

Do mule deer respond to the sounds of their predators?

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Running head: Acoustic predator discrimination

Abstract

Many, but not all, animals respond to the sounds of their predators to assess predation risk. For those that can, does this ability persist after a predator has gone extinct? Are all predatory species equally likely to generate antipredator responses? And, more generally, what are the proximate mechanisms underlying these responses? We reviewed the literature to draw generalizations about predator discrimination abilities and found that prey broadly are responsive to the sounds of both familiar and unfamiliar predators, that most of the predators used are birds and mammals, and that responses may require experience, but that some species appear predisposed to respond to certain types of predators. Given that ungulates face risks from a variety of predators, predator discrimination abilities in relatively few species of ungulates have been studied. We then asked whether mule deer (*Odocoileus hemionus*) possessed the ability to discriminate between predator vocalizations by broadcasting the sounds of coyotes (*Canis latrans*), mountain lions (*Puma concolor*), and locally extinct wolves (*Canis lupis*), as well as the song of novel non-predatory pied butcherbirds (*Cracticus nigrogularis*). We compared the difference in the proportion of time allocated to heightened responses (the sum of time allocated to alarm walk, stott, run, and stand-look) following playback compared to before playback. Mule deer both respond to predatory sounds, and discriminate among predators. This response was influenced by the familiarity to humans: deer greater than 0.5 km from human residences allocated more time to heightened responses both before and after stimulus playback. Taken together, we found that mule deer can respond to the sounds of some of their vocal predators, and retain an ability to respond to extinct wolves.

Keywords: Acoustic predator discrimination; Antipredator behavior; Human impacts; Mule deer; Risk assessment

Introduction

While most predators do not vocalize while hunting, many species are reported to respond to the sounds of their predators by engaging in antipredator behavior (Blumstein et al. 2008). The mechanisms by which prey are able to discriminate amongst their predators may be highly canalized, or it may require learning. Previous work with superb fairy-wrens (*Malurus cyaneus*) and heterospecific alarm call discrimination, found that wrens responded to alarm calls of congeners that acoustically resembled their own alarm calls, without having ever been exposed to them (Fallow et al. 2011). This suggests that experience with a particular predator species may not be required for prey to respond to novel threatening sounds as long as they are acoustically similar. Does this mechanism extend to predator discrimination? By studying the responses to sympatric and allopatric species, it is possible to begin to make generalizations about the underlying proximate mechanisms of predator discrimination.

In 2008, Blumstein et al. systematically reviewed the literature on experimental studies of acoustic predator discrimination. There have been a number of studies since then. We updated this review (Table 1) to identify gaps in current state of the field, and to draw generalizations about acoustic predator discrimination abilities. As we describe in the following paragraphs, the results of our review motivate our empirical study of mule deer (*Odocoileus hemionus*). Briefly, we found a strong bias in studies where primates were disproportionally studied (41/152), most of the predator vocalizations studied were from raptors (62/152), and predator cues were typically from sympatric predators (92/152).

To broaden the scope of the field beyond primates, we chose to study North American mule deer. Many mammals, including mule deer, are vulnerable to predators other than raptors, including canids and felids. North American felids and canids differ in that canids are more

social (Lehner 1978) and vocalize more than felids. Although there have been observations of mountain lions vocalizing while attacking prey (Smallwood 1993) and during estrus (Beier et al. 1995), vocalizations are rarely heard. Consequently, prey may have little exposure to felid vocalizations and may not have acquired an ability to associate felid vocalizations with predation risk over ecological time. On the other hand, prey may have acquired the ability over evolutionary time to ascribe risk to felid vocalizations. Thus, we chose to compare prey's responses to a felid (mountain lions, *Puma concolor*) and a canid (coyotes, *Canis latrans*). Such a study would be valuable in order to determine the extent to which prey's ability to respond to certain predators may be acquired over ecological or evolutionary time.

Similarly, a comparison of prey's responses to the acoustic cues of extant and locally extinct predators would also be valuable to identify proximate mechanisms underlying predator recognition. For example, moose (*Alces alces*) have reduced responsiveness to acoustic cues of extinct predators (Berger et al. 2001), but this ability rapidly returns once moose experience predators again (Berger 2007). By contrast, tammar wallabies (*Macropus eugenii*) retain the ability to recognize extinct predators based on visual cues but do not respond to acoustic cues (Blumstein et al. 2000). Thus, we also examined prey's response to locally extinct predatory wolves (*Canis lupus*). Wolves were extirpated in the early 20th century in our study region. While coyote and wolf vocalizations are unique, they do share similar acoustic properties (low frequency howls), which may account for similar responsiveness to both predators in other species (Blumstein et al. 2008). If indeed these shared acoustic properties are responsible for predator discrimination, this provides an opportunity to respond to several predatory canids regardless of prior experience and thus could be a mechanism of persistence.

Finally, humans may influence how animals assess risk (Coleman et al. 2008). Gunther's dik-diks (*Madoqua guentheri*) that were habituated to humans better discriminated predator sounds from bird songs while unhabituated individuals did not (Coleman et al. 2008). A study with Columbian black-tailed deer (*Odocoileus hemionus columbianus*) demonstrated that non-habituated deer fled from people at greater distances than habituated deer (Stankowich and Coss 2007). A previous study at our study site found that mule deer within a 0.5 km radius of human summer residences were able to differentiate yellow-bellied marmot alarm calls from non-predatory bird song, while those farther from human residences did not (Carrasco and Blumstein 2012). Thus, we also aimed to determine if and how distance to human residences influenced mule deer predator discrimination.

Literature Review

Methods

We expanded upon the Blumstein et al. (2008) literature review to both incorporate a recent surge of studies and to categorize responses more precisely. First, we searched Google Scholar for studies that cited Blumstein et al. (2008). We also used Google Scholar to search the key phrases “acoustic predator recognition,” “predator vocalizations,” “predator vocalisations”, “response to predators,” and “playback experiments and predation.” We looked at papers that were cited by each set of relevant papers thus identified. We summarized: the studied species (prey), the predator whose vocalization was used, the control animal whose call was used, the ecological and evolutionary experience of the prey to the predator, the behavior used to identify response to stimuli, and if the studied species was able to discriminate between the predator and control vocalizations. We specifically extracted details about each response compared to the

control species. For studies that did not use heterospecific animal vocalizations for the control (e.g., running water, white noise, silence, conspecific alarm calls), we left the control species column blank. For studies that did not distinguish between responses to individual predators or individual control animals, we filled that column with “multiple predators” or “multiple non-predators”, respectively. The ecological experience is categorized by “yes” and “no”: “yes” if the prey encountered the predator in its lifetime by the time of testing, and “no” if the predator has been extirpated or the prey was born and raised in captivity. The evolutionary experience is categorized by “yes” and “no”: “yes” if there is any known sympatry in the evolutionary history of the prey, and “no” if the predator call is novel or if the predator or prey was recently introduced to the study site. Thus, prey may have no evolutionary history, but ecological experience with a predator. We did not consider stimuli originating from an animal that is sympatric and known to not prey on the study species, even if the animal is a predator of other species. The observed response to experimentally broadcast vocalizations was broken down into four categories: change in time budget (change in time of scanning, flight, vigilance, foraging, relaxed behavior, and locomotion); the production of vocalizations or alarm calls; a glucocorticoid response; and change in reproductive success. For some animals, more than one type of response was observed. Because we wished to know if a species was able to respond in any way, we scored a comparison as responding if any of the responses were significantly different from control and/or baseline behavior.

