

1 Tape lures swell bycatch on a Mediterranean island  
2 harbouring illegal bird trapping

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12

## 13 Abstract

14 Mediterranean islands are critical for migrating birds, providing shelter and sustenance  
15 for millions of individuals each year. Humans have long exploited bird migration  
16 through hunting and illegal trapping. On the island of Cyprus, trapping birds during  
17 their migratory peak is considered a local tradition, but has long been against the law.  
18 Illegal bird trapping is a lucrative business, however, with trappers using tape lures that  
19 broadcast species' vocalizations because it is expected to increase numbers of target  
20 species. Yet, by how much the use of song playback increases capture rates remains  
21 underappreciated. In particular, it is not known whether song playback of target species  
22 affects bycatch rates. Here, we show with the use of playback experiments that song  
23 playback is highly effective in luring birds towards trapping sites. We found that  
24 playback increases six to eight times the number of individuals of target species  
25 captured, but also significantly increases bycatch. Our findings thus show that in  
26 contrast to popular belief that tape lures are a selective trapping method, they also lead  
27 to increased captures of non-target species, which can include species of conservation  
28 concern.

## 29 Background

30 Natural resources are globally threatened due to progressive overharvesting, with  
31 animal diversity being particularly affected by its consequences. Birds are very sensitive  
32 to anthropogenic impact, which has been a major cause of their decline[2,3]. In addition  
33 to indirect impacts on numbers caused by habitat loss and environmental toxification,  
34 birds have also been impacted directly, by being targeted for food, the pet trade and  
35 sport.

36           Every year, over two billion birds migrate along the Afro-Palearctic route and  
37 concentrate in large numbers around the Mediterranean Basin, which is an important  
38 biodiversity hotspot. Mediterranean islands are important stopover sites since they  
39 provide trophic resources and shelter for migrant bird species. Humans have long  
40 exploited this sudden, seasonal abundance of food resources through hunting. The need  
41 to supplement what would in the past have been a low-protein diet has made such  
42 habits widespread to the point of making them important culturally in several  
43 Mediterranean countries.

44           The island of Cyprus is an important stopover site for many millions of migrant  
45 birds each year comprising over 200 species. Relative to its size, no other country has  
46 greater hunting pressure in the Mediterranean basin. Illegal trapping in Cyprus involves  
47 killing mostly passerines, and is a common practice well rooted in Cypriot culture. Birds  
48 are trapped for food consumption and because of high demand, it is a lucrative business.  
49 Eurasian blackcaps (*Sylvia atricapilla*), known locally as ‘ambelopoulia’, are most  
50 sought-after by illegal trappers in Cyprus. Though blackcaps are the main target, the use  
51 of non-selective trapping methods involving mist nets and lime sticks results in the  
52 demise of individuals of many other species. Indeed, of the 155 species recorded  
53 captured with mist nets and lime sticks in 2018 in Cyprus, 82 are listed as conservation  
54 priority species under the EU Bird Directive or in BirdLife International’s Species of  
55 European Conservation Concern, which include the endemic Cyprus warbler *Sylvia*  
56 *melanothorax*.

57           Capture rates are expected to be amplified by using tape lures: devices involving  
58 a loudspeaker to broadcast the songs of target species. Tape lures are usually set by  
59 trappers in order to increase catch rates. They are typically played at night to attract

60 nocturnally migrating birds that may hear and respond to the song from great distances,  
61 while also reducing detection rates by the authorities.

62 Use of tape lures to increase catch rates is thought to harm both migratory and  
63 resident bird communities, but the extent to which calling devices attract birds to traps  
64 has not been quantified. Furthermore, since playbacks are typically aimed at attracting  
65 certain target species, we still do not know whether their luring effect is limited to those  
66 species or whether they increase the catch rate of other species that may use  
67 heterospecific vocalisations as habitat quality cues and for detection of predators.

