

Research



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Conservation biology

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

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Mediterranean islands provide shelter and sustenance for millions of migrating birds each year. Humans have historically exploited bird migration through hunting. In Cyprus, trapping birds during their migratory peak is considered a tradition, but has long been against the law. Illegal bird trapping is lucrative, however, with trappers using tape lures that broadcast birdsong to increase capture rates. It results in the slaughter of millions of birds each year. Yet, scientific studies quantifying capture rates of target and nontarget species using methods employed by trappers are lacking. Here, we show using playback experiments that tape lures lead to an order of magnitude greater capture rates of target species, but also significantly increase bycatch, which may include species of conservation concern. Conservation efforts focusing on minimizing illegal bird killing should also consider tape lures and their contribution to the overall impact of trapping on avian populations.

1. Background

Natural resources are globally threatened owing to progressive overharvesting, with animal diversity being particularly affected by its consequences [1]. Many migratory birds are sensitive to anthropogenic impact, which has been a major cause of their decline [2,3]. In addition to indirect impacts caused by habitat loss [4,5] and environmental toxification [6], birds have also been impacted directly, by being targeted for food, the pet trade and sport [2,7,8].

Every year, over two billion birds migrate along the Afro-Palaearctic route [9] and concentrate in large numbers around the Mediterranean Basin [2,7,10]. Mediterranean islands are important stopover sites that provide sustenance and shelter for migrating birds. Humans have long exploited this sudden, seasonal abundance of food resources through hunting [11,12]. The need to supplement what historically was a low-protein diet has made such habits widespread and important culturally in several Mediterranean countries [2,13,14].

The island of Cyprus is an important stopover site for millions of migrant birds each year comprising over 200 species [15], and where illegal bird trapping currently represents the main threat to both resident and migratory birds [2,16,17]. Relative to its size, no other country has greater hunting pressure in the Mediterranean basin [2]. Poaching in Cyprus involves killing mostly passerines, and is a common practice rooted in Cypriot culture [13] that has received widespread condemnation in mainstream media [11,12,18]. Birds are trapped for food [2,19] and because of high demand, it is a lucrative business [11,12]. Eurasian blackcaps (*Sylvia atricapilla*), known locally as ‘ambe-lopoulia’, are most sought-after by poachers in Cyprus [16]. Although blackcaps are the main target, the use of non-selective trapping methods involving mist nets and limesticks results in the demise of individuals of

many other species. Indeed, of 155 species recorded captured in 2018 in Cyprus, 82 are listed as conservation priority species under the EU Bird Directive [16] or in BirdLife International's *European birds of conservation concern* [20].

Poachers expect to amplify capture rates by using 'tape lures', playback devices that broadcast songs of target species. Birdsong typically blares from loudspeakers to attract migrating birds, which may respond to song from great distances [21]. Song playback has been shown to attract other species that may eavesdrop on heterospecific vocalizations as cues of habitat quality [22]. The use of tape lures to increase capture rates may thus harm both migratory and resident bird communities. Despite international condemnation, the massacre of birds in Cyprus continues, and hostile confrontations between hunters and conservationists are commonplace, mirroring conflicts in Malta [14]. One issue raised in the fight against poaching is that local authorities doubt the accuracy of estimates of bird casualties [18].

Here, we aimed to help conservation practitioners to estimate numbers of target and nontarget species captured by quantifying the effectiveness of target species' song playback in luring birds into nets in Cyprus. We used songs of Eurasian blackcap (hereafter blackcap), and of a local breeding species, Sardinian warbler (*Sylvia melanocephala*), to determine effects on capture rates of target and nontarget species. Both species may use vocalizations for conspecific and heterospecific interactions, including in competition for environmental resources. Because of this, we expected a strong response from conspecific as well as heterospecific competitors. Our findings should inform policy makers on the impact on wildlife of tape lures in illicit trapping operations.