Results

We found 152 instances in which a specific playback experiment was conducted that compared a predator vocalization to a control sound. This included comparisons in arachnids (N = 2), fish (N

= 1), amphibians (N = 1), reptiles (N = 6), birds (N = 13), and mammals (N = 129). While these numbers summarize the number of comparisons, there were only 67 different species studied. Of these 55/67 were mammals, and in mammals, 7/67 were ungulates, 16/67 were rodents, and 24/67 were primates.

Of the 152 comparisons, 62 raptor vocalizations were used as stimuli, while only 30 felid vocalizations and 32 canid vocalizations were used. There were four instances where multiple predator vocalizations were grouped together permitting inferences to be drawn about general, as opposed to specific, predator discrimination abilities. Fifty-seven of the predators were not ecologically exposed to the prey species, and eighteen of those fifty-seven were entirely novel predators. Ninety-six predators coexisted with the studied species, however three of those did not evolve with the prey, typically due to introduction of non-native predators. Most studies evaluated the ability to discriminate predator vocalizations by observing the change in time budget (135/154), followed by the production of a vocalization or alarm calls (41/154). Only three comparisons quantified a change in reproductive success, and three species had elevated glucocorticoid levels in response to hearing a predator vocalization.

There were instances where the predators had neither been ecologically nor evolutionarily exposed to the prey, yet the prey identified the sounds as a potential risk (Table 2). Particularly, members of the family Cervidae discriminated between the predator and the non-predator vocalizations (6/15) even though they had never been at risk of predation by the predators used. While other species did not typically react to historical predator calls, members of the family Cervidae from historically predated, but currently non-predated areas, retained the ability to discriminate between threatening sounds (6/9).

Predator species seemed to be a factor of the prey's ability to discriminate. Of the studies that played felid vocalizations to ecologically and evolutionarily inexperienced prey, 6/14 prey identified the vocalization as a predator. Similarly, historically preyed prey also distinguished between the novel felid call and the control (5/7). Canids also elicited a response from ecologically inexperienced prey (6/15).

Playback Experiments

Methods

Study Sites and Animals

The study was conducted in and around the site of the Rocky Mountain Biological Laboratory (RMBL) in the upper East River Valley, Gunnison County, Colorado, USA (38°57.508 N, 106°59.296 W). The habitat consists of sub-alpine meadows, aspen groves (*Populus tremuloides*), and willow thickets (*Salix sp.*). Experiments were performed from 30 May to 9 July 2012, when mule deer were on their summer range.

A single observer (AH) walked on trails between 05:00 h – 08:30 h and 18:30 h – 21:00 h, time periods when mule deer forage, in search of yearlings and adults. When a deer or group of deer was spotted foraging, a single individual was chosen to be the focal subject and approached to a separation distance of 40 m. Fifty-two experiments were completed successfully. On 29 occasions, a subject was in a group, in which case other group members (if encountered again) were tested on different days. Overall, 60% of focal subjects were exposed only to a single stimulus, while 40% were exposed to a maximum of one additional (different) stimulus. Subjects were uniquely identified by their specific markings, scars, antler size and shape, and pregnancy

status. These were sketched and described into our notebook and we were careful to avoid testing the same deer more than once.

We recorded the GPS coordinates of each experimental subject using a Garmin eTrex® H GPS unit (Garmin International, Inc., Olathe, Kansas), along with a description of the location, surrounding vegetation, time of day, wind speed (using the Beaufort scale), wind direction, and cloud cover. The experiment was not conducted if the wind speed exceeded 3 on the Beaufort scale or if it was raining. We also did not conduct an experiment if the subject was near a rushing stream so that we could be sure that the focal subject heard the broadcast stimulus.

To test for the effect of human disturbance on deer anti-predator behavior (Carrasco and Blumstein 2012), we determined the distance of the subject to RMBL and the 13 other cabins in the East River Valley. We used ArcGIS/ArcMap (ESRI, Redlands, California) to create a 0.5 km buffer around the homes and facilities of RMBL and South Gothic. Following Carrasco and Blumstein (2012), deer observed within 0.5 km were classified as ‘near’ and those observed outside of the 0.5 km were classified as ‘far’. We spent 150 h searching for deer: 44% of the time was spent outside of the 0.5 km radius. Typically, it was more challenging to approach deer within 40 m in the ‘far’ range than in the ‘near’ range, perhaps because deer were less habituated to humans (Stankowich and Coss 2007).

Stimuli

Each deer was exposed to one of four playback treatments: coyote calls, wolf howls, mountain lion calls, or pied butcherbird song (to serve as the control). We obtained 16 bit, 44 kHz vocalizations from commercial CDs and websites, which yielded three coyote, two wolf, two mountain lion, and three butcherbird exemplars of sufficient quality for playback. We saved the

audio files as uncompressed AIF files. Calls were played from an Apple iPod (Apple, Cupertino, CA, USA) connected to a Sony SRS-77G speaker (Sony Corp., Minato, Tokyo, Japan). We calibrated playback amplitude using a SPER Scientific 840029 digital sound level meter; the coyote, wolf, and butcherbird stimuli were broadcast at 95.0 dB SPL, while the mountain lion exemplars were broadcast at 87.0 dB SPL because they are naturally quiet calls and because broadcasting them any louder created obvious distortion.

Playback Procedure

Once a deer was within 40 m of the observer ($X = 32.3 \pm 8.31$ m SD), we began a 30 s pre-playback focal observation. After 30 s, a single stimulus was broadcast from the speaker (hanging from the observer's neck) pointed directly at the subject. Focal observations continued for an additional 60 s. Observations were dictated into an Olympus VN-7000 digital recorder (Olympus, Center Valley, PA, USA). There was no significant difference between the distances that the different stimuli were broadcast to the deer ($F_{3, 48} = 1.200$, $P = 0.320$).

We used a previously established ethogram of 14 known behaviors (Carrasco and Blumstein 2012): standing-and-looking, looking while chewing, foraging, walking-head down, walking-head up, sniffing ground, scratching, running, stotting, ear twitch, ear movement forward or backward, tail flick, and alarm walk. We also noted if a deer moved out of sight.

Statistical Analysis

Focals were scored and analyzed using JWatcher 1.0 (Blumstein & Daniel 2007). We calculated the total proportion of time in sight spent engaged in a “heightened response” (defined as the sum of the proportion time in sight allocated to stand-looking, alarm walking, running, and

stotting) for the 30 s baseline observation period and each of the four, 15-s time bins in the 60 s post-playback observation period. To determine if deer responded to a given treatment, we subtracted the proportion of time in sight allocated to heightened response in each 15-s time bin from the proportion of time allocated to heightened response in the initial baseline period. We calculated the 95% confidence intervals (CI) for each treatment for both the 0-15 s and 45-60 s time bins. If the 95% CI did not include 0, we inferred that the deer responded to the playback of a given treatment.

To capture deer's immediate response to playback, we elected to analyze the difference from baseline for the first 15-s time bin. We also examined the 45-60 s time bin in order to see if responses persisted. We fitted a general linear model with the difference between the time allocated after playback (either the 0-15 s or the 45-60 s time bin) and the baseline as a function of treatment, distance to town (scored as near or far) and the interaction between treatment and distance to town. We made planned, pairwise comparisons using Fisher's Least Significant Difference. All models were fitted using SPSS 20 (IBM, Armonk, New York) with an alpha of 0.05.