68 Here, we aim to quantify with playback experiments the effectiveness of  
69 playback of target species' song stimuli in luring birds into nets. We used recordings of  
70 Eurasian blackcap (hereafter blackcap) to determine effects of capture rates of  
71 blackcaps and other species compared to controls. We also tested whether playback of  
72 Sardinian warbler (*Sylvia melanocephala*) song - a local breeding species' - also  
73 increases capture rates of that species and non-target species. Both species may use  
74 vocalizations for conspecific and heterospecific interactions, including in competition  
75 for environmental resources. Because of this, we expect a strong response from  
76 conspecifics as well as competitor heterospecifics. Through this approach, we aim to  
77 determine the extent to which the use of such playback devices increases both catch  
78 rates and number of species caught. Our findings would inform authorities and  
79 conservation initiatives on the impact on wildlife of the use of tape lures in illicit  
80 trapping operations.

81

## 82 Methods

83

84 *Experimental design*

85 We conducted playback experiments between March and October 2016 and in  
86 September 2019 at 8 localities in Cyprus (Fig.1). For playback stimuli, we used  
87 recordings of blackcap and Sardinian warbler song. Blackcap is a medium sized migrant  
88 warbler that does not breed in Cyprus, but occurs in large numbers during migration  
89 peaks in spring and autumn, with some individuals overwintering. Sardinian warbler is  
90 partially migratory, and found year round in coastal and island populations, including in  
91 Cyprus, where it is common and increasing in numbers[30,31].

92 For each playback experiment session, we used two 12x2.5 m mist nets, with one  
93 acting as the experiment (with playback) and the other as control (without playback),  
94 and positioned about 100 m away from each other to reduce possible interference  
95 between the experiment and control nets. Blackcap and Sardinian warbler stimuli were  
96 alternately played in experimental sessions, where a session is an independent  
97 experimental period where playback is played continuously for one hour at one of the  
98 nets. In all cases, experimental sessions were paired, so that the experimental net in  
99 session one was then the control in session two, and vice versa.

100 Illegal trappers are unlikely to use a large variety of stimuli for a given target  
101 species, instead using a single stimulus they have found works well throughout. We  
102 aimed to replicate the approach of trappers in using a small number of stimuli in our  
103 experiments. We sourced from Xenocanto online repository ([www.xeno-canto.org](http://www.xeno-canto.org)) two  
104 blackcap recordings, XC269084 (RMS amplitude = 2712), and XC270439 (RMS  
105 amplitude = 2712). For Sardinian warbler we used XC98857 (RMS amplitude = 1180)  
106 and our own recording from western Cyprus (RMS amplitude = 1453). Amplitude  
107 values were obtained from Raven Pro 1.6.

108

## 109 *Statistical analyses*

110 We first conducted a t-test to determine whether there was an overall effect of  
111 playbacks on the total number of captured birds. We then compared Poisson and  
112 negative binomial generalized linear mixed models (GLMMs) implemented in R in the  
113 lme4 package to investigate how playbacks influence the number of captured birds.  
114 Given the slight overdispersion in our data, negative binomial GLMMs provided in all  
115 cases the best fit according to the lowest corrected Akaike Information Criterion (AICc)  
116 score calculated in the AICcmodavg package in R.

117 To assess whether playback attracted target species, we ran two models, one  
118 with number of captured blackcaps and the other with number of Sardinian warblers as  
119 dependent variables. In both models, we included as fixed factors the time, season, and  
120 type of playback: a categorical variable with three levels: 1) no playback, 2) blackcap  
121 playback and 3) Sardinian warbler playback.

122 To examine whether playback had an effect on non-target species, we specifically  
123 tested the effect of playbacks on all species captured excluding individuals of the species  
124 that emitted the given playback stimulus. Specifically, the effect of blackcap playback  
125 was tested using as dependent variable the total number of captured birds excluding  
126 blackcaps, whereas the effect of Sardinian warbler playback was tested using the total  
127 number of trapped birds minus Sardinian warblers. We included time and type of  
128 playback as fixed factors. We also included site as a random effect in all our models to  
129 account for variation among sites. Models with the best fit (lowest AICc score) for each  
130 set of GLMMs were validated by plotting residuals against predicted values and a qq-  
131 plot to detect possible deviations from the expected distribution. Model validation  
132 functions were provided in the DHARMA R package.