2. Material and methods

(a) Experimental design

We performed experiments between March and October 2016 and in September 2019 at nine localities in various habitats including orchards, maquis and acacia, along migration flyways and encompassing breeding populations of passerines in Cyprus [15] (electronic supplementary material, figure S1 and table S1). Blackcap does not breed in Cyprus, but occurs in large numbers during migration in spring and autumn [23]. Sardinian warbler is found year round across the Mediterranean [23], including in Cyprus, where it is common and increasing in numbers [24,25].

For each experimental session, we used two 12 × 2.5 m mist nets, with one designated 'experiment' and the other 'control', positioned 100 m (±10 m) apart to reduce possible interference between nets. Because such a distance might still influence captures in control nets, we also tested for this (see electronic supplementary material). Each session involved playing either blackcap or Sardinian warbler song continuously for 1 h at the experimental net. In all cases, sessions were paired, so that experimental nets in session 1 were controls in session 2, and *vice versa* (electronic supplementary material, table S1).

Poachers typically use one or two stimuli for a given target species, likely because they have consistently amplified capture rates (Sovereign Base Area police, Cyprus Game and Fauna Service, BirdLife Cyprus and Committee Against Bird Slaughter, personal communications 2020). To closely match that approach, we sourced from Xenocanto (www.xeno-canto.org) two blackcap recordings and one Sardinian warbler recording. We supplemented these with a recording of Sardinian warbler we obtained from western Cyprus in June 2010, using a Marantz PMD 661 recorder and Sennheiser ME66 microphone. We

caution, however, that using few replicates means our experiments could be biased because of exemplar effects [26]. Raven Pro 1.6 [27] was used to identify RMS amplitude on playback stimuli (electronic supplementary material, table S2). Stimuli were uploaded onto Apple iPod mp3 players connected to PAL (Tivoli Audio) portable loudspeakers in 2016, and Voombox (Divoom) or MEGABOOM 3 (Ultimate Ears) loudspeakers in 2019, set at maximum volume. The maximum amplitude (dBA) of playbacks with each speaker was measured at 1 m distance using an analogue sound level meter (RadioShack).

(b) Statistical analyses

We first used Wilcoxon signed-rank tests to determine the overall effect of playbacks on total numbers of captured birds and total bycatch. We then fitted negative binomial generalized linear mixed models (GLMMs) in glmmTMB [28] in R to investigate how playbacks influence numbers of captured birds. To assess the effect of playback on target species, we fitted two models, one with number of captured blackcaps and the other with number of Sardinian warblers as dependent variable, whereas for bycatch, we used total birds captured less numbers of the species targeted. In all models, we included as fixed factors experimental treatment, a categorical variable with three levels: (i) no playback, (ii) blackcap playback and (iii) Sardinian warbler playback, time of day, season and year. We expected a negative relationship between time of day and bird activity in hot climates as the day progresses, because birds have been shown to reduce their locomotory activity, remaining in cooler microhabitats, as a behavioural response to regulate body temperature and water balance [29,30]. The season was included to account for different species' phenology, with blackcap a nonbreeding visitor. The year was included to account for differences in broadcasting apparatus used. We included individual experiment, nested in site, as random effects in both models to account for variation among experiments and sites.

We also tested whether we caught more species in experiments than in controls with a Poisson GLMM using the number of species caught as response variable. We included season, year and experiment (categorical with levels: (i) playback and (ii) control) as fixed factors and experiment nested in location as random factors. Model selection was based on lowest corrected Akaike information criterion (AICc) score calculated in AICcmodavg in R [31], with model validation performed in DHARMA [32] and back-transformed GLMM estimates (electronic supplementary material, table S3) produced in 'effects' [33] in R.

