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Incubating Upland Goose (*Chloephaga picta*) differential response to livestock, human, and predator nest disturbance

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ABSTRACT—The Upland Goose (*Chloephaga picta*) is a ground-nesting bird that has suffered a precipitous population decline in the last 60 years. We monitored Upland Goose nests with camera traps in Santa Cruz province, Argentina, to study nest disturbances that could reduce reproductive success. We studied female behavior following nest disturbance by predators, livestock, or humans and compared it with situations when females leaving the nests voluntarily. At least 34% of nests were depredated, 92% of them by culpeo (*Pseudalopex culpaeus*) and gray (*Pseudalopex griseus*) foxes; only 29% of the monitored nests were successful. Livestock sniffled, licked, and nuzzled the incubating female and the nest contents, and 2 nests were trampled. Off-bout duration was affected by the identity of the intruder. The lengths of predator and human off-bouts were similar and higher than those of foraging and livestock off-bouts. To boost reproductive success, we recommend livestock exclusions and predator control on nesting areas to discourage fox predation. Nests monitoring protocols should include as few and widely spaced visits as possible, restricted to a few people. Given the ecological similarities between the Upland Goose and congeners, including the critically endangered Ruddy-headed Goose (*Chloephaga rubidiceps*), we extend these recommendations to all *Chloephaga* spp. breeding areas. *Received 2 July 2017. Accepted 18 January 2018.*

Key words: Argentina, ground-nesting bird, incubating female, nest monitoring, off-bout, Patagonia, sheldgeese.

Respuesta diferencial del Cauquén Común (*Chloephaga picta*) a disturbios en los nidos causados por ganado, humanos y predadores

RESUMEN (Spanish)—El Cauquén Común es un ave que nidifica en el suelo que ha sufrido una notoria declinación poblacional en los últimos 60 años. Monitoreamos nidos de Cauquén Común utilizando cámaras trampa en Santa Cruz, Argentina, con el fin de estudiar disturbios en el nido que podrían provocar una reducción en el éxito reproductivo. Estudiamos el comportamiento de las hembras luego de disturbios causados por predadores, ganado o humanos, y lo comparamos con situaciones en las cuales las hembras se alejan de los nidos voluntariamente. Al menos el 34% de los nidos fueron depredados, 92% por zorros colorados (*Pseudalopex culpaeus*) y grises (*Pseudalopex griseus*), siendo exitosos solo un 29%. El ganado olfateó, lamió y hocicueó a la hembra mientras incubaba, y el contenido de los nidos. Dos nidos fueron pisoteados. Quien causó el disturbio (tipo de disturbio), pero no por cuánto tiempo lo generó, afectó la duración de la pausa de incubación. La duración de las causadas por predadores y por humanos fue similar y mayor que las pausas de alimentación y que las causadas por el ganado. Con el fin de aumentar el éxito reproductivo, recomendamos el control de predadores y excluir al ganado en las áreas de nidificación. Los protocolos de monitoreo de nidos deberían incluir pocas visitas, lo más espaciadas posibles, y restringidas a pocas personas. Debido a la similitud ecológica entre el Cauquén Común y sus congéneres, incluido el críticamente amenazado Cauquén Colorado (*Chloephaga rubidiceps*), extendemos estas recomendaciones a todas las áreas de nidificación de las especies del género *Chloephaga*.

Palabras clave: Argentina, aves que nidifican en el suelo, cauquenes, incubación, monitoreo de nidos, Patagonia, pausas de incubación.

Nest predation is the main cause of breeding failure in birds, yet few examples exist of comprehensive studies in the Neotropics using camera traps to assess the real impact (Menezes and Marini 2017). Ground-nesting species are more sensitive to terrestrial and avian predators and agricultural intensification (Bas et al. 2009, Beja et al. 2014). Upland Goose (*Chloephaga picta*) is a ground-nesting species that reproduces in Patagonian steppe and forest (Carboneras and Kirwan 2016). The main activity in the Patagonian steppe region is large-scale livestock production, principally sheep and to a lesser extent cattle (INTA 2015). In over-grazed areas, where vegetation is short, nests are more visible and vulnerable to predation (Erdos et al. 2011). Incubating Upland Goose females do not receive food from their mates (Summers 1983), and although they must regulate egg temperature, they also must leave the nest (off-bout) to forage. Thus, a trade-off exists between thermal needs of the developing embryos and the female's own energetic needs (Williams 1996). Moreover, because nest predators are the main cause of breeding failure (Menezes and Marini 2017), nests remain unprotected when females leave to forage, making them more susceptible to predation.

