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Influence of egg oiling on colony presence of ring-billed gulls

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Abstract: Egg oiling is a form of management in which bird eggs are coated with mineral or corn oil, preventing gas exchange through the shell and killing embryos. Unlike other nest-disturbance techniques, egg oiling reportedly precludes colony abandonment and, thus, can be advantageous when managers wish to limit dispersal within the breeding season to other locations while stabilizing the population or reducing productivity. However, unintended, indirect effects of egg oiling are not well-characterized. We evaluated the influence of egg oiling on ring-billed gulls (*Larus delawarensis*) within the Lake Champlain basin, Vermont, during the nesting season to determine whether egg oiling affected colony presence of adults. We radio-marked 58 ring-billed gulls captured on Young Island during 2008 to 2009 and treated all ring-billed gull nests in the colony with egg oiling except for 50% of the nests of radio-marked gulls (control group). Using a radio receiver with automated data logger, we documented the presence of ring-billed gulls at the colony throughout the breeding season. We examined effects of treatment (nests oiled or control), sex, reproductive period (pre- and post-hatch), year, and interactive effects on colony presence (i.e., the proportion of nights ring-billed gulls spent at Young Island). Although we found no effect of treatment, sex, or interactive effects on colony presence, colony presence was 87% greater in the pre-hatch period, presumably due to behavioral mechanisms related to incubation or foraging. Overall colony presence was 118% greater in 2009 than in 2008, potentially a consequence of increased colony disturbance in 2008. We suggest that egg oiling does not influence colony presence of ring-billed gulls within the breeding season.

Key words: dispersal, egg oiling, human–wildlife conflicts, Lake Champlain, *Larus delawarensis*, nesting colony, ring-billed gull, Vermont, wildlife damage management

Potential negative effects of colonial-nesting waterbirds on sensitive plant communities are well-established (Hogg and Morton 1983, Daniel 1989, Lemmon et al. 1994, Bedard et al. 1995, Hebert et al. 2005). Ring-billed gulls (*Larus delawarensis*), double-crested cormorants (*Phalacrocorax auritus*), and other waterbirds regularly transfer and concentrate nutrients in the form of feces, bird carcasses, and fish carcasses from water to land, thereby altering soil chemistry, arthropod communities, and plant community richness and structure (Vidal et al. 1998, Ellis 2005, Ellis et al. 2006). Adverse consequences of this type of nutrient transfer to plant communities include loss of plant species diversity, accelerating plant species turnover, and facilitating success of invasive species (Vidal et al. 1998, Ellis 2005, Padrón et al. 2010).

Like other large lakes in the midwestern and northeastern United States, plant communities on Lake Champlain islands have been affected by increasing populations of waterbirds in recent years (Daniel 1989; J. Gobeille, unpublished data). In particular, double-crested cormorants and ring-billed gulls have adversely impacted plant communities on Young Island (Daniel 1989, Strickland et al. 2011). Once forested, Young Island's vegetation presently consists of invasive plant species, including bull thistle (*Cirsium vulgare*) and stinging nettle (*Urtica dioica*). Double-crested cormorants on Young

Island have been managed by the Vermont Fish and Wildlife Department (VFWD) and USDA Wildlife Services (WS) since 1999, with the goal of restoring native island vegetation (Garland et al. 1998). Management efforts have succeeded in eliminating nesting by double-crested cormorants (Strickland et al. 2011). However, as the nesting colony of cormorants on Young Island decreased, numbers of nesting ring-billed gulls increased substantially (J. Gobeille, Vermont Fish and Wildlife Department, unpublished data). To restore vegetation on Young Island, VFWD determined that in addition to reducing nesting by double-crested cormorants, the number of nesting ring-billed gulls should be reduced (Garland et al. 1998). Consequently, the breeding colony of ring-billed gulls on Young Island has been managed by VFWD and WS since 2005. Management has consisted primarily of egg oiling (Christens and Blokpoel 1991) to reduce the size of the colony, although some experimental culling of adults also has been conducted (see below). However, the unintended, indirect effects of egg oiling (e.g., "pushing" birds to other locations where conflicts could occur; see Belant 1997) are largely unexplored within the breeding season.