Results

We conducted a total of 52 playback experiments (coyote $N = 14$, wolf $N = 13$, mountain lion $N = 13$, butcherbird $N = 12$). There were 35 playbacks within 0.5 km of human homes and 17 playbacks outside of the 0.5 km buffer.

In the baseline period, distance, ($F_{1,44} = 10.853$, $P = 0.002$), but neither stimulus ($F_{3,44} = 1.233$, $P = 0.309$), nor the interaction between distance and stimulus ($F_{3,44} = 0.937$, $P = 0.431$) explained variation (adjusted $R^2 = 17.9\%$; Corrected Model: $F_{7,44} = 2.587$, $P = 0.025$) the

proportion of time allocated to relaxed behavior. In general, deer farther away from human residences were less relaxed. The mean ($\pm$ SE) proportion of baseline time that deer allocated to heightened response within and outside of the 0.5 km range were 0.304 ($\pm$ 0.059 SE) and 0.648 ($\pm$ 0.086 SE), respectively. This suggests that observer presence had an effect on the initial alertness of the subjects, because deer were more wary far from human residences. Because of these differences in baseline heightened response, it was appropriate to subtract the baseline from proportion of time with a heightened response for each time bin and focus on changes from baseline time allocation.

In the first 15-s following playback, deer responded to the playback of coyotes and wolves, but not to butcherbirds or mountain lions. Additionally, both stimulus type and distance from townsite (close/far) explained 28.8% (adjusted R^2) of variation (Corrected Model: $F_{7,44} = 3.942$, $P = 0.002$) in time allocated to heightened response (Stimulus: $F_{3,44} = 3.880$, $P = 0.015$; Distance: $F_{1,44} = 10.582$, $P = 0.002$; Interaction: $F_{3,44} = 0.736$, $P = 0.536$). Planned pairwise comparisons showed significant differences in heightened responses among coyote and butcherbird ($P = 0.017$), and wolf and butcherbird ($P = 0.003$).

In the 45-60-s following playback, deer responded to the playback of coyotes and wolves, but not to butcherbirds or mountain lions. Additionally, both stimulus type and distance from townsite explained 26% (adjusted R^2) of variation (Corrected Model: $F_{7,44} = 3.561$, $P = 0.004$) in the time allocated to heightened response (Stimulus: $F_{3,44} = 3.279$, $P = 0.030$; Distance: $F_{1,44} = 8.240$, $P = 0.006$; Interaction: $F_{3,44} = 0.922$, $P = 0.438$). Planned pairwise comparisons showed that mule deer distinguished between coyote and mountain lion ($P = 0.050$), coyote and butcherbird ($P = 0.049$), mountain lion and wolf ($P = 0.022$), and wolf and butcherbird ($P = 0.022$).

Discussion

Our literature review demonstrates that both ecological and evolutionary exposure to a predator does not ensure that prey respond to predator vocalizations. In the two best studied taxa (birds and mammals), there is no significant difference in the proportion of those that respond to familiar predators with which they evolved (birds: No = 2, Yes = 11; mammals: No = 9, Yes = 61; Chi squared = 0.0609; df = 1; P = 0.805). Nevertheless, some species that are neither ecologically nor evolutionarily exposed to a particular predator have the ability to respond appropriately. It is important to note that of the mammals that responded to the novel predator (Table 2), five of the six comparisons were performed on a single species – moose (Berger et al. 2001). Therefore, we cannot know if moose are uniquely capable of identifying potential predators. However, for animals that live in predator-free areas, but have evolutionarily experience with a specific predator species, two thirds of the animals tested did not discriminate between the predator and control calls. This suggests that loss of a predator can lead to loss of predator discrimination skills. Future studies with a more comprehensive data base will be required to draw conclusions about the amount of time or the number of generations over which antipredator behavior is lost. Finally, our review also identified a bias in predator vocalizations used for the playbacks (Table 3). All but one study used calls from birds and mammals. This reflects the studied prey species and their predator taxa. Thus, future studies would enhance our understanding if they broaden both the prey taxa studied and the predator taxa used.

Our empirical results indicate that mule deer discriminate between predator vocalizations. Within the first 15 s post-stimulus, the proportion of time spent displaying a heightened response to playbacks of coyote and wolf vocalizations were significantly different from the responses to

playbacks of the control stimulus. The response to the mountain lion was not significantly different from any of the other stimuli, including the control. Between 45 to 60 seconds after the vocalization, deer maintained a heightened response for the coyote and wolf calls, but the response was attenuated after hearing mountain lion and butcherbird vocalizations.

Few studies have performed playbacks with both sympatric felid and canid predators (Berger et al. 2001; Jones et al. 2004; Li et al. 2011). In our study, we found that deer allocate a greater proportion of time with a heightened response to canids than to felids. By contrast, Li et al. (2011) found that the duration of time taken for Père David's deer to return to their pre-stimulus behavior was similar between playbacks of familiar dogs and novel wolves. However, both of these responses were significantly less than those of the felids tested. Despite being isolated from predators for 1200 years in captivity (Li et al. 2011), Père David's deer responded to vocalizations of a potentially important ancestral predator, tigers (*Felis tigris*), suggesting that antipredator behavior may be retained following many generations of relaxed selection (Coss 1999; Blumstein 2006; Lahti 2009).

In some cases, antipredator behavior may be lost, but quickly reacquired upon exposure to predators. Predator-naïve moose exposed to predator vocalizations were unable to discriminate these calls from control sounds, a finding that suggests that this response requires some experience (Berger et al. 2001). However, upon being exposed to reintroduced wolves, moose quickly learned to be more vigilant (Berger 2007).

Why are mule deer able to respond to the calls of extinct wolves? A proximate explanation for this ability may be the superficial resemblance of wolf howls to coyote calls (Blumstein et al. 2008; Fallow et al. 2011). From the review, we were able to recognize patterns in which prey that were ecologically unfamiliar, but evolutionarily experienced with canids and reacted

appropriately to the canid vocalizations. Particularly, animals in the family Cervidae discriminated between predator and non-predator calls in non-predated habitats. This demonstrates that some species retain the ability to assess risk despite lack of exposure during their own lifetimes.

An ultimate explanation may be the multipredator hypothesis, which states that prey that are exposed to novel predators will maintain their antipredator behavior if they have other extant predators (Blumstein 2006). Thus, despite being not exposed to wolves for almost a century, mule deer in Gunnison County have been preyed upon by bobcats, coyotes, and mountain lions (Brandon Diamond, Colorado Parks and Wildlife, personal communication). And, if the presence of other predators selected for a robust syndrome of antipredator responses, the loss of a single predator may not be sufficient to break apart the syndrome.

However, the multipredator hypothesis does not explain the lack of a significant response to the mountain lion roar particularly because there were a few sightings during the time of the experiment around the RMBL. Indeed, throughout their range, deer are the primary prey of mountain lions. For instance, in the Sierra Nevada region of California, 68% of mule deer mortality was attributed to mountain lion predation, while coyotes are responsible for 28% of mule deer mortality (Pierce et al. 2004). In south-central British Columbia, 68% of mule deer mortalities were attributed to mountain lion predation (Robinson et al. 2002). More locally, a radio telemetry study (between December 2008 and December 2011) in Gunnison Country showed that coyotes and mountain lions were responsible for 22.5% and 17.7% of observed doe mortalities, respectively (Brandon Diamond, Colorado Parks and Wildlife, personal communication).

