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Predator aversion in resident generalist birds

A ghost of evolutionary past?

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Abstract:

Predator aversion is an important adaptation that can significantly lower the mortality rate among prey animals, but avoiding a predator requires knowing and recognizing them. The predator aversion of Common gulls and Mallard ducks at Prestvannet Lake, Tromsø, Northern Norway was tested in an experiment by placing differing objects resembling snakes next to bread during the summer and autumn of 2017. The birds were chosen because they were resident generalists who presumably used to interact with snakes, and now live in environments without them. The time spent before accessing the bait by a rubber snake, a garden hose and a control was used to gauge the fearful response to the treatments in question, with a longer duration implying a higher level of aversion or fear. The resulting data indicated that the common gull's ability to distinguish between objects was more substantial than that of the mallard duck and that the mallard duck was less sensitive to the differences between treatments. In addition, the presence of a potential predator seemed more influential on bird behavior than bird density and the associated competition between birds.

Introduction:

Neophobia, described by Adam L. Crane and Maud C. O. Ferrari (2017), is the fear of novel stimuli, propagating neophobic responses and neophobic behavior. It can be categorized into three main types [12]; gustatory neophobia, the aversion towards consuming novel food, even when fully palatable, presumably due to the possibility that the novel food might contain toxins, social neophobia, the fear of novel social situations, interactions with novel individuals, typically in competitive or aggressive contexts [12]. The final and most relevant one is predator neophobia, the novel stimuli of potential predators, guiding predator evasive behavior [12]. Such neophobic responses might be a result of visual, audible or chemical stimuli (odor), providing the prey animal with "warning signs" to the presence of a potential predator. Neophobic responses that an animal is expressing in the absence of novel food or competitors is assumed to be predator neophobia [12]. This behavior is also directed towards novel objects that express the beforementioned stimuli, potentially perceiving them as predators [12]. This also applies to objects that represent structures and habitats [12], and as such it is reasonable to say that a human made environment with human tools and toys represents a plethora of novel stimuli to an inexperienced animal. Neophobia provides an animal with the carefulness they need to survive initial encounters with potential predators and allows them to retain this information and use it the next time they encounter similar stimuli [17].

Greenberg (1990) proposed the "neophobia threshold hypothesis", linking neophobia to ecological plasticity of species, explaining that neophobia may be a result of natural selection, promoting genes that code for these responses. In terms of neophobia it is also important to remember that animals that has been a part of a coevolutionary arms race in the past do not perceive predators and resembling objects as completely novel [12]. Greenberg (1990) also noted that a very neophobic species is less likely to explore new resources and shift its niche, and conversely that generalists show lower levels of neophobia, making them more adaptive in environments with more potential novelty [16]. This holds true for many generalist birds that occupy crowded woods, rural areas or migrate over large distances, allowing them to interact with a more diverse cast of objects and organisms, full off potential dangers. However, for individuals that live in a relatively safe environment, freed from the pressure of their past predators, this fear and mode of anticipation might become a maladaptive burden on the animal, both in of costs of behavior (i.e. expending more energy avoiding trivial threats) and DNA, potentially dragging unused genetic material to the next generation. With a long absence of a predator over evolutionary time, one would expect that such traits would be selected against and eventually disappear. This could mean that the species that still show fear responses to a specific predator stimulus but live in an ecosystem devoid of this predator, could be indications of ghosts of their evolutionary past, back from a time when they were locked in an evolutionary arms race. How well (if at all) an animal responds to the stimuli of a predator might be an indication of how long ago this species was subject to the effects of coevolution with the given predator, or if they have overlapped in ecosystems at all. Lemurs, the only primates found on Madagascar, are much less responsive to venomous snakes compared to their African primate counterparts [19]. This is most likely due to the absence of venomous snakes prior to the splitting of the southern supercontinent Gondwanaland, consisting of the current day Africa, Madagascar, South America, India, Australia and

Antarctica. Venomous snakes are said to have originated in Asia and spread to Africa, North America and South America well after the splitting of Gondwanaland, providing little overlap for the inhabitants of Madagascar to be exposed to venomous snakes and little opportunity to develop strong fear responses as a result [11]. This phenomenon may be happening for many different species, augmented by the geographical isolation from their original ecosystems and spread of species across continents.

Arne Öhman (2009), describes predator-prey arms races as asymmetrical, putting more pressure on prey than predator. A fox, when chasing a hare, is only running to catch his dinner, while the hare is running to save his life. Therefore, there is a tendency for the evolution of prey to exaggerate the need for caution and the avoidance of danger [11]. This imbalance has likely amplified the fear and phobias of many species, showing higher reaction times and higher alertness when presented with visual images or movements of predators such as snakes or spiders, providing a possible explanation for human anxiety and irrational fears and phobias [18].

