1 **Automated broadcast of a predator call did not reduce predation pressure by Sugar**

2 **Gliders on birds**

3

Summary

5 Fear may elicit behavioural and physiological responses in animals. We conducted a pilot

6 study aiming to reduce bird nest predation in Tasmania by the introduced Sugar Glider

7 (*Petaurus breviceps*) by broadcasting calls of predatory owls. We designed a solar-powered,

8 automated weatherproof stereo for long-term call broadcast in a forest environment. This

9 device may have useful applications in other environments where long-term call broadcast

10 is required in remote field conditions. Call broadcast did not reduce the likelihood of Sugar

11 Glider nest predation on either active bird nests or artificial nests baited with farmed quail

12 eggs. If we elicited fear in Sugar Glider individuals with call broadcast, this fear did not result

13 in behavioural changes that could be exploited to achieve the conservation objective of

14 lower predation.

15

Key Words

17 Predation, nest survival, broadcast, landscape of fear, pest management

Introduction

19 Scare tactics (visual, auditory and olfactory) have historically been used with mixed results

20 and are a potential approach to mitigate the impacts of pest animals in sensitive ecosystems

21 (Suraci*, et al.* 2016). Scaring tactics utilise sensory cues to alter the behaviour of the target

22   species and can substantially alter their interactions with other trophic levels (Suraci *et al.*

23   2016). However, the challenges of implementing and monitoring scaring tactics in remote

24   locations for long periods is a barrier to their wider utilisation in conservation projects.

25

26   We report on a pilot study aiming to protect bird nests using predator call broadcast. In

27   Tasmania, the Sugar Glider (*Petaurus breviceps*) is an introduced invasive species

28   (Campbell*, et al.* 2018) and a major predator of bird nests including critically endangered

29   Swift Parrots (*Lathamus discolor*) (Stojanovic*, et al.* 2014). Its impact creates a need for

30   efficient, cost-effective methods to protect birds nesting in natural tree cavities. Sugar

31   Gliders are prey for forest owls (Todd 2012) and respond with alarm to their calls when

32   broadcast (Allen*, et al.* 2018). We test whether broadcasting calls of forest owls lowers

33   predation by Sugar Gliders on bird nests, and develop a solar-powered, automated

34   weatherproof stereo for long-term call broadcast in a forest environment.

35

Materials and Methods

37   We monitored forty nest boxes at two locations in south-eastern Tasmania (Eastern Tiers:

38   S42°13', E147°47' & Meehan Range: S42°49', E147°24') which have confirmed Sugar Glider

39   populations and a history of bird nest predation (Stojanovic, 2018). We monitored nest

40   boxes in paired control/treatment arrays comprising 10 nest boxes each. Arrays were >

41   400m apart and nest boxes were randomly spaced within 100m of array centroids. An

42   automated call broadcast unit (see below) was installed near the centroid of treatment

43   arrays. Owl calls were broadcast throughout the night and motion-activated cameras were

44   installed on nest boxes to confirm occupancy and predator identity.

45   We monitored predation of all birds that nested in our boxes because they were all

46   potential sugar glider prey (Stojanovic*, et al.* 2014). We manually inspected 14 nest boxes

47   occupied by birds (birds only nested at the Eastern Tiers site) before and after treatment to

48   confirm nest fates and we confirmed predator identity from camera images. Empty nests, or

49   those containing broken egg shells or carcasses, were scored as failed due to predation

50   (Sugar Gliders consume the egg contents, leaving empty crushed shells, which are distinct

51   from eggs accidentally broken by incubating birds).

52   Next, we baited nest boxes with farmed quail eggs at both the Eastern Tiers and the

53   Meehan Range sites to evaluate predation intensity with a larger sample of artificial nests.

54   One quail egg per nest box was deployed for 14 days (excluding two boxes that had become

55   occupied by Sugar Gliders) and predation was confirmed by checking for broken quail eggs

56   and by reviewing camera images.

57   *Stereo system and design*

58   We designed a custom stereo that was autonomously continually powered, weather proof

59   and light-sensitive. Stereos comprised a lumens sensor (Stojanovic*, et al.* 2018), two marine

60   grade amps facing opposite directions, a stereo unit (Response QM3815), and a 12V28A car

61   battery encased in a marine-ply box coated with weatherproof paint. The system was

62   powered by two 12V4A solar panels. An additional battery was added to trees with dense

63   canopies to ensure constant power. When light levels fell below 20 lumens (after sunset),

64   the stereo was activated and owl calls were broadcast.