Egg oiling is a form of management in which eggs are coated with mineral or corn oil, usually by backpack sprayer, during the early part of the incubation period. Coating eggs with oil prevents gas exchange through the shell, usually killing embryos within 1 to 2 days (Baker et al. 1993, Pochop et al. 1998 a, b). Egg oiling has been used to reduce recruitment of ring-billed gulls (Blokpoel and Hamilton 1989, Morris and Siderius 1990, Christens and Blokpoel 1991, Pochop et al. 1998b), double-crested cormorants (Gross 1951, Bedard et al. 1995, Shonk et al. 2004, Ridgway et al. 2012), herring gulls (*L. argentatus*; Gross 1951, Christens and Blokpoel 1991, Blackwell et al. 2000), Canada geese (*Branta canadensis*; Christens et al. 1995, Cummings et al. 1997), and mute swans (*Cygnus olor*; Watola et al. 2003). Birds incubating oiled eggs often continue to incubate until or even after the estimated hatching date (Blokpoel and Hamilton 1989, Christens and Blokpoel 1991, Bedard et al. 1995, Taylor and Fraser 2012). Thus, unlike other nest-disturbance techniques, such as egg removal or nest removal and destruction (Ickes et al. 1998), egg oiling may prevent colony abandonment.

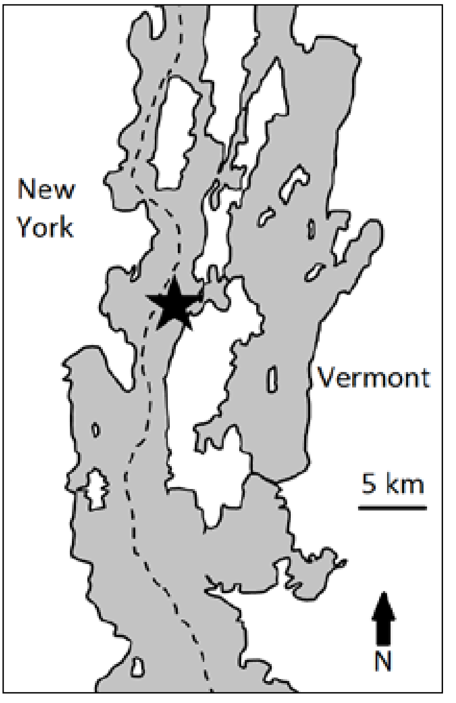

Figure 1. Location of Young Island (star) within the northern portion of Lake Champlain.

Despite its apparent advantages, it is unclear how egg oiling influences behavior of incubating birds (Morris and Siderius 1990, Taylor and Fraser 2012), or how potential behavioral changes might affect management goals. For example, studies of Canada geese (Christens et al. 1995) and herring gulls (Blackwell et al. 2000) indicated that oiled eggs were more likely to be abandoned or preyed on before estimated hatch date than eggs not oiled. Thus, egg oiling might cause some birds to abandon colonies and relocate elsewhere during the breeding season (Christens et al. 1995). Colony abandonment before estimated hatch date could lead to re-nesting by some species, thereby counteracting management goals aimed at halting growth of or reducing sizes of overabundant populations. Even in situations where managed populations do not re-nest following failed breeding attempts, it is often desirable during management to limit dispersal to other locations, especially when negative impacts to natural resources or property are of concern (Strickland et al. 2011).

A recent study of double-crested cormorants nesting on islands in Lake Champlain indicated that egg oiling reduced nesting-colony fidelity between years, but primarily when disturbance from egg oiling increased predation of eggs (Duerr et al. 2007). However, few data are available regarding the indirect effects of egg oiling on colonial waterbirds within a breeding season (but see Taylor and Fraser 2012). Such information would be beneficial because birds dispersed from one location potentially can cause conflicts in other locations (Belant 1997). In this study, we used radio telemetry to evaluate the influence of egg oiling on colony presence of ring-billed gulls on Lake Champlain within the breeding season.

Figure 2. Early evening at Young Island, Vermont, in 2009. More than 8,000 ring-billed gull nests were located on the 2.5-ha island in both 2008 and 2009.

Study area

Young Island (44° 44′ 24″ N, 73° 20′ 44″ W) is a 2.5-ha island located in Vermont waters of Lake Champlain, 1 km west of Grand Isle (Figure 1). Young Island is owned and managed by the state of Vermont. Daniel (1989) and Garland et al. (1998) discuss the history of land cover changes at Young Island. From 2004 to 2009, the annual number of ring-billed gull nests on Young Island ranged from 8,216 to 10,177 with a mean of 8,818 (F. Pogmore, Wildlife Services, unpublished data; Figure 2).