Despite a bird's fear, they can adapt to the presence of predators over evolutionary time, and even change the behavior in relation to when predation would be an issue, i.e. on a seasonal, daily or on a minute to minute basis [9]. Some birds may only display anti-predation effects during the seasons they are migrating, displaying higher alertness in wintering grounds with higher density or diversity of predators. Some also react to predation during migration itself, avoiding stopovers spots due to known predator populations (i.e. sandpipers avoiding migration stopovers with Peregrines (*Falco peregrinus*) [22]). Many birds deal with the unpredictability of foraging opportunities by storing fat when foraging is much more limited [21] and [25], leaving them more open to attack. When studying predation risks in birds, it is important to account for their foraging ecology as well [8]. In addition, some birds become more protective, cautious and sometimes more aggressive during breeding seasons, attempting to hide away the location by picking an inconspicuous nesting location or by distracting predators away from nesting grounds, creating loud noises that allure predators to travel in the opposite direction. This becomes more relevant for ground nesting birds, who often choose from a limited amount of hidden or inaccessible nest sites in order to minimize discovery by predators [23].

A prey animal is not alone in an ecosystem with predators. It is also influenced by other individuals of the same species, or individuals of other non-hostile species. Groups of birds provide each other with protection simply by covering a larger area, providing more eyes and ears to the potential dangers and alerting the flock should one appear. Some flocks of birds seem to even have designated sentinels that keep watch while other birds are foraging, incubating or rearing young. Some birds are exposed to risk when handling food, bowing their head downward to separate it into smaller pieces, leaving them open to sudden predator attacks from blindsides. But this of course depends on the quantity and type of food. A great tit, *Parus major*, must interrupt its handling to scan its surroundings [9]. Stephens and Krebs (1986) suggested that food-deprived birds might scan less when handling food, lowering their alertness compared to more satiated great tits, benefiting greatly from group effects. However, the larger the group, the harsher the competition between individuals becomes, both in terms of inter- and intraspecific competition. Equally distributed food between individuals in flocks would diminish into nothingness with increasing population sizes, and thus each bird must rush towards food to secure it for themselves. This means that birds could be more inclined to approach food sources if surrounded by many individuals of the same species or similar niche occupying birds, even if this exposes them to a nearby predator. Strong competition can shift the priorities of survival and reward individuals who act fast in risky situations.

Any object, manmade or not, can resemble predators and their shape or coloration [12] can result in predator aversion behavior. Although, without movement, sounds and odors, this response would likely be reduced compared to a real encounter. Movement is an important factor for the detection and identifying threats in nature. Ducks, pigeons, gulls and other animals found in urban environment are accustomed to great numbers of humans and human created environments and objects. These animals represent a group of generalists and show reduced levels of neophobia, making them less likely to flee after identifying a fear stimulus, be it from a human invention or a present predator. In recent times, humans have started putting up kites resembling predatory birds, trying to exploit the features and movement of a known predator. The goal is to lower the activity of birds surrounding rural areas, reducing noise, nesting and defecation on top of and around buildings. The movement of the kite itself may be more important than the physical shape of the kite, predator-like or not. Birds interact with various objects when in urban areas, and many are also scavenging among garbage and refuse, searching for something that resembles food. A bird will while searching, determine if an object is a potential food source or a potential predator, recognized by its shape, odor, sound and its movement. Its willingness to approach is assumed to be less likely should the object be moving, since generally something that is moving is more dangerous than non-moving objects. A flock of pigeons, gulls or ducks are likely to approach humans sitting still on a bench in a park, because they learn from past experiences that some people will offer them food, usually in the form of breadcrumbs or seeds. But the same birds will generally avoid people walking down a road and do get out of the way of fast moving automobiles, most likely because sudden movements and in many cases, sounds, presents a change of the normal peaceful status quo into an unpredictable burst of activity on both parts. There, in that moment, they seem way more fearful than otherwise observed, a reflex akin to a person covering and closing their eye to avoid incoming harm to it. Most birds likely developed this reaction due to the nature of some predators, most notably reptiles like snakes and crocodiles, quickly lashing out from hiding after laying still, camouflaged close to areas where prey would thread. In such a moment, birds need to react fast, most likely tossing aside its initial impression of an organism and reassessing it once at a safe distance. So, in addition to the images of certain predators, birds are sensitive to the subtle movement in their surroundings, showing higher awareness towards predator specific movement types, such as the slithering or sidewinding motions of a snake.

In Norway, it is said that leaving a rubber snake on top of a rooftop will ward off nearby seagulls, preventing them from nesting or defecating on that building’s roof. In most cases this seems to be correct, assuming that the seagulls are able to notice the snake before landing on a building. Their change in behavior when approaching or detecting the fake snake suggests that seagulls can identify this object as a potential predator. Most birds do display fear or aversion of most snakes, but does this apply to all birds, and in all regions? The climate in Norway is said to be too cold to propagate the growth of many and diverse reptile species, and unsurprisingly one can only find three snake species in all of Norway. These three species, the common European adder (*Vipera berus*) [5], the grass snake (*Natrix natrix)*

[5] and the smooth snake (*Coronella austriaca*) [5] are only found in greater numbers in the southern and western parts of Norway. Among them, the European adder occupies the largest area in Norway, ranging from Southern Norway to parts of Northern Norway. All three snakes' density greatly decreases as latitude increases, making them a rare sight in Arctic Norway. Due to this low density of snakes in Northern Norway, the chances of a bird encountering one is very low at any point during the year, making it unlikely to develop predator aversion from learning from encounters with snakes. Learning from encounters with predators have shown to have a lasting impact on prey, making them more likely to act differently should a similar encounter happen again. However, gulls still display aversion towards objects that they presumably have never seen (in this case a rubber snake), indicating that they have a built-in response towards certain shapes, coloration or odors, triggering a response akin to predator aversion behavior. A lack of observed predation does not mean a lack of behavioral sensitivity to predation [9].