So the question of why deer do not respond to mountain lion vocalizations is a compelling one. It is possible that the amplitude difference in broadcast calls was responsible for this result. However, mountain lion vocalizations were relatively long (longer than coyote and butcher bird vocalizations) and deer always oriented towards the speaker in response to playback. Another possibility is the structure of the vocalization. In contrast to the canid vocalizations, the initial amplitude is lower, and builds over time. It is possible that the slow build up of the roar does not cause the same startling effect as the yipping or howls of the two canids. While it seems likely that this slow build up might influence the initial response, once a predator was identified, there should be a sustained response to it. There was not.

It is therefore possible that deer simply do not respond to mountain lion roars. Mountain lions are much more solitary than either wolves or coyotes; hearing vocalizations is thus likely to be a rare event. Mountain lions are known to vocalize mostly while mating, a behavior that may be seldom observed in the wild (Beier et al. 1995).

Finally, our study confirms a previous result—the effect of distance to human residence on deer risk assessment (Carrasco and Blumstein 2012). There are two reasons for this possible effect: habituation (Stankowich and Coss 2007; Coleman et al. 2008), or humans may displace deer predators making areas around humans safer (Muhly et al. 2011). These are not mutually-exclusive hypotheses and future work will be required to identify the cause of this reduced wariness around humans.

Acknowledgements

We thank Brandon Diamond for sharing information about deer mortality in Gunnison County, Nick Waser and Mary Price for general background insights into mule deer, Shannon Sprott for

ArcMap and GIS assistance. Research was conducted under protocols approved by UCLA ARC protocol 2000-147-33.

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Table 1: Species for which playback studies have been performed to test for acoustic predator discrimination. Modified and expanded from Blumstein et al. (2008).

Studied Species			Predator used for vocalization playback					Animal used for control		Response type				
Family	Latin name	Common Name	Latin name	Common name	Order: Family	Eco Exp ^a	Evol Exp ^b	Latin name	Common name	TB ^c	V ^d	RS ^e	HL ^f	Ref
Class Arachnida														
Order Araneae														
Lycosidae	<i>Schizocosa ocreata</i>	Wolf spider	<i>Cyanocitta cristata</i>	Blue jay	Passeriformes: Corvidae	Y	Y	<i>Zenaida macroura</i>	Mourning dove	Y		Y		1
Lycosidae	<i>Schizocosa ocreata</i>	Wolf spider		Multiple predatory birds		Y	Y	<i>Pterophylla camellifolia</i>	Common true katydid	N		N		1
Class Actinopterygii														
Order Batrachoidiformes														
Batrachoididae	<i>Opsanus beta</i>	Gulf toadfish	<i>Tursiops truncatus</i>	Bottle-nosed dolphin	Cetacea: Delphinidae	Y	Y	Alpheidae family	Snapping shrimp pops		Y		Y	2
Class Amphibia														
Order Anura														
Bufonidae	<i>Bufo bufo</i>	Common toad	<i>Lutra lutra</i>	Eurasian otter	Carnivora: Mustelidae	Y	Y			N				3
Class Reptilia														
Order Squamata														
Polychrotidae	<i>Anolis cristatellus</i>	West Indian anole	<i>Falco sparverius</i>	American Kestrel	Accipitriformes: Accipitridae	Y	Y	<i>Coereba flaveola</i>	Bananaquit	Y				4
Polychrotidae	<i>Anolis sagrei</i>	Brown anole	<i>Falco sparverius</i>	American Kestrel	Falconiformes: Falconidae	Y	Y		Multiple non-pred birds	Y				5
Polychrotidae	<i>Anolis sagrei</i>	Brown anole	<i>Buteo jamaicensis</i>	Red-tailed hawk	Accipitriformes: Accipitridae	Y	Y		Multiple non-pred birds	Y				5
Polychrotidae	<i>Anolis sagrei</i>	Brown anole	<i>Margarops fuscatus</i>	Pearly-eyed thrasher	Passeriformes: Mimidae	Y	Y		Multiple non-pred birds	N				5
Polychrotidae	<i>Anolis sagrei</i>	Brown anole	<i>Quiscalus mexicanus</i>	Great-tailed grackle	Passeriformes: Icteridae	Y	Y			N				6
Polychrotidae	<i>Anolis sagrei</i>	Brown anole	<i>Falco sparverius</i>	American Kestrel	Falconiformes: Falconidae	N	Y			N				6
Class Aves														
Order Coraciiformes														
Bucerotidae	<i>Ceratogymna elata</i>	Yellow-casqued hornbill	<i>Stepanoaetus coronatus</i>	Crowned eagle	Accipitriformes: Accipitridae	Y	Y				Y			7
Order Cuculiformes														
Musophagidae	<i>Corythaeola cristata</i>	Great blue turaco	<i>Stepanoaetus coronatus</i>	Crowned eagle	Accipitriformes: Accipitridae	Y	Y	<i>Colobus badius</i>	Red colobus	Y				8
Musophagidae	<i>Corythaeola cristata</i>	Great blue turaco	<i>Pan troglodytes</i>	Chimpanzee	Primates: Hominidae	Y	Y	<i>Colobus badius</i>	Red colobus	Y				8
Order Passeriformes														