## 133 **Results**

134 We caught significantly more birds (t-test:  $t=-4.82$ ;  $p < 0.001$ ) in experimental nets  
 135 (mean = 2.77, sd = 4.17), catching 333 birds of 31 species, than in controls (mean = 0.75,  
 136 sd = 1.39), where we trapped 90 birds belonging to 24 species (Fig. 1, Table S1).  
 137 Numbers of blackcaps were positively affected by both conspecific (GLMM:  $z = 8.33$ ,  $p =$   
 138  $< 0.001$ ) and Sardinian warbler ( $z = 2.66$ ,  $p = 0.007$ ) playback, with more caught per  
 139 experiment in spring ( $z = 2.56$ ,  $p = 0.01$ ) compared to autumn (Table 1). By contrast,  
 140 Sardinian warbler numbers caught were positively affected by conspecific playback ( $z =$   
 141  $5.60$ ,  $p = < 0.001$ ) but not blackcap playback ( $z = 1.49$ ,  $p = 0.133$ ), while season also had  
 142 no effect on their capture rates (Table 1).

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147 **TABLE 1.** Results of negative binomial GLMMs investigating the effect of 1) blackcap  
 148 and Sardinian warbler playback on the number of blackcaps caught, 2) blackcap and  
 149 Sardinian warbler playback on number of Sardinian warblers caught, 3) blackcap  
 150 playback on heterospecifics minus blackcaps and 4) Sardinian warbler playback on  
 151 heterospecifics minus Sardinian warblers.

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153

154 **1) Response:**

155 **Blackcap**

156 Intercept -2.6407 0.5273 -5.008 < 0.001

157 Time -1.2525 0.3228 -3.880 < 0.001

158 Season: spring 1.5499 0.6039 2.567 0.010

159 Season: summer -3.9445 1.1372 -3.469 < 0.001

160 Blackcap playback 2.4530 0.2942 8.337 < 0.001

161 Sardinian warbler 0.9892 0.3706 2.669 0.007

162 playback

163

164 **2) Response:**

165 **Sardinian warbler**

166 Intercept -3.2102 0.5253 -6.111 < 0.001

167 Time -0.7189 0.3344 -2.149 0.031

168 Blackcap playback 0.7735 0.5160 1.499 0.133

169 Sardinian warbler 2.5011 0.4461 5.607 < 0.001

170 playback

171

172 **3) Response:**

173 **All species,**

174 **blackcap excluded**

175	Intercept	-0.7112	0.3095	-2.298	0.021
176	Time	-0.3455	0.1475	-2.342	0.019
177	Blackcap playback	0.5882	0.2504	2.350	0.018

178

179 **4) Response:**

180 **All species, Sardinian**

181 **warbler excluded**

182	Intercept	-1.0185	0.3510	-2.902	0.003
183	Time	0.1628	0.1620	1.005	0.315
184	Sardinian warbler playback	0.9200	0.3081	2.986	0.002