In short, it is expected that a mallard duck (*Larus canus*) and a common gull (*Anas platyrhynchos*) would try to avoid or hesitate to approach locations occupied by a predator such as a snake. Because of neophobia, learning and evolutionary history, they have an innate ability to recognize and detect predators based on shapes, colors, textures, odors, sound and movement. But how developed is this ability, and how similar can an object be to be considered dangerous? Mallard ducks also occupy a larger area worldwide than the common gull [27] and [28] and individuals could therefore have arrived from other parts of the world, who could have subject to predation. It is therefore likely that mallards display a higher level of fear of snakes due to a larger overlap with snakes. If an object is similar, but different enough to be considered a different object or animal, do they act differently and take different amounts of time to approach it and potential food in the same area? In this project I tested the behavioral impact of a potential predator and an unknown object placed next to a food source. Does a resident generalist bird's ability to distinguish between predators and non-predators guide its behavior, and how does this relate to its evolutionary past?

Project Method and Results:

I conducted the study close to Lake Prestvannet, an artificial lake, initially created in 1867 as a reservoir for drinking water for the inhabitants of Tromsø, Northern Norway [4]. The lake was a poor source of drinking water and was turned into a park land and nature reserve by 1921[4]. The pond area is often occupied in spring, summer and autumn by a high diversity of birds, including mallard duck, common gull, tufted duck, black-headed gull, common tern and arctic tern [4]. From May 1st until July 31st there is a thread restriction on a large portion of the lake's "wet grounds", areas close to the lake where most of the resident species nest and rear their young. The restriction is there to avoid people stepping too close to the nesting grounds, disrupting mating and/or incubating, especially when accompanied by dogs. Human made paths with benches at regular intervals surround the lake and the lake is a popular spot for people to regularly visit or pass through during the warmer months. People often stop around the lake to conduct bird watching or to feed any birds present, usually the common gull and mallard duck and usually with cheap bread. Birds in the area are quite used to being fed and will gather in great numbers close to where people seat themselves. The presence of people and noise draws the attention of other birds in the area, usually making the attentive birds a mix of different species.

Among the bird inhabitants, the common gull and the mallard duck occupy the largest numbers in and around the lake when not frozen. These birds mostly migrate over short distances compared to completely migratory birds, wintering in rural areas, fjords or migrating out to sea. As such they are often referred to as resident or non-migratory birds, staying in a relatively small area over the course of the year. Some mallards do migrate over longer distances and northerly breeding European mallards might migrate further south to winter in Western Europe [7] and [6]. However, in temperate regions, the mallard is also found to be largely resident [7] and [6]. Because of the proposed lack of longer migrations and the density of said birds around the lake, the common gull and the mallard duck were chosen for an experimental study of generalist resident bird behavior, testing the reactions of feeding in the presence of potential predators, objects that resemble a known predator (a rubber snake) and an unknown object (a garden hose).

Two experiments were conducted summer and fall 2017. Food, slices and minced pieces of bread, “kneippbread” purchased at Coop Extra in Elverhøy, Tromsø was placed at a total of four locations at Prestvannet Lake, Tromsø, in spots where mallard ducks and common gulls were often visiting. Prestvannet lake was chosen as the study area due to the high density of year-round generalist birds such as Mallard duck and Common gull. The spots were located within 3 meters of the lake itself and about 5 to 10 meters away from the nearest path used by people. The spots were also mostly clear of tall vegetation and slightly elevated to improve visibility for recording and for the birds to locate the food more easily. The two different experiments were intended to each account for the presence and absence of an observer (a person), in addition to lasting impacts of repeated feeding. During experiment 1, no observer was present during recording. During experiment 2, an observer was present during the recording. It was attempted for the observer to use different clothes from one recording to the next, however for some recordings, similar clothing was required due to wet and cold weather. For both experiments, 3 treatments were used to test the predator avoidance behavior of the mallard ducks and common gulls when encountering potential dangerous objects. Two of the treatments were “potentially dangerous objects”, the first a rubber snake, representing a predator that most birds would likely avoid, coiled up like a real snake, black with gray stripes around its curvature and with a white underside (Fig. 1). The second one was a coiled up short garden hose, black with a dark green chain link pattern along the entire length, serving as an unknown object that the birds might perceive as both a predator or just a noble object (Fig. 2). The third treatment was simply nothing, serving as the control for the experiments, providing the behavior of the birds when food was not associated with a potential danger.