65

66 Recordings of the Masked Owl (*Tyto novaehollandiae*) (Todd*, et al.* 2018) and Southern

67 Boobook (*Ninox boobook*) (Morcombe 2019) were broadcast. Sound file spectrograms and

68 frequency levels were adjusted in Premiere Pro and adjusted to a similar output volume

69 with no distortion. The sound files were exported as a 44.1 mHz mp3 file onto a SD card and

70 broadcast at a volume of ~90dB at 1 m. Broadcasts were audible to people within 100m.

71 Sound files were < 15 seconds. In our initial nesting bird trial, Masked Owl calls were played

72 at a rate of one call to five minutes of silence. In the artificial nest trial, both Masked Owl

73 and Southern Boobook calls were interspersed randomly between silence periods ranging

74 from one to 30 min.

75

76 *Analysis*

77 We fitted generalized linear models using nest survival (both for birds and quail eggs) as a

78 binomial response variable (survived/failed). Birds settled at only one site, so we only

79 considered the effect of treatment on nest survival. For the quail egg experiment, in

80 addition to a null model, we fitted treatment type, study site, and whether or not a bird had

81 nested in the box during the earlier study as fixed effects. Models were compared using

82 ΔAICc <2 using 'AICcmodavg' (Mazerolle 2019) in R (R CoreTeam 2019).

83 # Results

84 We recorded 14 bird nesting attempts (Tree Martin (*Petrochelidon nigricans*) = 9, Australian

85 Owlet-nightjar (*Aegotheles cristatus*) = 1, Common Starling (*Sturnus vulgaris*) = 4). Nest

86   predation by Sugar Gliders occurred at 12 bird nests (one Tree Martin nest and one

87   Common Starling nest survived). The treatment and control arrays each had a surviving

88   nest. The null model had a lower AICc (13.82) than the model containing the effect of

89   treatment (AICc 16.37) indicating that the treatment did not explain the survival of bird

90   nests. Based on the null model, the predation rate on bird nests was 0.89 (± 0.09 se, LCI:

91   0.57, UCI: 0.96).

92   Of the 38 quail eggs deployed in nest boxes, nine were eaten by Sugar Gliders. Six of these

93   were in control arrays and three in treatment arrays. The model containing the effect of

94   treatment (AICc = 45.67) was within ΔAICc<2 of the null model (AICc = 44.76), indicating

95   equivalent support for both models. We preferred the simpler null model which estimated

96   survival of quail eggs as 0.23 (± 0.06 se, LCI: 0.12, UCI: 0.38).

97

98   # Discussion

99   Protecting birds in natural hollows from Sugar Glider predation remains an important

100   conservation challenge. Our study suggests that even if Sugar Gliders feared our owl

101   broadcasts, this did not reduce their predatory behaviour on bird nests. It is possible that

102   regular call broadcast habituated Sugar Gliders to our treatments, but confirmation of this

103   possibility would require further study. Habituation is a limitation of scare tactics and could

104   be controlled for by implementing gaps of days between treatments (Suraci, 2016) or

105   employing motion-sensor activated broadcasts (Thuppil, 2016). Factors, such as population

106   density or food availability, may drive predatory behaviours of Tasmanian Sugar Gliders and

107   these factors require further research because they remain unknown.

108 Our results affirm that Sugar Gliders are severe predators of birds and we report the first

109 case of nest predation by Sugar Gliders on an Owlet-nightjar. We considered non-target

110 impacts of our method to be low because our small study areas are only a fraction of the

111 mean home range of the Masked Owl (Todd, 2012). A pilot trial on Tree Martin nests found

112 no effect of call broadcast on bird brood size or body condition (G.O. unpublished data).

113 Future predator call broadcast studies should include a fuller assessment of impacts to all

114 wildlife within the study area.

115 We developed a new tool to broadcast calls autonomously in remote field areas. Our solar

116 powered stereo design proved suitable for long-term field applications, and operated from

117 December to February with virtually no maintenance. One caveat for field applications of

118 our stereo design is that in forests, partially shaded solar panels may lower battery

119 performance. We overcame this problem using multiple solar panels positioned in areas of

120 maximal sunlight and by adding a second battery. The design of the stereo system may be

121 easily modified to include, for example, a timer (if more specific timing is required for call

122 broadcast than simple night/day schedules). Automated broadcast of predator calls has

123 potential for management of problematic species but we illustrate that behaviour may not

124 always result in avoidance and the desired conservation outcome.

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