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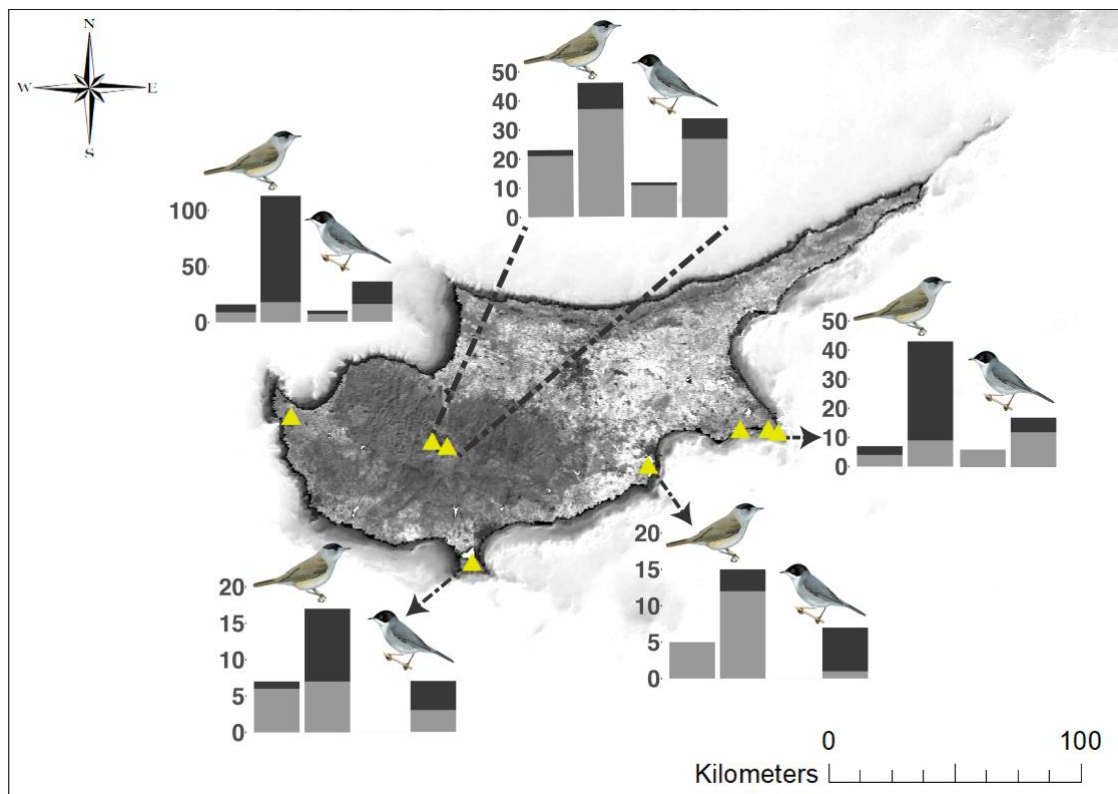
189 Bycatch numbers were also significantly higher in experimental (n = 106 individuals of

190 29 species) than in control nets (n = 61 individuals of 22 species) (Fig. 1). Both blackcap

191 (GLMM:  $z = 2.35$ ,  $p = 0.018$ ) and Sardinian warbler playback ( $z = 2.98$ ,  $p = 0.002$ ) elicited

192 higher numbers. A significant negative effect of time was also found ( $z = -2.34$ ,  $p =$

193 0.019), but only for bycatch in response to blackcap playback.



194



195 **FIGURE 1.** Map illustrating number of heterospecific (grey) and conspecific (black)  
196 individuals caught in control (left bar of pair) versus experimental (right bar of pair)  
197 nets with blackcap (left pair of bars) and Sardinian warbler (right pair of bars) playback  
198 stimuli at different localities: A) Agia Napa and Cape Greco, B) Larnaca Salt Lake, C)  
199 Akrotiri Salt Lake, D) Neo Chorio and E) Troodos mountains. Cyprus' background map  
200 illustrates Enhanced Vegetation Index for February 2020. Source: Esri. Bird illustrations  
201 courtesy of HBW [27,29].

## 202 Discussion

203 Our study shows that the use of tape lures results in an increase from six to eight times  
204 capture rates of target species. Tape lures may have a detrimental effect on other avian  
205 species since they also attract individuals of non-target species, which would also meet  
206 their demise at trapping sites.