Figure 1: *The treatment simulating a known predator in the form of a rubber snake, used during experiment 1 and 2. Photo by Ådne Hotvedt.*

Figure 2: *The treatment simulating a presumed novel object to birds. Was used during experiment 1 and 2. Photo by Ådne Hotvedt.*

Figure 3: *The bait used for experiment 1, two slices of bread, serving as the incentive for birds to get close to the three treatments. Photo by Ådne Hotvedt.*

Figure 4: *The bait used for experiment 2, roughly 1/3 of a bread slice, serving as the incentive for the birds to get close to each of the three treatments. Photo by Ådne Hotvedt.*

Experiment 1 took place from 20.06.2017 to 0.6.09.2017 with a two to three-day interval in between recording sessions to avoid lasting impact of the treatment on the area. Three spots were chosen, each with one treatment and 2 slices of bread (see figure 3). The treatment at each location was exchanged every recording session to avoid association of treatment and location, meanwhile the camera present and camera location used for recording remained the same for each location throughout the experiment. Ideally the cameras would have been rotated to each location after a recording but was not done due to issues of video storage and exchanging memory cards. The cameras used were three go-pro cameras, the Kitvision EscapeHD5 [1] action camera for location 1, Hero4 [2] for location 2 and Bushnell trophy cam [3] for location 3. The recordings started at 5:00 am for the first location, around 5:02 for the second location and estimated 5:04 for the third. The time differences between the locations are due to only one operator and therefore needing to run to each location to start recording. Each spot was recorded for roughly 30 minutes every recording session, with a few sessions lasting up to 15 minutes longer. Data was gathered from the recordings by taking the time from when recording started (in seconds) to the time when either a mallard duck or a common gull first fed on the bait, henceforth known as the Time (Nibble).

The data was used in a one-way anova in IMB SPSS Statistics Data Editor by using the treatment as the factor and the Time (Nibble) as the dependent parameter. Due to the low sample size of the first experiment, the results for both species were combined into the anova. This resulted in no apparent evidence that the treatment was the determining factor for how long it took for the birds to nibble on the bait ($N = 14$, $df = 2$, $F = 0.45$, $P = 0.65$). The treatment of rubber snake did however have a higher average time than the two other treatments but also had a lower sample size than the others and an outlier that was responsible for much of this inequality. This experiment did not account for the differences between the species, the impact of the location nor the quality of the bait, which differs from the next experiment.

Table 1: *The dates, locations, treatments and time until nibble for experiment 1.*

Date	**Treatment**	**Time Nibble (seconds)**	**Location**
20.jun.17	Rubber snake	**1095**	1
07.jul.17	Control	**1833**	1

07.jul.17	Rubber snake	**2668**	2
09.jul.17	Control	**831**	2
20.jul.17	Garden hose	**944**	1
22.jul.17	Rubber snake	**1630**	1
10.aug.17	Control	**1480**	2
12.aug.17	Garden hose	**1396**	2
14.aug.17	Control	**1208**	1
18.aug.17	Garden hose	**1416**	2
27.aug.17	Garden hose	**1410**	2
01.sep.17	Control	**1225**	2
03.sep.17	Rubber snake	**968**	1
03.sep.17	Rubber snake	**1471**	2

Table 2: *Sample size and means of the time (in seconds) until nibble for each treatment in experiment 1. The much higher average time of the rubber snake treatment is largely due to an outlier.*

	N	**Mean (s)**	**Std. Deviation**
Rubber snake	4	1590.3	773.6
Garden hose	5	1327.4	216.2
Control	5	1315.4	370.6

Experiment 2 took place from 27.09.2017 to 30.10.2017 at an interval of 1 day between recording sessions. A single spot was chosen based on the previous criteria, about 5-6 meters from a nearby path. At this location, three treatments were laid on the ground in a horizontal line at a 1.5-meter distance each with 1/3 of a bread slice minced into smaller pieces (see figure 4). The treatments were exchanged to the other spots on the horizontal line for each recording session in order to avoid association with placement and treatment. This scene was recorded by a Kitvision EscapeHD5 [1] until all bait by each treatment appeared to be gone. For some of the recordings this did not happen with all the treatment bait and recording was stopped prematurely. In those cases, the data for that treatment was incorporated as if the birds who ate the other treatments eventually ate the bait for this treatment too. The camera was placed in a central position, approximately 2 meters away from each treatment spot. Additional pieces of bread were thrown during recording at each treatment to attract the attention of birds in cases where birds lingered in the area, sitting still or otherwise displaying intent to investigate bait or the treatment objects. In the recordings, a stat, gaze was measured at the point of the video where each species first looked at one of the treatments to ensure that they were interested in the bait and aware of the treatments present. Two stats were created from the time the gaze happened; The time from gaze happened until a nibble was taken by a treatment, henceforth known as Time Nibble, and another set of numbers from gaze until a bird had eaten all the bait beside a treatment, henceforth known as Time Gone. Two additional sets of Time Nibble and Time Gone were also calculated based on the species separately, calculating the time only from the gaze of that species. The density of all birds present per minute since the first gaze until the last bait was gone was also estimated.

For experiment 2, it was attempted to have an equal number of observations for each treatment, with 9 per position, 27 recordings in total, however it was not possible to achieve an even distribution of data for each bird species. This was due to the randomness of the birds that were present during that recording day and each species differing in willingness to approach each treatment. In addition, during the last days of recordings, the lake was starting to freeze over, lowering gulls' presence in the area, while the mallard duck was still present. In two of the early recordings, an "error" was made, and the rubber snake was removed prematurely during recording, falsely giving that treatment method a false result. These numbers were removed from the results, making the total observations of the rubber snake treatment have 2 less than the other treatments.

