Incidence of Capped American Kestrel Eggs (*Falco sparverius)* in a Nest Box Program

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ABSTRACT

*Capped eggs occur in nests when a part of an eggshell from a previously hatched egg adheres to an unhatched egg, potentially killing the embryo within or preventing its hatching. During the last 3 of 11 breeding seasons (2008-2018) in an American Kestrel (*Falco sparverius*) nest box program in the Shenandoah Valley Raptor Study Area of Virginia, we observed capped kestrel eggs at an incidence of 2.3% (n = 4 of 177 successful nests). Detection of capped eggs is time sensitive and requires close examination of all unhatched eggs. The significance of egg capping is unclear but is likely not a significant factor limiting kestrel productivity or populations. We hypothesize that egg capping in kestrels is a symptom of aberrant behavior by female kestrels who do not promptly remove eggshells from the nest.*

INTRODUCTION

American Kestrel *(Falco sparverius)* populations in many regions of North America have been decreasing for decades (Farmer and Smith 2009). Several hypotheses have been proposed to explain the decline of kestrel populations, but no single factor has emerged as the major cause of widespread losses of kestrels (Smallwood et al. 2009, McClure et al. 2017). It is probable that multiple factors, each seemingly minor, cumulatively cause declines in kestrel populations; e.g., habitat loss and degradation (Smallwood and Bird 2002), loss of suitable nest cavities (Smallwood and Collopy 2009), decreased survival of adults (Smallwood et al. 2009), deleterious effects of toxins and pesticides (Hallmann et al. 2014), electric shock (Morrow and Morrow 2018a), methane flares injuring and killing kestrels (Morrow and Morrow 2018b), and aberrant behavior (Morrow and Morrow 2014).

Most altricial birds promptly remove, trample or eat eggshells, thus reducing chances of capping (Guigueno and Sealy 2012). Egg capping was first described in 6 species of 3 orders: Gadwall (*Anus strepera*), Merlin (*Falco columbarius*), Purple Martin (*Progne subis*), Tree Swallow (*Tachycineta bicolor*), Clay-colored Robin (*Turdus grayi*) and Northern Mockingbird (*Mimus polyglottos*) (Derrickson and Warkentin 1991). They suggested that capped eggs were prevented from hatching either by mechanically interfering with pipping or with gas transport across the eggshell. Egg capping is also reported in several species of birds of different orders in a review paper on passerine nest sanitation (Guigueno and Sealy 2012). Published rates of egg capping vary considerably in altricial species, from 1.49% in American Pipit (*Anthus rubescens*) nests (n = 1 capped egg in 69 nests) (Verbeek 1996), to 33% in an extreme case in clutches of Eastern Phoebes (*Sayornis phoebe*) parasitized by Brown-headed Cowbirds (*Molothrus ater*) which have larger and earlier hatching eggs (Hauber 2003).

In the Shenandoah Valley Raptor Study Area (SVRSA) we documented egg capping in American Kestrel using nest boxes. A typical clutch of 5 kestrel eggs hatches over a 2-3 day period, as the female usually commences incubation upon laying the fourth egg and there is some variability in pipping and hatching (Smallwood and Bird 2002). The first egg to hatch has no chance of becoming capped, but eggs that hatch subsequently have progressively higher chances of capping if eggshells are not promptly removed. Normally,

female kestrels help hatchlings out of their eggshells, and the shell fragments are promptly removed, trampled into nest or consumed by the female (Smallwood and Bird 2002). Female kestrels that do not remove eggshells from the nest promptly, we hypothesize, are exhibiting aberrant behavior. We have previously documented this aberrant behavior in kestrels within the study area (Morrow and Morrow 2014) and, by marking with USGS bands and recapturing banded kestrels, we are documenting individual histories of breeding success, hatching success, capped eggs, and behavior over several years.