3. Results

We caught significantly more birds (Wilcoxon signed-rank test: $V = 273.5$, $p < 0.001$) in experimental nets (mean = 2.77, 95% CI = 2.32–3.22), catching 333 birds (31 species), than in controls (mean = 0.75, CI = 0.46–1.04), where we caught 90 birds (24 species) (electronic supplementary material, table S4, figure 1). Blackcaps were attracted to both conspecific and Sardinian warbler playback, with fewer caught per experiment in summer, and more in spring, compared with autumn (table 1a; see electronic supplementary material, table S5 for model selection table). We also caught more blackcaps in 2019 than in 2016, indicating differences in blackcap abundance, but speakers used in 2019 also broadcast stimuli at higher amplitudes than in 2016 (electronic supplementary material, table S6). Sardinian warblers, by contrast, were positively affected by conspecific playback, but not blackcap playback (table 1b), while neither blackcap nor Sardinian warbler capture rates differed between controls (electronic supplementary material, table S7). Bycatch

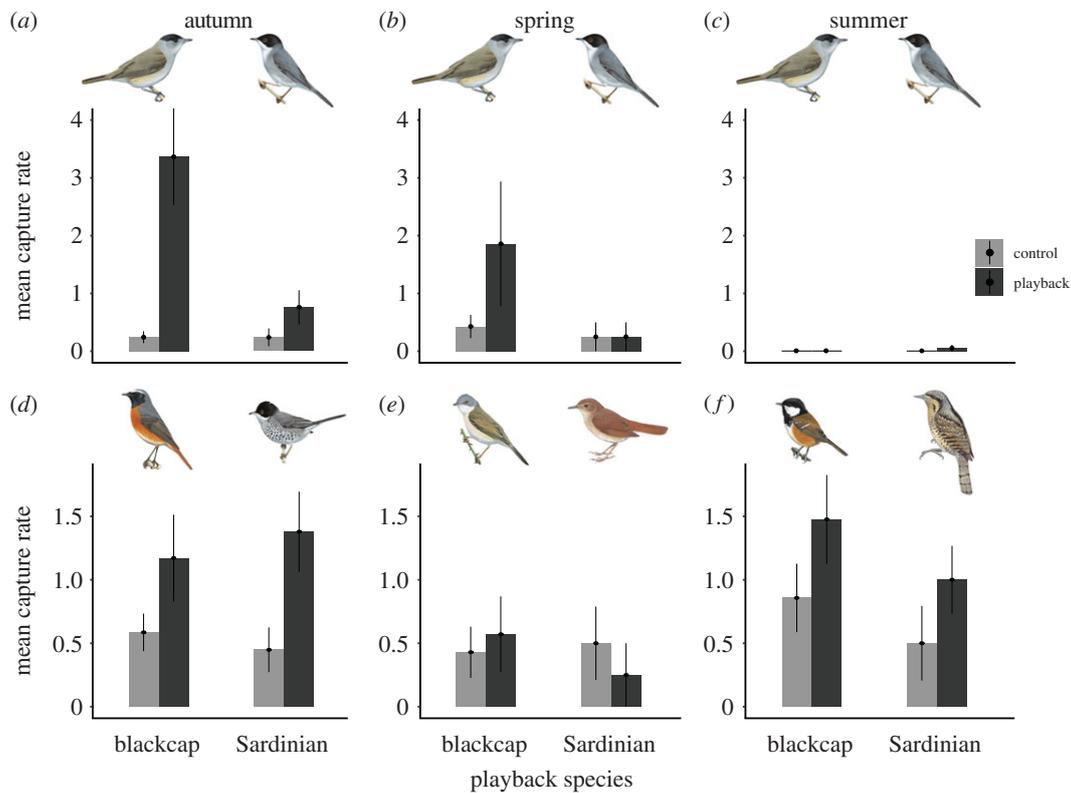


Figure 1. Bar charts illustrating mean (\pm s.e.) numbers of individuals of target species (a–c) and bycatch (d–f) caught per experiment in autumn (a,d), spring (b,e) and summer (c,f) in control (grey bars) versus experimental (black bars) nets with blackcap (left two bars per panel) and Sardinian warbler (right two bars per panel) playback stimuli. Bird illustrations, used with permission from HBW Alive [34], represent target species (top row) and examples of bycatch (bottom row, from left to right: *Phoenicurus phoenicurus*, *Sylvia melanothorax*, *Sylvia communis*, *Luscinia megarhynchos*, *Periparus ater*, *Lynx torquilla*) captured in respective experiments and seasons. Species shown for bycatch are for illustrative purposes and do not reflect any significant capture rates of those species.

numbers were also significantly higher in experimental ($n = 106$ individuals of 30 species) than in control nets ($n = 61$ individuals of 23 species) (Wilcoxon signed-rank test: $V = 515.5$, $p < 0.001$) (figure 1), with both playbacks attracting more birds to experimental than control nets (table 1c). Significantly more nontarget birds were caught in summer compared with autumn, and in 2019 than in 2016. We also caught more species in experimental nets than in controls (table 1d).