The time between Time Nibble and Time Gone in experiment 2 could be interpreted as the handling time, but in very few instances is this true. This was because the individuals that nibbled at a treatment was not always the same that finished eating it. There are some instances where the bait disappeared mere seconds after the nibble happened, which would roughly equate to the handling time, but could also be a result of multiple birds eating at a treatment simultaneously.

One common magpie (*Pica pica)* was present in recording of experiment 2, slightly influencing the average number for this specific day. The magpie did not take any food present, nor did it seem to react to the presence of the treatments. Its disinterest in the bait and the corresponding treatments made it unlikely to influence the competition of the other species.

Table 3: *The table shows the time it took for birds to nibble and finish the bait (in seconds) placed at a corresponding treatment as well as the average bird density during experiment 2.*

-	**Time Bait Nibble**	-	-	**Time Bait Gone**	-	-	**Bird Density**
Date	Rubber Snake	Garden Hose	Control	Rubber Snake	Garden hose	Control	Per minute
27.sep	199	153	189	206	164	194	6.5
28.sep	1020	112	45	1020	137	57	3.9
29.sep		923	42		993	213	3.3
30.sep	1080	27	328	1080	326	339	8.1
01.okt		86	21		1109	32	8.4
02.okt	254	120	17	256	203	45	8.6
03.okt	1003	19	90	1003	399	405	3.2
04.okt	98	53	1	403	129	67	3.1
05.okt	40	123	9	101	184	38	5.0
07.okt	691	340	125	958	958	326	5.4
09.okt	891	30	133	891	891	354	2.5
10.okt	663	10	86	698	239	202	1.8
11.okt	4	86	173	259	126	218	3.8
13.okt	39	48	13	75	536	25	2.8
14.okt	79	119	10	105	150	38	2.0
15.okt	2	895	595	895	895	749	3.9
20.okt	190	241	50	308	259	70	12.2
21.okt	2054	236	259	2054	487	452	2.1
22.okt	336	235	9	388	237	65	4.1
23.okt	21	112	5	188	129	70	15.5

24.okt	319	371	5	354	404	62	2.1
25.okt	70	11	155	125	64	185	1.3
26.okt	63	124	32	170	193	59	3.5
27.okt	1231	1126	813	1298	1169	852	4.5
28.okt	25	253	138	777	816	168	1.9
29.okt	36	90	21	62	115	45	4.0
30.okt	86	2	66	125	66	101	1.7

This data was used in two one-way anovas like before, with Time Nibble and Time Gone as dependent variables and treatment as the factor. These two anova's did not account for the species difference and treated their numbers as if there was only 1 species. As mentioned before, the treatment of rubber snake had 2 less observations (29th of September and 1st of October), making its sample size 25 instead of 27. The test for Time Nibble showed a significant effect of the treatment on the time before a bird would nibble on the bait (N = 78, df = 2, F = 4.5, P = 0.015, see table 4). The test for Time Gone showed similar results (N = 78, df = 2, F = 5.9, P = 0.004, see table 5).

Table 4: *Sample size and means for each treatment from Time nibble for both species.*

Treatment	**N**	**Mean (seconds)**	**Std. Deviation**
Rubber Snake	25	419.8	526.2
Garden Hose	27	220.7	293.0
Control	27	127.0	189.0

Table 5: *Sample size and means for each treatment from Time Gone for both species.*

Treatment	**N**	**Mean (seconds)**	**Std. Deviation**

Rubber Snake	25	552.0	497.4
Garden Hose	27	411.4	363.4
Control	27	201.2	214.0

An ancova was then done to compare the effect of the treatments when accounting for the density of both birds as a covariate, treatment as fixed factor and Time Nibble and Time Gone as dependent variables. The assumption was that the density influenced the willingness to attempt to get the bait, making them more likely to do so quicker and therefore lower the average time. The ancova still resulted in a significant effect, with very similar values to the previous analysis (Time Nibble: N = 79, df = 2, F =4.41, P = 0.016, Time Gone: N = 79, df = 2, F = 5.82, P = 0.004), which meant that the effect of the treatment was likely stronger than the influence of intra- and interspecific competition if both species were considered one.

Separate anova's and ancova's were then performed for each species individually in the same way as before. These operations had lower sample size than their combined stats because some recordings were dominated by common gulls and others by mallard ducks. In addition, it was not possible to guarantee that the bait by a treatment was nibbled and last taken (Gone) by the same species, yielding an unequal distribution of observations for each treatment.

Common Gull:

For the common gulls, the anova test for both Time Nibble (N = 36, df = 2, F = 4.0, P = 0.03) and Time Gone (N = 28, df = 2, F = 6.0, P = 0.007) show large differences between the treatments, generally spending longer to forage by the rubber snake (see table 6 and 7). It took almost 400 more seconds (6 minutes and 40 seconds) for Time Nibble and Time Gone to happen compared to the garden hoses averages.

The ancova accounting for total density yielded similar results as the anova for both birds, (Time Nibble: N = 36, df = 2, F = 4.0, P = 0.03, Time Gone: N = 28, df = 2, F = 7.3, P =

0.003), as well as the ancova accounting for the common gull density (Time Nibble: N = 36, df = 2, F = 4.1, P = 0.03, Time Gone: N = 28, df = 2, F = 6.2, P = 0.007).