METHODS

The SVRSA is in northern Rockingham and southern Shenandoah counties of Virginia, encompassing approximately 36000 ha. The SVRSA is comprised of a variety of land uses: row crops, livestock pastures, hay fields, commercial fruit orchards, vineyards with scattered patches of wood lots, and wooded ridges with widely scattered residential and commercial areas. The study area is fully described elsewhere (Morrow and Morrow 2015).

Following the SVRSA nest box protocol, we record numbers of eggs laid, hatched and unhatched eggs for each nest attempt in each nest box. The Number of eggs that hatch is counted 6-8 days after estimated hatch date, e. g., 37-41 days after clutch initiation (depending on clutch size). During this nest check, all unhatched eggs are examined for cracks, pips and capping. Capped eggs are photographed returned to the nest box and checked for hatching or ejection from the nest box 3-7 days later. In addition, we attempt to capture all breeding kestrels inside nest boxes to either mark them with USGS aluminum bird bands or read band numbers on recaptured birds. Nest defense behaviors of breeding kestrels in and near nest boxes have been recorded since 2016.

RESULTS

During the 2016, 2017 and 2018 breeding seasons, we documented a total of four capped American Kestrel eggs in 177 successful nests (defined as nests that hatched at least one young and thus have the potential of having a capped egg). The observed incidence of capped eggs is one per 44 nests (2.3%), and can also be expressed as one capped egg in 216 kestrel eggs laid (0.5%) in successful nest boxes. The first capped egg in the SVRSA was detected in 2016, two more were found in 2017 and one in 2018, each in a different nest box. Prior to observing the capped egg in 2016, unhatched eggs in our boxes were not closely examined for capping, so the egg capping rates are calculated for only the past three years, when we were actively looking for capped eggs.

By banding and recapturing kestrels breeding in SVRSA nest boxes, we have breeding histories for most of the adult females who stayed within the study area. In two boxes with capped eggs, the breeding females were captured in boxes but had no USGS bands, so we banded and released them; one has not been recaptured in the study area to date. The other of the females was recaptured the next year breeding in a different nest box and displayed aberrant behavior by abandoning a full clutch of eggs after we recaptured her. In the third box with a capped egg the female flushed from the box and was not captured. In the fourth box the female had a history of nesting in the same box three years in a row. She produced 5 chicks in 2015, 1 in 2016 (we postulate 4 of 5 eggs in this early clutch chilled and were ejected from the nest box, but they could have been depredated), and in 2017 she produced four chicks from five eggs, one of which was capped and did not hatch. She behaved abnormally in 2017 by flushing from the box twice, leaving her full clutch of eggs. To date this female has not been recaptured in the SVRSA and another female used her nest box in 2018, so we speculate she died or left the study area.

By recording the behaviors of kestrels in the study area, we have documented several types of aberrant behavior ranging from poor hygiene (discussed below), lack of nest defense, and females that flush from full clutches of eggs upon hearing us approaching the nest box (unpubl. data). One of the four capped eggs occurred in a nest box that

is located within the territory of a resident male kestrel that exhibited aberrant behavior by not properly cleaning his talons after feeding, leading to the development of ball-like accretions on his talons, rendering some ineffective (Morrow and Morrow 2014). In the three other boxes with capped eggs we documented breeding female kestrels exhibiting other types of aberrant behavior: three flushed from a full clutch of eggs with little provocation; two providing no nest defense such as vocalizing, flying overhead, making mock stoops during checking of nest boxes or defending the box against starlings removing bedding material. In our study area, females incubating full clutches of eggs do not readily flush from the box, defending their nest boxes during nest checks by flying nearby and/or vocalizing, and they do not allow the mulch we have placed inside to be removed from the box during nesting attempts.

Capped eggs are rare and difficult to detect without close examination. From 2008 until 2016, when we discovered the first capped kestrel egg, we gave unhatched eggs in nest boxes little attention, aside from counting the number of unhatched eggs. The nest box protocol was revised to include examination of all unhatched kestrel eggs. At times, capped eggs appear to be normal when the color and speckling of the unhatched egg and cap are similar. These caps are easy to miss but the cap can be detected tactilely by handling the egg. At other times, capping is visually obvious, appearing as an abnormally shaped or cracked egg (Fig. 1), or as a two-toned egg in instances where eggshell color and/or speckling are dissimilar.