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Incubating individuals are frequently forced to leave the nest involuntarily. In such situations, they leave the nest abruptly and do not cover the eggs with down, as they usually do when leaving it to forage (Summers 1983). Eggs remain exposed and more conspicuous to opportunistic predators, but they also lose thermic isolation. Livestock disturbance of incubating females increases the risk of nest desertion (Shrubb 1990). Females risk their own safety by staying on the nest when a predator is nearby, but are forced to leave the nesting site when the predator approaches the nest (Montgomerie and Weatherhead 1988). In partial predations, when only some of the eggs are consumed and parents carry on with the nesting attempt, the remaining eggs are unattended until female returns to the nest. Moreover, scientists who study reproductive biology aspects have to periodically monitor nests, forcing the female to flee.

In parts of its distribution, the Upland Goose is sympatric with 2 other *Chloephaga* spp., the Ashy-headed Goose (*C. poliocephala*) and the Ruddy-headed Goose (*C. rubidiceps*). Sixty years ago, all 3 species were abundant in Patagonia where they breed and in southern Buenos Aires province where they overwinter (Hudson 1920, Ripley 1950). In 1931, sheldgeese were declared "agricultural pests" because they were considered harmful to agriculture (Pergolani de Costa 1955). The government promoted hunting and massive egg destruction at breeding grounds and the use of aircraft to scare them away from crops at wintering grounds (Weller 1975, Blanco et al. 2003). Nest depredation by introduced carnivores is currently one of the major threats (Cossa et al. 2017). Furthermore, sheldgeese breeding areas are grazed by sheep and cows, which could deplete tall grasses suitable for nesting, lead to the loss of nests due to trampling, and disturb reproductive pairs. As a result, the 3 *Chloephaga* species are classified as endangered in Argentina: the Ruddy-headed Goose is critically endangered, the Ashy-headed Goose is threatened and the Upland Goose is vulnerable (Secretaría de Ambiente y Desarrollo Sustentable and Aves Argentinas [SAyDS] 2008). Despite regulations that ban the hunting, capture, and trade of *Chloephaga* species in Argentina (Resolution No. 551/2011, SAyDS), no management actions have been implemented to secure and improve the reproductive success and ensure the conservation of these species (Cossa et al. 2017).

We studied nest disturbances that could reduce the reproductive success of the most abundant Upland Goose. We studied female behavior following disturbance by livestock, predators, or humans and compared it with situations when females leave the nests voluntarily to forage. We also analyzed the effect of disturbance duration on female return time. In addition, we explored incubating females' reaction to human disturbance. Finally, we recommend management actions and nest monitoring protocols for areas where sheldgeese reproduce.

Methods

Study site

The study was conducted from early November to late December 2015 (382 camera-days monitoring nests) in private lands located in northwestern Santa Cruz Province, Argentina (46°38′S–47°15′S, 71°50′W–70°25′W; Fig. 1), near the recently created Patagonia National Park. The predominant habitat type is Patagonian steppe, dominated by bushy vegetation associated with grasses and low herbaceous dicotyledons. Lowland areas are dominated by grasses (Cabrera 1971). The local assemblage of mammalian predators is composed of gray fox (*Pseudalopex griseus*) and culpeo fox (*Pseudalopex culpaeus*); Pampas cat (*Leopardus colocolo*); Patagonian hog-nosed skunk (*Conepatus humboldtii*); and 2 species of mustelids, lesser grison (*Galictis cuja*) and the invasive American mink (*Neovison vison*). Principal avian predators are Kelp Gull (*Larus dominicanus*), Southern Caracara (*Caracara plancus*), and Chimango Caracara (*Milvago chimango*). Livestock varies among properties and includes sheep, cows, and horses. The native wild camelid, guanaco (*Lama guanicoe*), is also present.

Nest monitoring

The Upland Goose builds its nests on the ground close to water (generally $<$500 m) along river valleys, ponds, and the seacoast (Summers 1983). Because territories are defended by the male while the female incubates (Summers 1983), we searched for nests by focusing on male activity