Corvidae	<i>Corvus brachyrhynchos</i>	American crow	<i>Bubo virginianus</i>	Great horned owl	Strigiformes: Strigidae	Y	Y	<i>Hylocichla mustelina</i>	Wood thrush	Y	9
Corvidae	<i>Corvus brachyrhynchos</i>	American crow	<i>Buteo lineatus</i>	Red-shouldered hawk	Accipitriformes: Accipitridae	Y	Y	<i>Hylocichla mustelina</i>	Wood thrush	Y	9
Corvidae	<i>Corvus brachyrhynchos</i>	American crow	<i>Polyboroides radiatus</i>	Madagascar harrier hawk	Accipitriformes: Accipitridae	N	N	<i>Hylocichla mustelina</i>	Wood thrush	Y	9
Emberizidae	<i>Melospiza melodia</i>	Song sparrow		Multiple predatory animals		Y	Y		Multiple non-predators	Y	10
Maluridae	<i>Malurus lamberti</i>	Variegated Fairy-wren	<i>Cracticus torquatus</i>	Grey Butcherbird	Passeriformes: Artamidae	Y	Y		Multiple non-pred birds	Y	11
Maluridae	<i>Malurus lamberti</i>	Variegated Fairy-wren	<i>Strepera versicolor</i>	Grey Currawong	Passeriformes: Artamidae	Y	Y			Y	11
Maluridae	<i>Malurus lamberti</i>	Variegated Fairy-wren	<i>Falco cenchroides</i>	Nankeen Kestrel	Falconiformes: Falconidae	Y	Y			Y	11
Maluridae	<i>Malurus splendens</i>	Splendid Fairy-wren (females)	<i>Cracticus torquatus</i>	Grey Butcherbird	Passeriformes: Artamidae	Y	Y		Multiple non-pred birds	Y Y	12
Order Psittaciformes											
Psittaculidae	<i>Platycercus elegans</i>	Crimson rosella	<i>Falco peregrinus</i>	Peregrine falcon	Falconiformes: Falconidae	Y	Y	<i>Platycercus elegans</i>	Crimson rosellas	Y	13
Psittaculidae	<i>Platycercus elegans</i>	Crimson rosella	<i>Aquila audax</i>	Wedge-tailed eagle	Accipitriformes: Accipitridae	Y	Y	<i>Platycercus elegans</i>	Crimson rosellas	N	13
Class Mammalia											
Order Artiodactyla											
Bovidae	<i>Bison bison</i>	Bison	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	Y	Y	<i>Alouatta</i> sp.	Howler monkey	N	14
Bovidae	<i>Bison bison</i>	Bison	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	Y	Y	<i>Alouatta</i> sp.	Howler monkey	Y	14
Bovidae	<i>Bison bison</i>	Bison	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	N	Y	<i>Alouatta</i> sp.	Howler monkey	N	14
Cervidae	<i>Alces alces</i>	Moose	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	Y	Y	<i>Alouatta</i> sp.	Howler monkey	Y	14
Cervidae	<i>Alces alces</i>	Moose	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	<i>Alouatta</i> sp.	Howler monkey	N	14
Cervidae	<i>Alces alces</i>	Moose	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	Y	Y	<i>Alouatta</i> sp.	Howler monkey	Y	14
Cervidae	<i>Alces alces</i>	Moose	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	<i>Alouatta</i> sp.	Howler monkey	N	14
Cervidae	<i>Alces alces</i>	Moose	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	N	Y	<i>Alouatta</i> sp.	Howler monkey	N	14
Cervidae	<i>Alces alces</i>	Moose	<i>Canis lupis</i>	Wolf	Carnivora: Canidae	Y	Y	**		Y	15
Cervidae	<i>Alces alces</i>	Moose	<i>Canis lupis</i>	Wolf	Carnivora: Canidae	Y	Y	**		Y	15
Cervidae	<i>Alces alces</i>	Moose	<i>Canis lupis</i>	Wolf	Carnivora: Canidae	Y	Y	**		Y	15
Cervidae	<i>Alces alces</i>	Moose	<i>Canis latrans</i>	Coyote	Carnivora: Canidae	Y	Y	**		Y	15
Cervidae	<i>Alces alces</i>	Moose	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	**		Y	15
Cervidae	<i>Alces alces</i>	Moose	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	**		Y	15
Cervidae	<i>Alces alces</i>	Moose	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	**		Y	15
Cervidae	<i>Alces alces</i>	Moose	<i>Canis lupis</i>	Wolf	Carnivora: Canidae	N	Y	**		Y	15
Cervidae	<i>Alces alces</i>	Moose	<i>Canis lupis</i>	Wolf	Carnivora: Canidae	N	Y	**		Y	15

Cervidae	<i>Alces alces</i>	Moose	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	N	Y	**	Y	15		
Cervidae	<i>Alces alces</i>	Moose	<i>Canis latrans</i>	Coyote	Carnivora: Canidae	N	Y	**	Y	15		
Cervidae	<i>Alces alces</i>	Moose	<i>Canis latrans</i>	Coyote	Carnivora: Canidae	N	Y	**	N	15		
Cervidae	<i>Alces alces</i>	Moose	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	**	Y	15		
Cervidae	<i>Alces alces</i>	Moose	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	**	Y	15		
Cervidae	<i>Alces alces</i>	Moose	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	**	N	15		
Cervidae	<i>Cervus elaphus</i>	Elk	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	Y	Y	<i>Alouatta</i> sp.	Howler monkey	Y	14	
Cervidae	<i>Cervus elaphus</i>	Elk	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	Y	Y	<i>Alouatta</i> sp.	Howler monkey	N	14	
Cervidae	<i>Cervus elaphus</i>	Elk	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	<i>Alouatta</i> sp.	Howler monkey	N	14	
Cervidae	<i>Cervus elaphus</i>	Elk	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	Y	Y	<i>Alouatta</i> sp.	Howler monkey	Y	14	
Cervidae	<i>Cervus elaphus</i>	Elk	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	<i>Alouatta</i> sp.	Howler monkey	N	14	
Cervidae	<i>Cervus elaphus</i>	Elk	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	N	Y	<i>Alouatta</i> sp.	Howler monkey	N	14	
Cervidae	<i>Elaphurus davidianus</i>	Père David's deer	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	Y	<i>Corvus corone</i>	Crow	Y	Y	16
Cervidae	<i>Elaphurus davidianus</i>	Père David's deer	<i>Panthera leo</i>	Lion	Carnivora: Felidae	N	N	<i>Corvus corone</i>	Crow	Y	Y	16
Cervidae	<i>Elaphurus davidianus</i>	Père David's deer	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	N	Y	<i>Corvus corone</i>	Crow	Y	N	16
Cervidae	<i>Elaphurus davidianus</i>	Père David's deer	<i>Canis lupus familiaris</i>	Dog	Carnivora: Canidae	Y	Y	<i>Corvus corone</i>	Crow	Y		16
Cervidae	<i>Rangifer tarandus</i>	Caribou	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	<i>Alouatta</i> sp.	Howler monkey	N		14
Cervidae	<i>Rangifer tarandus</i>	Caribou	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	Y	Y	<i>Alouatta</i> sp.	Howler monkey	Y		14
Cervidae	<i>Rangifer tarandus</i>	Caribou	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	N	<i>Alouatta</i> sp.	Howler monkey	N		14
Cervidae	<i>Rangifer tarandus</i>	Caribou	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	N	N	<i>Alouatta</i> sp.	Howler monkey	N		14
Order Carnivora												
Canidae	<i>Lycaon pictus</i>	African wild dog	<i>Panthera leo</i>	Lion	Carnivora: Felidae	Y	Y		Y	Y		17
Canidae	<i>Lycaon pictus</i>	African wild dog	<i>Crocuta crocuta</i>	Spotted hyena	Carnivora: Hyaenidae	Y	Y		Y			17
Felidae	<i>Acinonyx jubatus</i>	Cheetah	<i>Panthera leo</i>	Lion	Carnivora: Felidae	Y	Y		Y			18
Felidae	<i>Acinonyx jubatus</i>	Cheetah	<i>Crocuta crocuta</i>	Spotted hyena	Carnivora: Hyaenidae	Y	Y		Y			18
Mustelidae	<i>Enhydra lutris</i>	Sea otter	<i>Orcinus orca</i>	Killer whale	Cetacea: Delphinidae	Y	Y		N			19
Phocidae	<i>Phoca vitulina</i>	Harbour seal	<i>Orcinus orca</i>	Killer whale	Cetacea: Delphinidae	Y	Y	<i>Ornicus orca</i>	Fish-eating killer whales	Y		20
Order Dasyuromorphia												
Dasyuridae	<i>Dasyurus viverrinus</i>	Tasmanian eastern quoll	<i>Tyto novaehollandiae castanops</i>	Masked owl	Strigiformes: Tytonidae	Y	Y	<i>Bos taurus</i>	Cow	Y		21
Dasyuridae	<i>Dasyurus viverrinus</i>	Tasmanian eastern quoll	<i>Sarcophilus laniarius</i>	Tasmanian devil	Dasyuromorphia: Dasyuridae	Y	Y	<i>Bos taurus</i>	Cow	Y		21
Dasyuridae	<i>Dasyurus viverrinus</i>	Tasmanian eastern quoll	<i>Vulpes vulpes</i>	Red fox	Carnivora: Canidae	Y	N	<i>Bos taurus</i>	Cow	Y		21
Dasyuridae	<i>Dasyurus</i>	Tasmanian	<i>Felis catus</i>	Cat	Carnivora: Felidae	Y	N	<i>Bos taurus</i>	Cow	N		21

