance threshold; (3) they will react more and up to larger distances when the fish bait was decomposed for longer time (i.e. for seven rather than for three days).

2 Materials and Methods

This study was carried out at two sites, an urban park in the city of Belém (1º28'31"S, 48º29'57"W), northern Brazil, and a public football field at a small town located 70 km from Belém (1º10'02"S, 48º27'33"W). Black vultures are very common urban birds in the Amazon region, gathering in large numbers at street markets and refuse dumps where they feed on organic waste (Novaes & Cintra, 2015). They are also relatively common in

urban parks and residential areas where open rubbish bins and piles of waste in plastic bags are commonly found (Araujo et al., 2018).

We investigated the range of olfactory perception of black vultures by examining their behaviour in the presence of decomposing fish placed at distances between 10 to 50 m. We chose experimental subjects among birds that were isolated from flocks and either standing at the ground level or perched on streetlight poles lower than 8 m. For each bird selected, we placed two small plastic bags (36 x 23 cm), one with sand and the other with decomposing fish, at pre-determined distances (10, 20, 10, 40 or 50 m). The observer wore a long raincoat to conceal its movements while dropping the plastic bags and moved in a straight path and constant speed simulating the behaviour of transient people (see Supporting Video 1). Both bags were dropped at equal distances from each focal bird, but in nearly opposing directions. Distances were previously measured with a rangefinder. The bag with sand was always the dropped first, and the fish bag was kept in a styrofoam hermetic case until being dropped. This prevented birds to be influenced by olfactory cues before the start of the experiment. Plastic bags were loosely knotted, leaving two wide openings on the top to allow the fish odour to be released. Fish bait in each bag consisted in two king weakfish (*Macrodon ancylodon*) ca. 20 cm long, which were bought in a local fish market and aged in a styrofoam box for three or seven days, depending on the experimental set. Bird reactions to the bait were observed and video recorded from a distance higher than 30 m (see Supporting Video 2). The experiment stopped after the subject approached and tried to open the bag or in case it showed no reaction to the bait after 30 min. We aborted experiments when non-focal individuals got close and interacted with focal birds.

The experimental trials were carried out twice a week between April 2020 and March 2021, from 6:30 to 8:30 am, in days with no perceptible wind. We conducted a maximum of three trials each day using subjects that were at least 50 m apart, to reduce the changes of pseudo replication and interactions between subjects. We also interspersed trials between the two study areas to minimize the changes of habituation.

We tested the effects of fish bait distance and decay time on the olfactory detection by black vultures using two binomial Generalized Linear Models (GLM). The first model was exclusive for the experiment where we used fish bait aged for seven days, for which we tested a wider range of distances (10 to 50 m). The second model tested the fish bait distance and decay time effects simultaneously, but we used only data recorded at distances of 10 and 20 m. In both models the response variable was assigned as 1 if the

bait was detected and 0 otherwise. Models were fit in R (R Core Team, 2018) through the function glm of the package stats. Goodness-of-fit was evaluated through maximum likelihood pseudo R squared.

2.1 Ethical note

The experimental procedures of this study were approved by the Instituto Chico Mendes de Conservação da Biodiversidade (license SISBIO 66269-1) and the Ethics Committee for Animal Use of the Federal University of Pará (license CEUA 9117141118).

3 Results

We tested 56 individuals at distances ranging between 10 and 50 m using fish aged for seven days and 20 individuals at 10 and 20 m using fish aged for three days (Table 1). Considering all birds tested, 21 birds reacted to our experimental setup of which 17 reacted to the fish bait (Table 1). Subjects reacted significantly more towards the bag with fish than that with sand (chi-squared test: $\chi^2 = 7.96$, df = 1, p-value = 0.0048). Subjects that reacted to our experimental setup took between 3 and 30 minutes to approach the plastic bags (mean = 11.3).

TABLE 1 Summary of behavioral data of black vultures recorded during the field experiments. Values represent the number of birds distributed according to their behaviour to each experimental condition.

	Fish aged for seven days			Fish aged for three days		
Distance	Fish	Sand	No reaction	Fish	Sand	No reaction
10 m	7	0	6	2	1	7
20 m	4	2	7	1	1	8
30 m	2	0	8	-	-	-
40 m	0	0	10	-	-	-
50 m	1	0	9	-	-	-

The probability of the fish bait detection was significantly affected by the distance between the bait and the bird and the decay time of the bait (Figure 1, Table 2). Birds had ca. 50% chances of finding seven-day-old bait at 10 m distance, but detection probability declined sharply towards larger distances (Figure 1, Table 2). At 40 and 50 m the bait was found only once (Table 1). At 10 and 20 m, birds had significantly higher chances of finding the seven-day-old bait than the tree-day-old bait (Figure 1, Table 2). Birds were only attracted to the bag with sand four times among all trials, with no apparent relationship to distance or the bait decay time (Table 1).