Table 6: *Sample size and means for each treatment from Time Nibble for common gull.*

Treatment	N	Mean (seconds)	Std. Deviation
Rubber Snake	10	607.2	654.2
Garden Hose	13	224.6	313.0
Control	13	148.2	169.3

Table 7: *Sample size and means for each treatment from Time Gone for common gull.*

Treatment	N	Mean (seconds)	Std. Deviation
Rubber Snake	8	892.4	572.3
Garden Hose	11	498.0	326.5
Control	9	240.3	230.4

Mallard duck:

The anova results from comparing both species and the common gulls differed from the mallard ducks results, in which the anova test did not prove significance of the effect of the treatment on Time Nibble (N = 43, df = 2, F = 0.59, P = 0.56) nor Time Gone (N = 51, df = 2, F = 1.9, P = 0.16). In addition, there were smaller differences between the means of rubber snake and garden hose (see table 8 and 9).

Table 8: *Sample size and means for each treatment from Time Nibble for mallard duck.*

Treatment	N	Mean (seconds)	Std. Deviation
Rubber Snake	15	288.5	370.4
Garden Hose	14	263.6	376.8
Control	14	155.6	282.0

The ancova for mallard duck with total density as a covariate did not provide large enough differences to say the presence of other birds had a big impact, (Time Nibble: N = 43, df = 2, F = 0.60, P = 0.56, Time Gone: N = 51, df = 2, F = 1.9, P = 0.16) including in the ancova that only accounted for the density of mallards (Time Nibble: N = 43, df = 2, F = 0.60, P = 0.56, Time Gone: N = 51, df = 2, F = 1.9, P = 0.16).

Table 9: *Sample size and means for each treatment from Time Gone for mallard duck.*

Treatment	N	Mean (seconds)	Std. Deviation
Rubber Snake	17	351.6	364.5
Garden Hose	16	362.3	410.9
Control	18	157.1	256.4

Lastly, multiple anova's were performed with Time Nibble and Time Gone for both species as the dependent variable and total density as the factor to test if the average time was related to the current density of birds. Time Nibble Both: N = 78, df = 26, F = 1.7, P = 0.06 (see table 10). Time Gone Both: N = 78, df = 26, F = 2.6, P = 0.002 (see table 11).

Discussion:

The common gull responds more acutely to the presence of a snake than the presence of a garden hose, its reaction likely tied to its ability to recognize the features of the rubber snake. The mallard duck's ability is not as sensitive and reacts the same way to a rubber snake as they do with a garden hose, spending on average the same time before feeding by both treatments (see tables 8 and 9). The presence of other birds does not seem to alleviate their fear, and competition does not make either species attempt to feed next to a rubber snake or garden hose faster.

The common gulls and mallard ducks observed during the experiments were not captured and not marked. As such it was not possible to establish whether a bird that showed up one day was the same as the bird the day before. Ideally one should try to avoid having individuals influence the results by learning and adapting due to previous encounters. The results work under the assumption that the birds in the recordings are not the exact same ones returning every day because they recognized the observer that recorded and fed them food. There was no way of excluding the previous visitors and arrange a fresh roster of birds every day. However, if the time until feeding does not become gradually lower throughout the experiment, this could indicate that these birds are not adapting to the ongoing experiment over time, which could also mean that the visiting birds are different. In addition, it would be more ideal to only study the effects of the treatments on one species at a time, somehow excluding the other species or picking a study area where only one species dominates, which could also remove the potential influence of intraspecific competition.

The data gathered from the experiments only contribute to data portraying the behavior of common gulls and mallard ducks reacting to the visual stimuli of a potential predator. As such there is a focus on action and inaction by the respective species, offering only the density of birds present during recordings and time spent before accessing bait at each treatment. The experiments only handled the data of birds present in view of the camera, potentially missing out on other birds close by, flying above or avoiding the area due to perceived predator presence. Audible signs of distress and warnings may also contribute to predator evasive behavior, for example sentinels warning other birds in the flock that a potential danger is approaching and create a ruckus as a response. Other individuals will then be less likely to approach, or at least approach with more care. Such criteria could have been incorporated in the project as a covariant and to see if this also impacted the main aversion response. Communication and vocalization is important for detection and aversion and should be a part of the way anti predation effects are observed. If similar experiments are conducted, they should try to include the differences between the noises made with and without a "predator" present and how this effect other birds of the same and other species.

Another non-included factor that might influence the cautiousness of approaching treatments is movement. If the experiment was done with treatments that included some movement, the results could have been different, likely making the birds even more hesitant to approach and attempt to get their bait. This could either have been done by giving the treatments constant movement, or to simulate predators, by only moving when a bird was close to them, akin to the sit-and-wait strategies that many predators, like snakes, utilize. However, this could have shifted the focus of the use of the treatment on the movement itself, away from the differences of the treatments.

The common gulls nested during the summer, from May to late July, and during that time their behavior around the lake was significantly different compared to afterwards. The gulls showed higher aggressiveness towards people passing by the wet marsh area of the lake where the gulls nested, squawking loudly at and swooping downwards at by passers, attempting to scare them off and discourage them from approaching. This behavior seemed to cease into August, most likely because their juveniles were now large enough to fly and forage on their own, relieving their parents of responsibility and refocusing on their own survival. This difference is notable and may have resulted in fewer results for experiment 1, where only 14 out of 46 (10 of which were common gulls) recordings had any birds attempt to eat the bait. Experiment 2 on the other hand, had at least one species visiting every recording and took place from September to October, outside of the breeding and rearing period. However, the difference in bird engagement might also be a result of both the presence of an observer and the difference in food quality.