	<i>viverrinus</i>	eastern quoll											
Order Diprotodontia													
Macropodidae	<i>Macropus eugenii</i>	Tammar wallaby	<i>Aquila audax</i>	Wedge-tailed eagle	Accipitriformes: Accipitridae	Y	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			22
Macropodidae	<i>Macropus eugenii</i>	Tammar wallaby	<i>Canis lupis dingo</i>	Dingo	Carnivora: Canidae	N	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			22
Macropodidae	<i>Macropus eugenii</i>	Tammar wallaby	<i>Aquila audax</i>	Wedge-tailed eagle	Accipitriformes: Accipitridae	N	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			23
Macropodidae	<i>Macropus eugenii</i>	Tammar wallaby	<i>Canis lupis dingo</i>	Dingo	Carnivora: Canidae	N	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			23
Macropodidae	<i>Macropus rufogriseus banksianus</i>	Red-necked wallaby	<i>Canis lupis dingo</i>	Dingo	Carnivora: Canidae	N	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			24
Macropodidae	<i>Macropus rufogriseus banksianus</i>	Red-necked wallaby	<i>Aquila audax</i>	Wedge-tailed eagle	Accipitriformes: Accipitridae	Y	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			24
Macropodidae	<i>Thylogale thetis</i>	Red-necked pademelon	<i>Canis lupis dingo</i>	Dingo	Carnivora: Canidae	N	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			24
Macropodidae	<i>Thylogale thetis</i>	Red-necked pademelon	<i>Aquila audax</i>	Wedge-tailed eagle	Accipitriformes: Accipitridae	Y	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			24
Macropodidae	<i>Thylogale thetis</i>	Red-necked pademelon	<i>Aquila audax</i>	Wedge-tailed eagle	Accipitriformes: Accipitridae	Y	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			25
Macropodidae	<i>Thylogale thetis</i>	Red-necked pademelon	<i>Canis lupis dingo</i>	Dingo	Carnivora: Canidae	N	Y	<i>Gymnorhina tibicen</i>	Australian magpie	N			25
Order Perissodactyla													
Tapiridae	<i>Tapirus indicus</i>	Malayan tapir	<i>Panthera tigris</i>	Tiger	Carnivora: Felidae	N	Y	***		Y			26
Tapiridae	<i>Tapirus terrestris</i>	Lowland tapir	<i>Panthera onca</i>	Jaguar	Carnivora: Felidae	N	Y	***		Y			26
Order Primates													
Atelidae	<i>Alouatta macconnelli</i>	Red howler	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	Y	Y	<i>Lipaugus vociferans</i>	Screaming piha	Y			27
Atelidae	<i>Alouatta palliata</i>	Mantled howler monkey	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	Y	Y	<i>Tinamus major</i>	Tinamou	Y			28
Atelidae	<i>Alouatta palliata</i>	Mantled howler monkey	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	N	Y	<i>Tinamus major</i>	Tinamou	Y			28
Atelidae	<i>Alouatta palliata</i>	Mantled howler monkey	<i>Haliaeetus leucocephalus</i>	Bald eagle	Accipitriformes: Accipitridae	N	N	<i>Tinamus major</i>	Tinamou	N			28
Atelidae	<i>Ateles paniscus</i>	Black spider monkey	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	Y	Y	<i>Lipaugus vociferans</i>	Screaming piha	Y			27
Callitrichidae	<i>Callithrix geoffroyi</i>	Geoffroy's marmoset	<i>Buteo jamaicensis</i>	Red-tailed hawk	Accipitriformes: Accipitridae	N	Y	<i>Corvus corax</i>	Common raven	Y			29
Callitrichidae	<i>Callithrix jacchus</i>	Common marmoset	<i>Panthera pardus</i>	Leopard	Carnivora: Felidae	Y	Y			N	Y		30
Callitrichidae	<i>Saguinus midas</i>	Golden-handed tamarin	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	Y	Y	<i>Lipaugus vociferans</i>	Screaming piha	Y			27
Callitrichidae	<i>Saguinus oedipus</i>	Cotton-top tamarins	<i>Leucopternis albicollis</i>	White hawk	Accipitriformes: Accipitridae	N	Y	<i>Formicarius analis</i>	Black-faced antthrush	N	N		31
Callitrichidae	<i>Saguinus oedipus</i>	Cotton-top tamarins	<i>Panthera onca</i>	Jaguar	Carnivora: Felidae	N	Y	<i>Formicarius analis</i>	Black-faced antthrush	N	N		31
Callitrichidae	<i>Saguinus oedipus</i>	Cotton-top	<i>Eira barbara</i>	Tayra	Carnivora: Mustelidae	N	Y	<i>Formicarius analis</i>	Black-faced	N	N		31