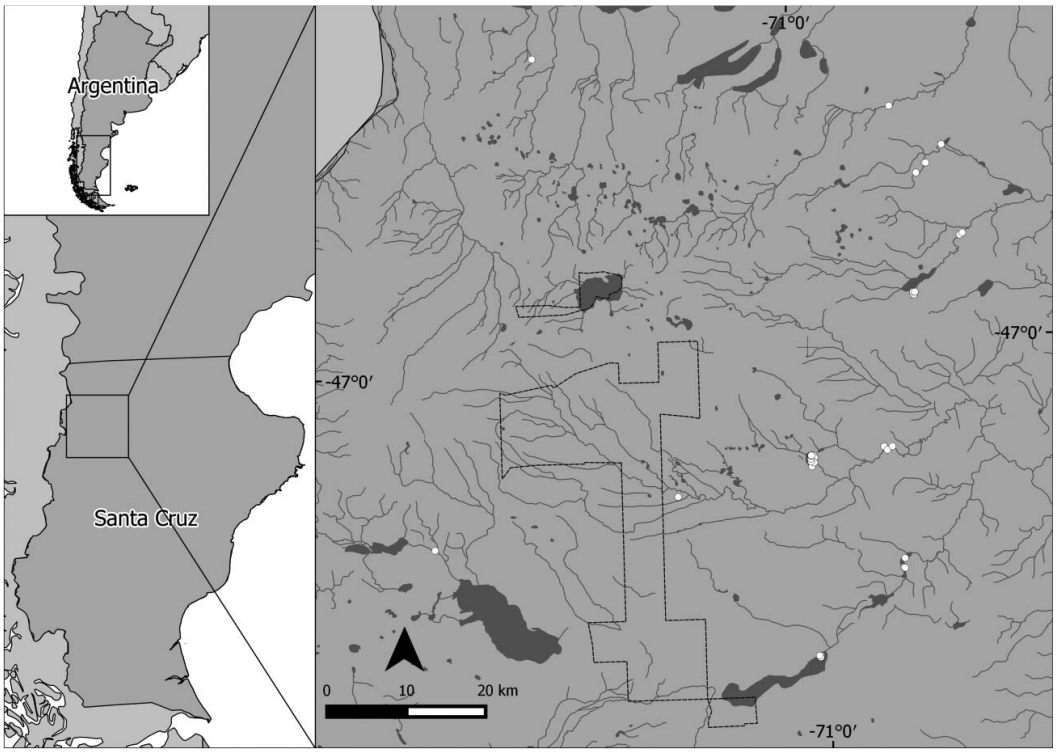

Figure 1. Upland Goose study area in Argentina. White dots correspond to Upland Goose's monitored nests, lines represent water courses, dark gray areas represent lakes and lagoons, and dashed lines represents the boundaries of Patagonia National Park.

and inspecting potential nesting sites. Nests were found at different stages (laying and early incubation), and the monitoring began at the time we found each nest. We monitored 35 Upland Goose nests using camera traps until the chicks hatched or the nest was depredated, abandoned, or trampled (382 nest days, range 1–36 d per nest). When possible, we determined predator species. Cameras were tied to a 40 cm stake 5 m away from the nest and programmed to take a picture (Bushnell HD Essential and Reconix PC800 models) or take a picture and a 10 s video (Bushnell HD max) when detecting movement. The interval between detections was set to 10 s and the sensor level to automatic. The nests were revisited every 7 d to monitor nest content and to check the camera battery and memory.

Data analysis

We scored pictures and videos to record the time (s) the female spent away from the nest. We classified these off-bouts as "foraging off-bouts" (the female covered the eggs with down and left the nest, or the female left the nest for no apparent reason), "livestock off-bouts" (the female left the nest due to livestock approaching), "predator off-bouts" (the female left the nest due to predator approaching or depredation), or "human off-bouts" (the female left the nest due to a human approaching). We also scored "disturbance duration" as the time that the cause of the disturbance (livestock, human, or predators) remained <5 m from the nest.

We constructed a generalized linear mixed model (GLMM) with gamma error distribution, log link function (Zuur et al. 2009), and nest/female as the random factor to test the effect of off-bout type (factor predictor variable with foraging, livestock, predator, and human off-bouts as levels) and disturbance duration (numeric predictor variable) on off-bouts duration (numeric response variable). We employed a backward selection

Table 1. Estimate (SE), *t*-test values and significance (*P*) of off-bout type predictor variable for off-bout duration. Disturbance duration was a nonsignificant predictor variable and was excluded from the simplified model. * Indicates significant differences ($P < 0.05$).

	Estimate (SE)	*t*	*P*
Intercept	7.63 (0.21)	36.28	< 0.001*
Off-bout type (foraging off-bouts)	0.25 (0.19)	1.31	0.19
Off-bout type (predator off-bouts)	1.14 (0.35)	3.24	0.001*
Off-bout type (human off-bouts)	1.19 (0.22)	5.5	< 0.001*

procedure, removing nonsignificant terms from the model one by one, in decreasing order of probability (Zuur et al. 2009). The significance of fixed effects was tested using analysis of deviance tests (command *anova*; Zuur et al. 2009). We only included nests/females in which the cameras could record at least 2 off-bouts. The levels of the factor predictor variable were compared using Tukey contrasts. Statistical analyses were carried out using R software 3.3.1 (R Core Team 2016). We used *lme4* 1.1-12 (Bates et al. 2015) and *multcomp* (Hothom et al. 2008) R packages. All tests were 2-tailed, and values are reported as means (standard error), and differences were considered significant at $P < 0.05$.