207 Bird song functions in mate choice and territory defence[25,26], so theoretically  
208 should only attract conspecific breeding birds, and their close competitors[38]. Indeed,  
209 geographic variation in song has been shown to reduce response levels because of  
210 differences in dialects[39,40] or resulting from adaptation to habitat differences[41].  
211 Song may also have a function during migration, however, and birds may use  
212 conspecific signals to assess environmental quality[42] and trophic resource  
213 availability[43]. Season also plays an important role in determining response rates.  
214 Spring represents a period of intense migratory activity for many species and this may  
215 explain why spring positively affects blackcaps responsiveness in our study. The  
216 approach of the breeding season may increase responsiveness as a consequence of  
217 increased hormone levels associated with increased territoriality, as demonstrated in  
218 other passerines.

219           According to our results, Sardinian warbler playback also had a positive effect in  
220 attracting blackcaps into nets, whereas blackcap playback did not elicit the same  
221 response from Sardinian warblers. Blackcaps have been shown to recognize other  
222 species[24,28], and the strong response elicited by Sardinian warbler stimuli is likely to  
223 have arisen due to similar dietary requirements; both species feed mainly on fruits  
224 outside of the breeding season and shift towards an insect-based diet as the breeding  
225 season approaches[27,29]. Furthermore, some migrant species use resident species as  
226 indicators of habitat-quality and food availability[45] as well as to infer the presence of  
227 predators from the calls of resident prey species[46]. We suggest blackcap responses to  
228 Sardinian warbler playback also reflect migrants eavesdropping on heterospecific  
229 vocalisations for their own benefit. However, because Sardinian warblers are resident  
230 species, they are less likely to rely on other species to locate food resources and would  
231 not be expected to recognize vocalisations of a species that does not breed in Cyprus,  
232 such as blackcap. Notwithstanding, no response by Sardinian warbler to blackcap song  
233 might even reflect avoidance behavior, whereby resident species avoid migratory birds  
234 to escape competition for food, which has been shown in Sardinian warbler[47].  
235 However, we did not find that Sardinian warbler avoided blackcap experimental nets  
236 more than controls.

237           In our study, we also show that other species responded positively to both  
238 blackcap and Sardinian warbler playbacks. Related heterospecific birds such as *Sylvia*  
239 warblers (e.g. *S. curruca* and *S. melanothorax*) responded to the calls, possibly because  
240 of overlapping diet and habitat requirements[28], thus contributing to the strong  
241 positive response to both playbacks. Also, response to heterospecific vocalization might  
242 be directly related to phylogenetic relatedness since they tend to share similar song  
243 features, as demonstrated in other taxa[48]. Heterospecific responses of more distantly-

244 related species such as willow warbler (*Phylloscopus trochilus*), spotted flycatcher  
245 (*Muscicapa striata*), European chaffinch (*Fringilla coelebs*) and common redstart  
246 (*Phoenicurus phoenicurus*) may also be elicited by a food expectancy or the advantages  
247 of safety in numbers and increased risk detection. Under the latter scenario,  
248 eavesdropping heterospecific signals such as warning signals may lead to important  
249 advantages such as a rapid response to threats and therefore an optimization of  
250 foraging[23].

251 In this paper, we show that tape lures boost capture rates at trapping sites. The  
252 joint use of non-selective traps with tape lures increases the number of both individuals  
253 and range of species caught, which often include threatened species or local endemics  
254 such as the Cyprus warbler, which might already be in population decline because of  
255 other factors such as habitat disturbance and competition with recent colonizers[30].  
256 The tradition of using lime sticks to catch migrant birds for a meal is illegal, much  
257 because of the non-selectivity of this methods and because the extensive use of these  
258 methods leads to a mass killing of birds in the Mediterranean[15,16,49]. The industrial  
259 level illicit trapping of millions of birds using playback devices to lure birds into vast  
260 mist nets needs immediate action by the authorities and the continued attention of  
261 conservation practitioners. Targeting the source of song playbacks is likely to be the  
262 most effective way of finding the traps – it is what attracts the birds into the traps in the  
263 first place.

264

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