		tamarins							antthrush			
Callitrichidae	<i>Saguinus oedipus</i>	Cotton-top tamarins	<i>Leucopternis albicollis</i>	White hawk	Accipitriformes: Accipitridae	N	Y	<i>Alouatta sp.</i>	Red howler monkey	N	N	31
Callitrichidae	<i>Saguinus oedipus</i>	Cotton-top tamarins	<i>Panthera onca</i>	Jaguar	Carnivora: Felidae	N	Y	<i>Alouatta sp.</i>	Red howler monkey	N	N	31
Callitrichidae	<i>Saguinus oedipus</i>	Cotton-top tamarins	<i>Eira barbara</i>	Tayra	Carnivora: Mustelidae	N	Y	<i>Alouatta sp.</i>	Red howler monkey	N	N	31
Cebidae	<i>Cebus olivaceus</i>	Wedge-capped capuchin	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	Y	Y	<i>Lipaugus vociferans</i>	screaming piha		Y	27
Cebidae	<i>Saimiri sciureus</i>	Squirrel monkey	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	Y	Y	<i>Lipaugus vociferans</i>	screaming piha		Y	27
Cebidae	<i>Sapajus apella</i>	Brown capuchin	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	Y	Y	<i>Lipaugus vociferans</i>	screaming piha		Y	27
Cercopithecidae	<i>Cercopithecus ascanius</i>	Red-tailed monkey	<i>Stepanoaetus coronatus</i>	Crowned eagle	Accipitriformes: Accipitridae	Y	Y	<i>Colobus badius</i>	Red colobus	Y		8, 32
Cercopithecidae	<i>Cercopithecus ascanius</i>	Red-tailed monkey	<i>Pan troglodytes</i>	Chimpanzee	Primates: Hominidae	Y	Y	<i>Colobus badius</i>	Red colobus	Y		8, 32
Cercopithecidae	<i>Cercopithecus campbelli</i>	Campbell's monkey	<i>Stephanoaetus coronatus</i>	Crowned hawk eagle	Accipitriformes: Accipitridae	Y	Y				Y	33
Cercopithecidae	<i>Cercopithecus campbelli</i>	Campbell's monkey	<i>Panthera pardus</i>	Leopard	Carnivora: Felidae	Y	Y				Y	33
Cercopithecidae	<i>Cercopithecus diana</i>	Diana monkey	<i>Stepanoaetus coronatus</i>	Crowned eagle	Accipitriformes: Accipitridae	Y	Y				Y	34, 35
Cercopithecidae	<i>Cercopithecus diana</i>	Diana monkey	<i>Panthera pardus</i>	Leopard	Carnivora: Felidae	Y	Y				Y	34, 35
Cercopithecidae	<i>Cercopithecus mitis</i>	Blue monkey	<i>Stepanoaetus coronatus</i>	Crowned eagle	Accipitriformes: Accipitridae	Y	Y	<i>Colobus badius</i>	Red colobus	Y		8
Cercopithecidae	<i>Cercopithecus mitis</i>	Blue monkey	<i>Pan troglodytes</i>	Chimpanzee	Primates: Hominidae	Y	Y	<i>Colobus badius</i>	Red colobus	Y		8
Cercopithecidae	<i>Cercopithecus nictitans martini</i>	Putty-nosed monkeys	<i>Panthera pardus</i>	Leopard	Carnivora: Felidae	Y	Y				Y	36
Cercopithecidae	<i>Cercopithecus nictitans martini</i>	Putty-nosed monkeys	<i>Stepanoaetus coronatus</i>	Crowned eagle	Accipitriformes: Accipitridae	Y	Y				Y	36
Cercopithecidae	<i>Colobus badius</i>	Red colobus monkey	<i>Stepanoaetus coronatus</i>	Crowned eagle	Accipitriformes: Accipitridae	Y	Y	<i>Bycanistes subcylindricus</i>	Black-and-white casqued hornbill	Y		37, 38, 8, 32
Cercopithecidae	<i>Colobus badius</i>	Red colobus monkey	<i>Pan troglodytes</i>	Chimpanzee	Primates: Hominidae	Y	Y	<i>Bycanistes subcylindricus</i>	Black-and-white casqued hornbill	Y		37, 38, 8, 32
Cercopithecidae	<i>Colobus guereza</i>	Mantled guereza monkey	<i>Panthera pardus</i>	African leopard	Carnivora: Felidae	N	Y	<i>Loxodonta africana</i>	African elephant	Y	Y	39
Cercopithecidae	<i>Colobus guereza</i>	Mantled guereza monkey	<i>Pan troglodytes</i>	Chimpanzee	Primates: Hominidae	Y	Y	<i>Loxodonta africana</i>	African elephant	N	Y	39
Cercopithecidae	<i>Colobus guereza</i>	Mantled guereza monkey	<i>Stepanoaetus coronatus</i>	Crowned eagle	Accipitriformes: Accipitridae	Y	Y	<i>Loxodonta africana</i>	African elephant	Y	Y	39
Cercopithecidae	<i>Colobus guereza</i>	Mantled guereza monkey	<i>Crocuta crocuta</i>	Spotted hyena	Carnivora: Hyaenidae	N	N	<i>Loxodonta africana</i>	African elephant	N	N	39
Cercopithecidae	<i>Simias concolor</i>	Pig-tailed langur		Multiple felids	Carnivora: Felidae	N	Y	<i>Pycnonotus melanoleucos</i>	Black-and-white bulbul	Y		40
Indriidae	<i>Propithecus verreauxi</i>	White sifaka	<i>Cryptoprocta ferox</i>	Fossa	Carnivora: Eupleridae	Y	Y	<i>Coracopsis nigra</i>	Lesser vasa parrot	N	Y	41
Indriidae	<i>Propithecus</i>	White sifaka	<i>Polyboroides</i>	Harrier hawks	Accipitriformes:	Y	Y	<i>Coracopsis nigra</i>	Lesser vasa parrot	Y	Y	41

	<i>verreauxi</i>		<i>radiatus</i>		Accipitridae								
Indriidae	<i>Propithecus verreauxi</i>	White sifaka	<i>Canis lupus familiaris</i>	Dog	Carnivora: Canidae	Y	Y	<i>Coracopsis nigra</i>	Lesser vasa parrot	N	Y		41
Lemuridae	<i>Eulemur fulvus rufus</i>	Redfronted lemur	<i>Cryptoprocta ferox</i>	Fossa	Carnivora: Eupleridae	Y	Y	<i>Coracopsis nigra</i>	Lesser vasa parrot	Y	Y		41
Lemuridae	<i>Eulemur fulvus rufus</i>	Redfronted lemur	<i>Polyboroides radiatus</i>	Harrier hawk	Accipitriformes: Accipitridae	Y	Y	<i>Coracopsis nigra</i>	Lesser vasa parrot	N	Y		41
Lemuridae	<i>Eulemur fulvus rufus</i>	Redfronted lemur	<i>Canis lupus familiaris</i>	Dog	Carnivora: Canidae	Y	Y	<i>Coracopsis nigra</i>	Lesser vasa parrot	Y	Y		41
Lemuridae	<i>Lemur catta</i>	Ring-tailed lemur	<i>Buteo jamaicensis</i>	Red-tailed hawk	Accipitriformes: Accipitridae	Y	N	<i>Hylocichla mustelina</i>	Wood thrush	Y			42,43
Pitheciidae	<i>Chiropotes santanas</i>	Bearded saki	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	Y	Y	<i>Lipaugus vociferans</i>	Screaming piha		Y		27
Pitheciidae	<i>Pithecia pithecia</i>	White-faced saki	<i>Harpia harpyja</i>	Harpy eagle	Accipitriformes: Accipitridae	Y	Y	<i>Lipaugus vociferans</i>	Screaming piha	Y			27
Tarsiidae	<i>Tarsius spectrum</i>	Spectral tarsier		Multiple predatory birds		Y	Y			Y	Y		44, 45
Order Rodentia													
Cricetidae	<i>Microtus pennsylvanicus</i>	Meadow vole	<i>Mustela erminea</i>	Stoat	Carnivora: Mustelidae	Y/N*	Y			Y			46
Cricetidae	<i>Microtus socialis</i>	Social vole	<i>Strix aluco</i>	Tawny owl	Strigiformes: Strigidae	Y	Y	<i>Homo sapien</i>	Human	Y		Y	47, 48
Cricetidae	<i>Peromyscus leucopus</i>	White-footed mouse	<i>Strix varia</i>	Barred owl	Strigiformes: Strigidae	Y	Y			Y			49
Dipodidae	<i>Jaculus jaculus</i>	Lesser Egyptian jerboa	<i>Strix aluco</i>	Tawny owl	Strigiformes: Strigidae	Y	Y	<i>Homo sapien</i>	Human	Y			48
Gliridae	<i>Eliomys melanurus</i>	Asian garden dormouse	<i>Strix aluco</i>	Tawny owl	Strigiformes: Strigidae	Y	Y	<i>Homo sapien</i>	Human	Y			48
Muridae	<i>Acomys cahirinus</i>	Cairo spiny mouse	<i>Strix aluco</i>	Tawny owl	Strigiformes: Strigidae	Y	Y	<i>Homo sapien</i>	Human	N		Y	47,48
Muridae	<i>Gerbillus allenbyi</i>	Allenby's gerbil	<i>Tyto alba</i>	Barn owl	Strigiformes: Tytonidae	Y	Y			Y			50
Muridae	<i>Gerbillus perpallidus</i>	Pallid gerbil	<i>Strix aluco</i>	Tawny owl	Strigiformes: Strigidae	N	Y			N			51
Muridae	<i>Gerbillus perpallidus</i>	Pallid gerbil	<i>Tyto alba</i>	Barn owl	Strigiformes: Tytonidae	N	Y			N			51
Muridae	<i>Gerbillus perpallidus</i>	Pallid gerbil	<i>Falco peregrinus</i>	Peregrine falcon	Falconiformes: Falconidae	N	Y			N			51
Muridae	<i>Gerbillus pyramidum</i>	Greater Egyptian gerbil	<i>Tyto alba</i>	Barn owl	Strigiformes: Tytonidae	Y	Y			Y			50
Muridae	<i>Mastomys natalensis</i>	Natal multimammate mouse	<i>Tyto capensis</i>	Grass owl	Strigiformes: Tytonidae	Y	Y	<i>Stephaniibyx coronatus</i>	Crowned plover	N			52
Muridae	<i>Mus musculus</i>	Mouse	<i>Strix aluco</i>	Tawny owl	Strigiformes: Strigidae	N	Y		Multiple non-pred birds	N			51
Muridae	<i>Mus musculus</i>	Mouse	<i>Tyto alba</i>	Barn owl	Strigiformes: Tytonidae	N	Y			N			51
Muridae	<i>Mus musculus</i>	Mouse	<i>Falco peregrinus</i>	Peregrine falcon	Falconiformes: Falconidae	N	Y			N			51
Muridae	<i>Otomys angoniensis</i>	Angoni Vlei rat	<i>Tyto capensis</i>	Grass owl	Strigiformes: Tytonidae	Y	Y	<i>Stephaniibyx coronatus</i>	Crowned plover	N			52
Muridae	<i>Rattus norvegicus</i>	Rat	<i>Strix aluco</i>	Tawny owl	Strigiformes: Strigidae	N	Y			N			51