Methods

We captured and radio-marked ring-billed gulls on April 24, 2008, and April 28, 2009. Using dip nets, we captured incubating individuals away from nests near the center of the colony at night (Bub 1991). We fitted gulls with 12-g backpack-style VHF radio transmitters (Model AVB152; Sirtrack Ltd., North Liberty, Ia.) using Teflon ribbon (King et al. 2000). We determined sex using bill measurements (Ryder 1978) and attached standard metal leg bands before releasing individuals on-site. During each year, radio-marked gulls were separated randomly and equally into treatment and control groups. Following release, we located all telemetered birds at their nests and marked nests using numbered wooden stakes.

During each year, we oiled all eggs in every ring-billed gull nest on Young Island 2 to 3 times, except for those in the control group. During oiling operations, we flushed birds from nests and used backpack sprayers to apply a coating of corn oil to the eggs (see Garland et al. 1998 and Duerr 2007 for a more detailed description of egg oiling procedures). Incubating gulls in control groups also were flushed from nests, but eggs were not oiled. In 2008, we oiled eggs in 8,048 nests on May 1 and 8,558 nests on May 20. In 2009, we oiled eggs in 7,798 nests on May 4, 8,216 on May 19, and 4,457 on June 8. In both years, we oiled all nests in the treatment groups during each oiling event, but not nests in the control group.

Other management actions on Young Island that may have disturbed incubating ring-billed gulls included culling of adult ring-billed gulls and double-crested cormorants. On June 9 and 10, 2009, we culled 356 and 54 ring-billed gulls, respectively, with noise-suppressed rifles. No gulls were shot on Young Island in 2008. Radio-marked gulls were visually identified (transmitters were bright orange), and, thus, spared from shooting. In 2008 on 8 days between May 5 and September 22, 96 double-crested cormorants were culled with noise-suppressed rifles. On 17 days between May 13 and September 12, 2009, 276 double-crested cormorants were similarly culled. For both ring-billed gulls and double-crested cormorants, all egg oiling and culling was conducted by WS or VFWD personnel as part of management plans for Young Island under a Migratory Bird Depredation Permit (Garland et al. 1998; see also Strickland et al. 2011).

We used an ATS R4500S radio receiver placed in the center of Young Island and equipped with an ATS R2100 automated data logger (Advanced Telemetry Systems Inc., Isanti, Minn.) and omni-directional antenna to document presence of radio-marked ring-billed gulls on the island. We programmed the receiver to acquire radio signals from all gull transmitters within range (≤1.2 km) every 20 minutes from the time of transmitter attachment until the end of the post-hatch period (see below). We did not observe other potential nesting or nocturnal roosting locations for ring-billed gulls within range of the receiver.

Table 1. Mean proportion of nights spent at the nesting colony by radio-tagged ring-billed gulls (*Larus delawarensis*) in response to egg oiling, Young Island, Lake Champlain, Vermont, 2008–2009.

Year	Treatment	Sex	N	Pre-hatching period[1]		Post-hatching period[2]	
				$\bar{x}$	SE	$\bar{x}$	SE
2008	Control	Female	5	0.42	0.14	0.23	0.07
		Male	9	0.59	0.11	0.25	0.06
	Oiled	Female	6	0.37	0.16	0.15	0.06
		Male	8	0.47	0.14	0.13	0.03
2009	Control	Female	5	0.90	0.05	0.40	0.10
		Male	9	0.86	0.10	0.49	0.11
	Oiled	Female	7	0.99	0.01	0.62	0.05
		Male	8	0.83	0.09	0.62	0.11

[1] April 24 to May 18, 2008; April 28 to May 22, 2009.
[2] May 19 to June 27, 2008; May 23 to July 1, 2009.