We also estimated the daily nest survival rate (DSR) with RMark 2.2.2 (Laake 2013) R package. We assumed a constant DSR and calculated the survival probability for the laying period (6 d), the incubation period (30 d), and for the entire nesting period (36 d; Summers 1983).

Results

Of the 35 nests monitored, only 10 hatched at least one egg, 12 were completely depredated, 1 was lost due to trampling, 1 was abandoned (presumably due to territory competition with another Upland Goose couple), and 11 failed due to undetermined reasons. DSR was 0.94 (0.01), and survival was 0.69 for the laying period, 0.16 for the incubation period, and 0.11 for the entire nesting period.

Females left the nest when predators approached. Of the 12 completely depredated nests, 11 were attributed to culpeo and gray foxes and 1 to Kelp Gull. Five nests were partially depredated: 3 by culpeo foxes, 1 by domestic dog, and 1 by Kelp Gull. All except 1 fox predation occurred at night between 2000 and 0400 h GMT-3. One culpeo fox, the domestic dog, and Kelp Gulls depredated during daytime. We recorded the duration of 4 predator off-bouts (mean 165.00 [SE 72.36] min): 3 by culpeo foxes, and 1 by a domestic dog.

Livestock sometimes ignored nests, but at other times they were curious about the incubating females. We documented livestock sniffing, licking, and nuzzling the incubating female and the nest content. Females' responses to livestock varied from leaving the nest when livestock approached the nest to defending the nest by pecking or staying in the nest, even while livestock were nuzzling. In 5 of the 35 recorded nests, females were forced by livestock to leave the nest at least once. One female left the nest due to livestock stalking 8 times in 21 d. Two disturbances caused by horses occurred at night. One nest was lost due to trampling by cattle and another nest was first trampled by sheep and later depredated by a fox. We recorded the duration of 11 livestock off-bouts (mean: 28.63 [SE 6.48] min), 6 due to cattle, 4 due to horses, and 1 due to sheep (Supplemental Video S1).

As researchers/humans approached to monitor nests and camera traps, the incubating females flushed from the nest. Flushing distance varied heavily between females and day of monitoring (<1–10 m). We recorded the duration of 33 human off-bouts (104.73 [SE 10.18] min).

We registered the duration of 224 foraging off-bouts (40.56 [SE 2.27] min). These off-bouts always occurred during daytime, from early morning with the first light of the day to late afternoon before dark. Neither female nor male were filmed near (~5 m) the nest while foraging.

Disturbance duration did not affect off-bout duration ($\chi^2_1 = 0.11$, $P = 0.75$). Only off-bout type affected off-bout duration and was included in the simplified model $\chi^2_3 = 80.33$, $P < 0.001$; Table 1). The identity of nests/females (random factor)

Table 2. Tukey contrasts between off-bout types for the response variable off-bout duration in nesting Upland Goose. * Indicates significant differences ($P < 0.05$).

	Estimate (SE)	*z*	*P*
Predator off-bouts vs. foraging off-bouts	0.9 (0.3)	3	0.01*
Livestock off-bouts vs. foraging off-bouts	0.25 (0.19)	−1.31	0.53
Human off-bouts vs. foraging off-bouts	0.94 (0.11)	8.24	<0.001*
Livestock off-bouts vs. predator off-bouts	1.14 (0.35)	3.24	0.006*
Human off-bouts vs. predator off-bouts	0.04 (0.32)	0.14	1
Human off-bouts vs. livestock off-bouts	1.19 (0.22)	5.5	<0.001*

accounted for 19% of the total variance. The duration of predator off-bouts and human off-bouts was higher than the duration of foraging off-bouts and livestock off-bouts (Table 2, Fig. 2). No difference was found between predator off-bouts and human off-bouts or between foraging off-bouts and livestock off-bouts (Table 2, Fig. 2).

Discussion

We used camera traps to assess off-bout duration of incubating Upland Goose females, comparing the duration of foraging off-bouts and disturbance off-bouts caused by livestock, predators, and humans. This methodology allowed us to monitor several Upland Goose nests simultaneously and continuously and is less invasive than other methods. The magnitude of the period during which the nest was unattended by female could be considered an indirect estimate of the intensity of nest disturbances by livestock, predators, and humans. Predator and human off-bouts were longer than foraging and livestock off-bouts, indicating that Upland Goose considers predators and humans more dangerous than livestock.