Experiment 1 had more instances of birds taking a nibble of the bait than cases of finishing the food present, leaving it there until the end of the recording. The wholesomeness and the rough edges of the slices of bread makes eating take longer than if minced into small pieces, forcing the bird to pick it apart, increasing handling time significantly. Sometimes the birds would pick out the soft insides of the slices, leaving the harder crust behind. The increased handling time forces the bird to focus its attention and energy on picking it apart, lowering its awareness and expending extra energy doing so. Most birds that are fed by people are likely more used to small pieces being thrown instead of entire slices, both because the person likely wants to distribute it more evenly and because it makes the activity last longer for them. Therefore, the characteristics of a whole bread slice should be more novel, making them less appealing than scattered crumbs, which are more recognizable. That is not to say that a bird does not recognize a slice as food, many seagulls will attempt to steal food right next to people or even out of their hands. Many birds are often scanning the ground for possible food, rummaging through grass and dirt with their beaks, and often scavenging in rural areas, finding food remains in refuse and garbage. This is likely one of the reasons that neophobia is less prominent in generalists, making them more adaptive in diverse ecosystems [25]. Displaying plasticity in behavior in changing environments and towards new objects and organisms allows them more flexibility should food sources be scarce or disappear.

The individuals of common gulls that were captured on video during experiment 2 were mostly juveniles (all recordings showed gray and brown feather coloration on gulls, indicating that they were not fully developed) that most likely were hatched during the summer of 2017. For the mallard ducks present in the recordings from experiment 2, the similarities between the juveniles and the adults were too strong to be indicative of their age. Many of the juveniles simply looked like medium sized female adults, and at the time of the recordings of experiment 2(September-October), the size of most juveniles was roughly the same as adults. Thus, one cannot assume that the mallard juveniles present acted entirely out of instinct, and that their evasive behavior could not be a result of observing older individuals and learning from their interaction. The common gull juveniles on the other hand were not accompanied by the older gulls and is assumed to never have interacted with a snake and never observed their parents or older gulls do the same. So, despite never encountering a snake, these birds are likely born with the ability to distinguish between different objects and identify historical predators. As the data from experiment 2 suggests, common gulls can differentiate between the treatments.

There is an argument to be made about the similarity of the garden hose and the rubber snake. As mentioned, the neophobic response to a novel object is generally stronger the less familiar an animal is with it [12]. The rubber snake is a very non-novel object in terms of likely evolutionary history, because it shares the features that birds likely identify with a real snake, i.e. scaling, coloration, head shape and gradual decrease in circumference along the rear end. The garden hose on the other hand, while an object a bird does not encounter every day, it does share a similar tubular appearance and coiled up shape with a real or fake snake. In this regard it may not be different enough to justify labeling it as a different stimulus for these experiments. For this reason, it may not be as viable as a novel object and for testing the neophobic differences between the use of rubber snake and garden hose. It does however serve as a rough estimate to whether the general shape of an object is enough for it to be considered a threat to a prey animal. It is not surprising that the control has lower means for the Nibble and Gone time compared to the means for rubber snake and garden hose, but it is interesting that some birds seem to hesitate less when trying to forage the bait next to the garden hose than the rubber snake. The results for experiment 1 and 2, (excluding the mallard duck when viewed separately) shows that these differences do seem to have a significant impact on the time before a bird would attempt to forage next to them, although the sample sizes are smaller for common gulls than for mallard ducks. It took a significant shorter time (on average 400 fewer seconds; see tables 6 and 7) for a common gull to nibble and finish the bait by the garden hose than the rubber snake, implying a stronger aversion towards the latter. This could mean that from the viewpoint of a bird, the appearance of the rubber snake is different enough to justify approaching them differently. In my view, a common gull’s ability to recognize a snake is more sophisticated than expected.

For the mallard duck however, my results do not justify the same conclusion, implying that the mallards are not as sensitive to the subtle differences between the rubber snake and the garden hose. This is contrary to what one should expect based on the large-scale distribution of mallard ducks in the Northern Hemisphere, where one expects the mallards to encounter snakes more often than a common gull would. However, the data show no significant difference for the comparison of the forage time between treatments for the mallards. The average differences between the Time Nibble and Time Gone for rubber snake and garden hose are less than 30 seconds (see tables 8 and 9) for the mallards in experiment 2. This implies that the mallard perceives them almost as the same treatment, showing no strong distinction between them. In fact, the mean for Time Gone was 30 seconds higher for garden hose than rubber snake, the opposite from Time Nibble (see table 9).