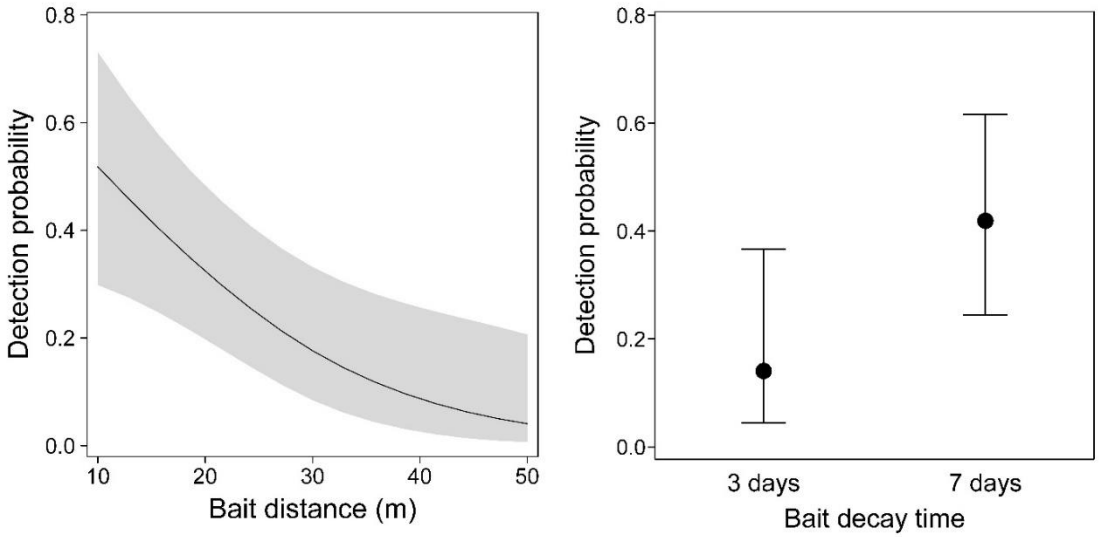

FIGURE 1 Effects of bait distance and decay time in the olfactory detection by black vultures. The left plot results from a univariate binomial GLM exclusive for the experiments with bait with seven days of decay. The right plot represents the bait decay time partial effect of a bivariate binomial GLM with data of trials up to 20 m of distance (see Table 1 for details). Shading areas (left plot) and error bars (right plot) represent 95% confidence intervals.

TABLE 2 Summary of binomial GLMs testing the effects of fish bait distance and decay time on the olfactory detection by black vultures. The response variable was assigned as 1 if the bait was detected and 0 otherwise. The first model was exclusive for bait with seven days of decay and had higher discrimination of the detection distance. The second model tested the effects of bait distance and decay time but only included data recoded up to 20 m of distance. The maximum likelihood pseudo R^2 is presented as indicator of goodness of fit. Significant relationships are shown in bold and are plotted in Figure 1.

Model	Parameter	Estimate	SE	*Z*	P-value	Pseudo R^2
Model 1	Intercept	0.87986	0.71338	1.233	0.217744	0.16
	Distance	-0.08068	0.02974	-2.713	**0.0067**	
Model 2	Intercept	-042446	1.12979	-0.376	0.7071	0.12
	Decay time	1.48165	0.75847	1.953	**0.0508**	
	Distance	-0.09227	0.06970	-1.324	0.1856	

4 Discussion

The results of our experiment clearly indicate that black vultures do have a sense of smell, contrary to the assumptions of earlier studies (e.g. Buckley, 1996; Houston, 1986; Lisney et al., 2013; Novaes & Cintra, 2015; Sazima, 2007; Stager, 1964). As we predicted in our first hypothesis, subjects were attracted to the bag containing fish in 81% of the times they approached the plastic bags, systematically ignoring the bag with sand that served as control. Given that both plastic bags were visible to the birds, the systematic reactions towards the bag with fish proved that the plastic bag per se did not represent a strong stimulus to search for food, contrasting to the observations of Sazima (Sazima, 2007). This was not totally surprising as in both our study sites dumped garbage and particularly plastic bags are very abundant, likely reducing the stimulus for inspection. This result also demonstrates that we were successful in concealing the process of placing the bags in the range of reaction of the birds. However, we cannot ignore that some birds did react to the bag with sand, showing that visual cues were used to some extend in addition to olfactory cues.