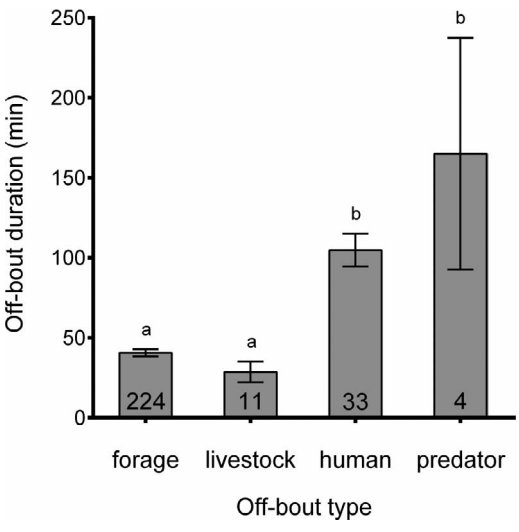

Figure 2. Upland Goose off-bout duration according to off-bout type. Sample sizes are given inside the bars. Different letters indicate significant differences ($P < 0.05$). Monitored nests/females = 22.

Our results show that nest depredation by fox is the main cause of nest failure in the Upland Goose inhabiting the Patagonian steppe. Culpeo and gray foxes were the main nest predators, with less than a third of the monitored nests being successful. This reproductive success is lower than reported for Navarino Island (36.7%, Ibarra et al. 2010) and for the Malvinas/Falkland Islands subspecies (73%, Summers 1983; 75%, Quillfeldt et al. 2005), although the number of possible predators is lower in those 2 areas. On Navarino Island, the American mink and feral cats and dogs are the only terrestrial predators (Rozzi and Sherriffs 2003), and in Malvinas/Falkland Islands, the gray fox is only present in restricted areas (Poncet et al. 2011).

Cattle, horses, and sheep disturbed incubating females, forcing them to leave nests involuntarily. Nests left uncovered and without female protection are more susceptible to predation, exemplified by one of the trampled nests, which was then depredated by a fox before the female returned to the nest, causing a livestock–predator combined effect. These involuntary off-bouts could also lead to excess cooling (or heating) of the eggs, which could extend the incubation period or result in embryo death. In addition, livestock could increase the risk of nest desertion (Shrubb 1990, Temple et al. 1999). However, the time elapsed until the female returned to the nest following disturbance by livestock is similar to that recorded for foraging

off-bouts and is shorter than predator and human off-bout duration. Some of the disturbance occurred at night, whereas foraging off-bouts were always during daytime. Possibly, female geese do not perceive livestock as a putative predator and thus return to the nest sooner. Although livestock are occasional egg consumers (Nack and Ribic 2005), they directly influence nest losses by trampling (Jensen et. al 1990). In our study, at least 2 nests were trampled, 1 by cattle and 1 by sheep.

In agreement with previous studies (Frid and Dill 2002, Beale and Monagham 2004), the goose response to human-induced disturbance was similar to the response to predator disturbance. The return time after a human disturbance is similar to that following a predator disturbance and is longer than livestock or foraging off-bouts.

Our results indicate that incubating females do not sense disturbance duration, but rather off-bout type determinates its duration, which also suggests that incubating females flee instead of remaining near the nest waiting for the disturbance to clear/pass. Field observations during nest visits (while setting camera traps) suggest that during human-predator off-bouts, the female joins its mate to possibly forage together.

We present novel information about breeding behavior for sheldgeese conservation. Our results regarding the impact of humans and livestock and the importance of predator control/exclusion should be considered when planning management actions at reproductive areas. Future studies must assess whether the impact of these type of disturbances (that drive different responses in the incubating female) are related to differential reproductive success. Because we were able to document direct negative effects by livestock on nests by trampling, however, our recommendation is to limit livestock densities or, if possible, to exclude them altogether during the sheldgeese breeding season to avoid disturbance. In addition, temporal or permanent carnivore exclusion would boost sheldgeese reproduction. Domestic dogs depredate nests and thus should be kept away from reproductive areas. Researcher disturbance sometimes affects nesting success and behavior (Götmark 1992), as demonstrated by our observations. Considering the potential impacts caused by scientists while female birds are incubating, we recommend they control potential predators they encounter during the nest visits. In addition, researchers should plan ahead to limit nest visits when developing the study. In addition, we advise restricting access to reproductive sites within protected areas and inform landowners to avoid Upland Goose nests to prevent incubating females from leaving their nests.

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