Following Strickland et al. (2011), we used telemetry data to determine the number of nights each radio-marked gull spent at Young Island. If a radio-marked gull was recorded ≥2 times between midnight and 0500 hours in a given night, we assumed that the individual roosted at Young Island that night (Anderson et al. 2004). We calculated the proportion of nights each radio-marked gull spent at Young Island as our measure of colony presence during 2 periods (i.e., pre-hatch and post-hatch) each year. We assumed that the gulls were captured at the onset of incubation and defined the pre-hatch period to conclude 25 days after onset of nesting to correspond with mean incubation period (Ryder 1993). The pre-hatch period occurred from April 24, 2008, to May 18, 2008, and from April 28, 2009, to May 22, 2009. Data collection did not commence until the date of first treatment. As such, we excluded any days between the time individuals were radio-marked and the first date of treatment when calculating the proportion of nights spent on Young Island. The post-hatch period concluded 40 days after the pre-hatch period to correspond with the mean number of days until fledging and when adults leave colony sites (Ryder 1993). The post-hatch period occurred from May 19, 2008, to June 27, 2008, and from May 23, 2009, to July 1, 2009.

We performed all analyses in program R 2.12.1 (R Development Core Team 2010), using $\alpha = 0.05$. We used the glm function in the stats package of R 2.12.1 to fit generalized linear models. We evaluated treatment, sex, year, and period as main effects; and treatment and sex, sex and period, and treatment and period as interactive effects on colony presence. We included sex as a main effect because male and female ring-billed gulls might differ in parental investment (Dulude et al. 1987). Based on previous research (Belant et al. 1993, Ryder 1993, Blackwell et al. 2000), we expected colony presence to be lower for gulls on treated nests and lower for all gulls during the post-hatch period.

Results

We captured and radio-marked 28 and 30 ring-billed gulls in 2008 and 2009, respectively. In 2008, 14 gulls (5 females, 9 males) were from control nests and 14 (6 females, 8 males) were from treatment nests (i.e., oiled; Table 1). In 2009, 15 gulls (5 females, 10 males) were from control nests and 15 (7 females, 8 males) were from treatment nests. We excluded 1 male from analyses (control group in 2009) that had no associated data, likely due to transmitter failure. We found no effect of treatment ($z_{1,106}$ = -0.16; $P = 0.87$), sex ($z_{1,106}$ = 0.18; $P = 0.85$), or interactive effects of treatment and sex ($z_{1,106}$ = -0.53; $P = 0.60$), sex and period ($z_{1,106}$ = 0.05; $P = 0.96$), and treatment and period ($z_{1,106}$ = 0.39; $P = 0.70$) on colony presence following egg oiling. However, we found an effect of period ($z_{1,106}$ = -2.13; $P = 0.03$) and year ($z_{1,106}$ = 4.09; $P < 0.001$). Irrespective of sex, treatment, or year, colony presence was 87% higher in the pre-hatch period ($n = 57$, $\bar{x} = 0.69$, SD = 0.36) compared to the post-hatch period ($n = 57$, $\bar{x} = 0.37$, SD = 0.28). Irrespective of sex, treatment, or period, colony presence was 118% higher in 2009 (n = 58, $\bar{x} = 0.72$, SD = 0.30) than in 2008 ($n = 56$, $\bar{x}$ = 0.33, SD = 0.31).

Discussion

We found no evidence that egg oiling influenced colony presence of ring-billed gulls within the breeding season. Nevertheless, human disturbance in breeding colonies can reduce nesting success of gulls (Gillett et al. 1975, Robert and Ralph 1975) and other waterbirds (e.g., brown pelicans [*Pelicanus occidentalis*; Anderson 1988] and black-crowned night-herons [*Nycticorax nycticorax*; Fernández-Juricic et al. 2007]). Ickes et al. (1998) reported that nest destruction or egg removal in recently established ring-billed gull colonies can cause colony abandonment; however, Blokpoel and Tessier (1992) found that ring-billed gulls did not abandon an established colony when their eggs were destroyed or oiled. Also, ring-billed gulls exhibit strong nest-site tenacity during disturbance when their nests are not destroyed (Southern 1977, Southern and Southern 1985, Christens and Blokpoel 1991). During both years of our study, we observed no clear change in colony presence immediately following egg oiling and also found more ring-billed gull nests 15 to 19 days past the first application of oil than during the initial oiling effort. Ring-billed gulls may recognize egg oiling as a disturbance less severe than nest destruction or egg removal.