Our data suggest that egg capping is only detected on non-viable kestrel eggs. However, there is the possibility that viable capped eggs exist, but evidence of capping is destroyed when they hatch. It has been suggested that capping can cause suffocation of the embryo due to decreased water and oxygen exchange through the eggshell (Derrickson and Warkentin 1991). Federal and State banding permits do not allow us to investigate the viability of capped eggs, so we photograph and place them back in the nest box.

DISCUSSION

To our knowledge, this is the first report of egg capping in American Kestrels. The only report of egg capping in genus *Falco* is for Merlins, in which the egg capping rate was two capped eggs in 145 successful nests (1.4%) (Derrickson and Warkentin 1991). Our observed average incidence of four capped eggs in 177 successful nests (2.3%) in the SVRSA during 2016-2018 is higher than reported in Merlin nests. Egg capping in kestrels is rare but not unexpected. While discussing potential reasons to explain why 34% of kestrel nest boxes had partial hatching failures, Wiebe (1996) mentioned egg capping as a possible cause of failure to hatch but found no evidence of egg capping in 493 kestrel eggs from 170 nests where at least one young hatched.

There are many reasons that kestrel egg capping has not been previously documented: volunteers or researchers are currently not looking for capping, capped eggs are simply overlooked, by the time the nest is checked capped eggs have disappeared from the nest, and nest box programs have volunteers who are not permitted to handle eggs. Documentation of capped eggs is time sensitive, as unhatched eggs may be ejected, depredated, trampled or eaten by the female kestrel before they are detected. The latter behavior was recorded by a Cornell nest box video camera showing a female kestrel feeding the unhatched egg to her nestling (2018). Capped kestrel eggs likely occur more often than documented herein due to these factors. We recommend all unhatched eggs in successful nests (clutches where any eggs have hatched) be examined carefully, both visually and tactilely, for evidence of capping within a few days of expected hatch date.

Decreased nesting productivity in American Kestrels is not considered to be a main driver of American Kestrel population declines (Smallwood et al. 2009, McClure et al. 2017). Our observations indicate egg capping is rare thus we conclude capping is not a major contributor to decreased kestrel reproductivity. In addition, hatchability of capped eggs was experimentally tested by Arnold

(1992) using American Coot (*Fulica americana*) eggs. He concluded there was a non-significant 6% decrease of hatchability of capped eggs compared to uncapped control eggs in an incubator.

We suggest egg capping in kestrel nests is a subtle symptom of aberrant behavior. It may not be a coincidence that the capped egg found in 2018 was in the same territory as the resident male kestrel who did not properly clean his talons (Morrow and Morrow 2014). The area surrounding that, and many other SVRSA nest boxes, is cornfields sprayed with herbicides and pesticides. In the other nest boxes with capped eggs we documented female kestrels exhibiting aberrant behaviors ranging from inappropriately flushing off full clutches of eggs to absence of nest defenses. Our hypothesis is that exposure to herbicides and pesticides causes kestrels to behavior aberrantly. Walker (2003) states that neurotoxic pesticides including organochlorine, organophosphorus, carbamate, pyrethoid and neonicotinoids, have the potential to cause behavioral disturbances in birds. Agrochemicals are the single biggest threat to farmland bird populations, as agricultural intensification is linked to population declines of most species of farmland birds due to both direct and sublethal effects (Hallmann et al. 2014 and Stanton et al. 2018). To test our hypothesis would require experimentation using captive breeding kestrels to determine if there is a correlation between exposure to agrochemicals and aberrant behavior and egg capping.

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Fig. 1. Capped American Kestrel egg from a SVRSA kestrel nest box containing 4 nestlings. At first glance, this unhatched egg appears to be unusually oblong and cracked; both anomalies are due to the eggshell cap that has adhered to it.