We were also able to prove our second hypothesis that bird reactions became less frequent as the distance to the fish bait increased. Importantly, we were able to estimate that the sensitively threshold for the olfaction of black vultures was between 40 and 50 m, where the probability of reaction to the fish bait was nearly zero (Figure 1). Obviously, the olfaction sensitively threshold varies with the amount of volatile odorants that are emitted by the bait, which depend its size, type and putrefaction level (Smith & Paselk, 1986). Still, it is extraordinary that a species thought to not use the sense of smell were able to locate food by scent at least up to 30 m far away. The lack of studies with a similar experimental setup for other vulture species prevents us to draw clear comparisons on olfaction sensitively, but it becomes clear from previews studies that the turkey vulture is able to locate carrion at by scent at much larger distances (Smith et al., 2002; Stager, 1964). In an experimental study, Stager (1964) showed that turkey vultures responded to the release of ethanethiol (a by-product of carrion decomposition) at more than 180 m. Nevertheless, being able to smell food at 30 m makes it possible for black vultures to locate carrion at the tropical forest floor by flying over the canopy, a niche described as exclusive to Cathartes species (Houston, 1986; Houston, 1988). However, it becomes clear from the literature that black vultures are more successful to find foraging

opportunities by tracking other scavengers then by locating food themselves (Buckley, 1997; Houston, 1988).

Our third hypothesis also held, as we were able to show that birds were more attracted to fish aged for seven days than for three days (Figure 1). The release of volatile odorants increases with the decomposition process likely increasing the olfaction stimulus for the birds (Smith & Paselk, 1986). However, it was shown before that turkey vultures did not perform better to find four-day-old carrion than they did for one-day-old carrion (Houston, 1986). This result was interpreted as a preference by fresher food rather than olfaction stimulus (Owre, 1961). Still, in the case of our experiment, we have no reason to think that birds had less interest in fresher fish, as they were clearly engaged to eat it in the few cases where they found it.

Overall, our results allow us to refute the common assumption that black vultures lack the sense of smell. However, we reinforced the idea that black vultures have a more limited sense of smell than the turkey vultures, a species to which have been often compared. This agrees with the higher development of the olfactory apparatus in the turkey vulture and some ecological traits of each species. However, the urban environment may have presented black vultures new challenges where the use of smell is highly relevant. This species is currently more successful in urban than natural areas, and here potential food blends with large amounts of other anthropogenic waste. In such a context, the sense of smell may be critical for their foraging success, particularly for subdominant individuals that are displaced shortly after the food is found.

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Data accessibility

All data recorded is provided in this article.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

CONSIDERAÇÕES FINAIS

Nossos resultados mostram que a distância e o estado de putrefação da carcaça são fatores que influenciam na identificação olfativa dos alimentos por parte dos urubus de cabeça preta. Portanto, as predições acerca da detecção de alimentos em distâncias menores, com alto grau de putrefação foram confirmadas. Constatamos que os limites de percepção olfativa do urubu-de-cabeça-preta é cerca de 30 metros para encontrar peixe ou carcaças com 7 dias de putrefação e cerca de 20 metros para alimentos com 3 dias de putrefação.

As evidências corroboram com a ideia geral do urubu-de-cabeça-preta possuir menor acuidade olfativa, quando comparado às espécies do gênero *Cathartes*. No entanto, os resultados obtidos nesta pesquisa mostram que o urubu-de-cabeça-preta pode utilizar o olfato durante o forrageio, particularmente quando procura alimento em pilhas de lixo urbano. De maneira que, quando oferecido duas opções similares aos urubus, os indivíduos podem escolher, através do olfato, a opção contendo alimento. Entretanto, concordarmos que os urubus-de-cabeça-preta utilizam principalmente pistas visuais para identificar fontes de alimento e que a espécie possui habilidades olfativas limitadas.

Nossos resultados vão contra a conclusão disseminada acerca do urubu-de-cabeça-preta não possuir olfato ou não o utilizar durante o forrageio (Houston, 1988; Stolen, 2000; Wallace & Temple, 1987). Também vai contra a conclusão de Sazima 2007 de que os urubus não conseguem distinguir sacolas contendo ou não alimento. Diante do exposto, concluímos que o urubu-de-cabeça-preta possui senso olfativo funcional, à medida que, em área urbana e sem influência de outras espécies de urubus, é capaz de selecionar a alternativa contendo alimento.

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