Competition can be impactful for the foraging for birds. With high density of birds, one or more individuals will likely try to rush for any food present, pushing and pecking at food or other birds, pursuing a high risk high reward mentality. Birds will often try to intimidate others by flapping their wings and aggressively charge towards them to secure a meal that they are watching over. This does not always mean that the bird who is reserving the meal is going to try to forage, but simply making sure that no others get it. In this project, many individuals would sit or stand close to the bait placed by one of the treatments, most likely waiting for the right moment to strike. In such a situation, the presence of many other birds should force the bird sitting at the bait to secure it or to let an interloper simply have it for themselves. The result from the ancova's done for experiment 2 with bird density as a covariate suggests that the presence of other birds did not heavily influence Time Nibble or Time Gone for both species. This likely means that the treatments used were a stronger influence on the foraging time than the abundance of other birds. The anovas comparing the Time Nibble and Time Gone and the density of birds did also not result in the expected negative linear relationship (i.e. more birds equal faster foraging) (see appendix, tables 10 and 11) that one would expect, further solidifying the thought that competition was not as impactful in this project.

The likely evolutionary explanation for the persistence of fear, aversion and sensitivity towards predator shaped objects (and the predators themselves) is that natural selection is not directly affecting these traits. If a trait is maladaptive, hindering fitness and lowering survival, it is likely to be selected against because its adaptation is no longer valid. Moving into a new environment or ecosystem, a species will start adapting to these new conditions, prioritizing traits that propagate their fitness. They do however carry the remnants of the past and depending on how long these traits remain irrelevant, they should eventually disappear or change into more relevant ones. But some traits, not directly maladaptive or too costly might stick around for extended time, making a difference in only specific situations. A bird has no way of knowing that a trait might potentially be useful and does not actively decide to keep them around. Instead, forces like natural and sexual selection act on visual phenotypic clues, reflecting their genetic makeup. Anti-predation behavior is easy to observe to other individuals of a species, but if an area does not have a high enough predation risk, this is no longer subject to selection. The predation sensitivity that the bird carries no longer has any major positive impact on fitness but is still active and can be observed in projects such as this. Predator aversion is powerful tool for survival but can be maladaptive if a bird is too sensitive towards everything it perceives. The birds studied in this project are likely less responsive to predators than other birds in other parts of the world and might be the case in Norway. The occasional occurrence of snakes could have a small impact on survival of birds in more southern parts of Norway but is unlikely to have a high impact on mortality rates of mallards and common gulls. Over time, one would expect these predator phobias to disappear, assuming most individuals of these species continue to live in environment without them. But, considering the tendency for animals to hang on to their primordial phobias (i.e. fear of spiders and snakes in humans), this might take quite some time.

In conclusion, a snake like object may induce predator aversion behavior in common gulls and mallard ducks, making them more hesitant to feed next to them. This effect can be observed by individuals with no prior personal predator interaction and among species that do not overlap with snakes, indicating that they used to be a part of a coevolutionary arms race, but no longer occupy the same areas of the world. Their sensitivity towards them persists and is likely a ghost of their evolution past. The effect of a rubber snake is likely stronger for common gulls than mallard ducks, as they seem to have a better ability to recognize specific traits of a snake. The density and the influence of competition of birds also does not seem to overrule the impact of predator presence. Predator aversion behavior is however more complicated, and a more comprehensive study is most likely needed. Possibly one that incorporates other aspects such as the audible cues, group interactions and movements of birds.

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Appendix:

Table 10: *Means and sample size for the anova between Time Nibble (both species) and bird density.*

Birds per min	N	Mean	Std. Deviation
1.3	3	78.7	72.4
1.7	3	51.3	43.9
1.8	3	253.0	357.1
1.9	3	138.7	114.0
2.0	3	69.3	55.1
2.1	3	849.7	1043.0
2.14	3	231.7	198.0
2.5	3	344.7	477.1
2.8	3	33.3	18.2
3.1	3	50.7	48.5
3.2	3	382.0	538.1
3.3	2	482.5	623.0
3.5	3	73.0	46.8
3.8	3	87.7	84.5
3.87	3	497.3	454.4
3.9	3	392.3	544.6
4.0	3	49.0	36.3
4.1	3	193.3	167.4
4.5	3	1056.7	217.5
5.0	3	57.3	58.9
5.4	3	385.3	285.7
6.5	3	180.3	24.2
8.1	3	478.3	542.3
8.4	2	53.5	46.0
8.6	3	130.3	118.9
12.2	3	160.3	98.9
15.5	3	46.0	57.7

Table 11: *Means and sample size for the anova between Time Gone (both species) and bird density.*

Birds per min	N	Mean	Std. Deviation
1.3	3	124.7	60.5
1.7	3	97.3	29.7
1.8	3	379.7	276.3
1.9	3	587.0	363.4
2.0	3	97.7	56.4
2.1	3	997.7	915.0
2.2	3	273.3	184.7
2.5	3	712.0	310.0
2.8	3	212.0	281.7
3.1	3	199.7	178.8
3.2	3	512.3	446.8
3.3	2	603.0	551.5
3.5	3	140.7	71.7
3.8	3	201.0	68.1
3.9	3	846.3	84.3
3.94	3	404.7	534.4
4.0	3	74.0	36.5
4.1	3	230.0	161.6
4.5	3	1106.3	229.5
5.0	3	107.7	73.2
5.4	3	747.3	364.9
6.5	3	188.0	21.6
8.1	3	581.7	431.6
8.4	2	570.5	761.6
8.6	3	168.0	109.8
12.2	3	212.3	125.7
15.5	3	129.0	59.0