	<i>Rattus norvegicus</i>	Rat	<i>Tyto alba</i>	Barn owl	Strigiformes: Tytonidae	N	Y		N	51	
Muridae	<i>Rattus norvegicus</i>	Rat	<i>Falco peregrinus</i>	Peregrine falcon	Falconiformes: Falconidae	N	Y		N	51	
Sciuridae	<i>Marmota flaviventris</i>	Yellow-bellied marmots	<i>Canis latrans</i>	Coyote	Carnivora: Canidae	Y	Y		Y	53	
Sciuridae	<i>Marmota flaviventris</i>	Yellow-bellied marmots	<i>Canis lupus</i>	Wolf	Carnivora: Canidae	N	Y		Y	53	
Sciuridae	<i>Marmota flaviventris</i>	Yellow-bellied marmots	<i>Aquila chrysaetos</i>	Golden eagle	Accipitriformes: Accipitridae	Y	Y		Y	53	
Sciuridae	<i>Spermophilus beecheyi</i>	California ground squirrel	<i>Crotalus viridis oregonus</i>	Northern pacific rattlesnakes (large)	Squamata: Viperidae	Y	Y		Y	54	
Sciuridae	<i>Tamias striatus</i>	Eastern chipmunk	<i>Buteo platyterus</i>	Broad-winged hawk	Accipitriformes: Accipitridae	Y	Y	<i>Hylocichla mustelina</i>	Wood thrush	N	55

^a An indication (Y = Yes; N = No) of whether the studied species has ecologically experienced the predator species (within its lifetime).

^b An indication (Y = Yes; N = No) of whether the studied species has evolutionarily experienced the predator species (historically coexisted).

^c Tested for the change in time budget (TB) of behaviors (scan, flight, vigilance, forage, relaxed behavior, locomotion)

^d Tested for the production of vocalization (V) or alarm call

^e Tested for the change in reproductive success (RS)

^f Tested for the change in hormone levels (HL)

^{c, d, e, f} Y = type of response was tested for and observed; or N = type of response was tested for, but not observed

* not clear from the manuscript

** these studies were compared to a control stimulus that was the sound of running water

*** all individual tapirs were tested at zoos with different species of elephants; all responded to felids and none to elephants.

References

¹Lohrey et al. 2009; ²Remage-Healey et al. 2006; ³Llusia et al. 2010; ⁴Huang et al. 2011; ⁵Cantwell 2010; ⁶Elmasri et al. 2012; ⁷Rainey et al. 2004; ⁸Hauser and Wrangham 1990; ⁹Hauser and Caffrey 1994; ¹⁰Zanette et al. 2011; ¹¹Greig et al. 2010; ¹²Greig and Pruett-Jones 2010; ¹³Adams et al. 2006; ¹⁴Berger 2007; ¹⁵Berger et al. 2001; ¹⁶Li et al. 2011; ¹⁷Webster et al. 2011; ¹⁸Durant 2000; ¹⁹Kuker 2008; ²⁰Deecke et al. 2002; ²¹Jones et al. 2004; ²²Blumstein et al. 2000; ²³Blumstein et al. 2004; ²⁴Ramp et al. 2011; ²⁵Blumstein et al. 2002; ²⁶Zenzinger 2010; ²⁷Neal 2009; ²⁸Gil-da-Costa et al. 2003; ²⁹Searcy and Caine; ³⁰Kemp and Kaplan 2011; ³¹Friant et al. 2008; ³²Treves 1999; ³³Zuberbühler 2001; ³⁴Zuberbühler et al. 1999; ³⁵Zuberbühler 2000; ³⁶Arnold and Zuberbühler 2006; ³⁷Bshary and Noë 1997; ³⁸Gebo et al. 1994; ³⁹Schel and Zuberbühler 2009; ⁴⁰Yorzinski and Ziegler 2007; ⁴¹Fitchel and Kappeler 2002; ⁴²Karpanty and Grelle 2001; ⁴³Macedonia and Yount 1991; ⁴⁴Gursky 2002; ⁴⁵Gursky 2003; ⁴⁶Pusenius and Ostfeld 2000; ⁴⁷Eilam et al. 1999; ⁴⁸Hendrie et al. 1998; ⁴⁹Schmidt 2006; ⁵⁰Abramsky et al. 1996; ⁵¹Kindermann et al. 2009; ⁵²Crafford et al. 1999; ⁵³Blumstein et al. 2008; ⁵⁴Swaigood et al. 1999; ⁵⁵Schmidt 2008

Table 2: Number and type of responses to predator vocalization by class of studied species. Eco No = no ecological experience with the predator species within its lifetime; Eco Yes = ecological experience. Evol No = did not coevolve or historically exist with the predator species; Evol Yes = coevolve or historically existed. Values are the number of comparisons where there was No discrimination or where there (YES) was discrimination. Blanks indicate that studies have not been conducted.

Class	Eco No / Evol No		Eco No / Evol Yes		Eco Yes / Evol No		Eco Yes / Evol Yes	
	No	Yes	No	Yes	No	Yes	No	Yes
Arachnida								2
Actinopterygii								1
Amphibia							1	
Reptilia			1				2	3
Aves		1					2	11
Mammalia	11	6	25	13	1	2	9	61

Table 3: Number and type of responses to predator vocalizations by class. Eco No = no ecological experience with the predator species within its lifetime; Eco Yes = ecological experience. Evol No = did not coevolve or historically exist with the predator species; Evol Yes = coevolve or historically existed. Values are the number of comparisons where there was No discrimination or where there (YES) was discrimination. Blanks indicate that studies have not been conducted.

Predator Class	Eco No / Evol No		Eco No / Evol Yes		Eco Yes / Evol No		Eco Yes / Evol Yes	
	No	Yes	No	Yes	No	Yes	No	Yes
Reptilia								1
Aves	1	1	13	2	0	1	10	41
Mammalia	10	6	13	11	1	1	3	33

Figure Legends

Fig. 1 Exemplars of acoustic stimuli used to study predator discrimination illustrated by spectrograms and waveforms.

Fig. 2 Mule deer's response to stimuli in the 0-15 s time bin and 45-60 s time bin after the playback of vocalizations of butcherbirds (control), mountain lions, wolves, and coyotes. Heightened response includes the sum of the proportion of time allocated to the behaviors stand-and-look, alarm walk, run, and stott.