In contrast to this study, Christens et al. (1995) and Blackwell et al. (2000) observed greater loss of oiled nests compared to control nests for Canada geese and herring gulls, respectively, suggesting reduced fidelity of birds at oiled nests (see Blokpoel and Hamilton 1989, Christens and Blokpoel 1991). That we observed high fidelity within the breeding season may in part be a consequence of varying levels of predation (which can lead to nest abandonment; Duerr et al. 2007) among study sites. Christens et al. (1995) and Blackwell et al. (2000) studied mainland colonies accessible to mammalian predators. Although we did not monitor nest predation at Young Island, the number of potential predators was likely less than that studied by Christens et al. (1995) and Blackwell et al. (2000) because of few mammal predators at Young Island. The relative lack of predators at Young Island may have prompted some gulls to roost on Young Island at night even when not attending the nest. Also, if predators are more likely to prey on oiled eggs than non-oiled eggs (Blackwell et al. 2000), the likely difference in predation pressure between mainland and island colonies might have contributed to the lack of treatment effect observed in our study.

We observed lower colony presence in 2008 than 2009. Although the reason for this difference is unclear, in 2008 we captured gulls at night with relatively high visibility, during which most of the colony moved to the water surrounding Young Island while we were present. In 2009, the night of capture was much darker, resulting in less colony disturbance. Thus, lower colony presence in 2008 could have been due to greater disturbance during capture and banding that year. Further, we visited the colony to capture and band gulls 4 days later in 2009 (April 28) than in 2008 (April 24). If we assume the nesting cycle began on the same date in 2008 and 2009, our disturbance in the colony 4 days later in the nesting cycle also may have influenced the increased presence observed in 2009. Based on the expected benefit hypothesis in which parental investment is adjusted to account for current clutch size and time invested in incubation (Carlisle 1982, Armstrong and Robertson 1988, Pöysä et al. 1997, Ackerman and Eadie 2003, Bourgeon et al. 2006), we would expect gulls with greater energy invested in reproduction to be less likely to abandon nests.

Our observation of lower colony presence during the post-hatch period than the pre-hatch period was unsurprising. Several studies have demonstrated prolonged incubation by gulls following egg-oiling (Blokpoel and Hamilton 1989, Christens and Blokpoel 1991); however, gulls do reduce attentiveness and ultimately abandon oiled clutches (Blackwell et al. 2000). Belant et al. (1993) noted that for herring gulls, time spent at the nest decreased from 18.9 hours/day during incubation to 9.7 hours/day during chick-rearing to 5.7 hours/ day post-fledging. Belant et al. (1993) suggested that adults were forced to forage farther from the nest to feed young as the breeding cycle progressed, resulting in less time spent at the nest. Further, the propensity of adults to leave the breeding colony after chicks fledge (Coulson and Butterfield 1986) may have been reflected in our lower estimate of colony presence in the post-hatching period. Whether the mechanism that caused reduced nest-site attendance is recognition of unviable eggs, a behavioral cue that triggers increased foraging at the perceived time of hatching, or a combination of these or other factors is unclear.

Our data are unique in that most investigations of potential sex differences in parental investment have been conducted during the day. We found similar nighttime colony attendance between sexes of ring-billed gulls, regardless of treatment (i.e., egg oiling). Hebert and McNeil (1999) likewise determined that male and female ring-billed gulls were equally likely to incubate and feed chicks at night. Additionally, Conover (1989) reported that for male-female pairs, the 2 sexes did not differ in the amount of time spent in any parental behavior. In contrast, Southern (1981) and Dulude et al. (1987) reported that male ring-billed gulls spend more time on territory than females, and Dulude et al. (1987) concluded that males have greater overall investments in reproduction than females. Any potential greater parental investment by male ring-billed gulls was not observed in colony presence relative to females.

Management implications

We suggest that egg oiling is unlikely to affect colony presence of ring-billed gulls within the breeding season, and, thus, unlikely to cause breeding individuals to disperse to other locations. Managers interested in long-term, local stabilization in gull abundance should consider egg oiling as a potential method. However, population reduction using egg oiling is a multi-year process, and, when short-term population reduction is necessary, culling reproductive adults is generally more effective than egg oiling (see Blackwell et al. 2002). Also, managers should minimize colony disturbance during egg-oiling operations, especially if eggs are likely to be preyed on when incubating gulls are flushed from nests, as potential for re-nesting increases (Ickes et al. 1998).

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