4. Discussion

Our study shows that use of tape lures results in an 11-fold increase in capture rates of target species. Indeed, in autumn, when trapping is rampant, blackcap numbers were almost fourteen times higher in experimental nets than in controls. Tape lures also attract more individuals of nontarget species, as well as a greater number of species, revealing more bycatch is expected to meet its demise at trapping sites. Yet, our increased capture rate estimates are likely conservative. Loudspeakers used in 2019 broadcast song at higher amplitudes than in 2016. If higher amplitude stimuli are more effective in luring birds to their demise, then poachers may swell numbers even more with powerful tape lures that can attract migrating birds from greater distances [21]. Furthermore, our use of few stimulus exemplars might also bias capture rates [26], e.g. if resident birds become habituated to specific exemplars. The proximity of playbacks might also increase captures in control nets if birds are drawn into the general area. More blackcaps caught in control nets in 2019

than 2016 suggests this possibility (electronic supplementary material, table S7).

Birdsong functions in mate choice and territory defence [35,36], so theoretically should only attract conspecific birds, and their close competitors (e.g. [37]). The song may also have a function during migration, however, and birds may use vocal signals to assess environmental quality [21,38] and dietary resource availability [39]. Indeed, some passerines, including blackcaps, may recognize other species' song [23,40], especially if they share dietary and habitat preferences with those species whose songs they recognize, such as other *Sylvia* warblers (e.g. *Sylvia curruca* and *Sylvia melanothorax*) [23]. Phylogenetic relatedness might also correlate with similarity in song features [41].

Heterospecific responses from more distantly related species such as willow warbler (*Phylloscopus trochilus*), spotted flycatcher (*Muscicapa striata*), European chaffinch (*Fringilla coelebs*) and common redstart (*Phoenicurus phoenicurus*), however, are more likely to be elicited by either a food expectancy or the advantages of safety in numbers and increased risk detection [42]. By eavesdropping heterospecific signals, such as warning signals, birds may respond more rapidly to threats and optimize their foraging during migration [43]. That lower numbers of target species are captured in summer is largely because of the absence of blackcap during the breeding season and lower prevalence of these species at higher elevations where summer experiments took place. By contrast, increases in bycatch in summer suggest heterospecific attraction to vocal activity as an indication of dietary resources when parents are actively feeding young [22]. Our findings of a strong luring effect

Table 1. Best fit models on the effect of blackcap and Sardinian warbler playback on the number of (a) blackcaps, (b) Sardinian warblers, (c) bycatch individuals, and (d) species per experiment. $N = 240$ experiments (playback and control nets).

	estimate	s.e.	z	p
(a) blackcaps				
intercept	-3.074	0.449	-6.835	<0.001
time	-1.564	0.255	-6.127	<0.001
season: spring	0.96	0.402	2.388	0.016
season: summer	-2.886	1.078	-2.676	0.007
playback: blackcap	2.607	0.279	9.337	<0.001
playback: Sardinian warbler	0.86	0.347	2.477	0.013
year: 2019	1.225	0.26	4.712	<0.001
(b) Sardinian warblers				
intercept	-2.99	0.601	-4.977	<0.001
time	-0.6	0.329	-1.822	0.068
playback: blackcap	0.615	0.538	1.144	0.252
playback: Sardinian warbler	2.328	0.461	5.042	<0.001
(c) total bycatch				
intercept	-1.054	0.264	-3.985	<0.001
time	-0.135	0.109	-1.243	0.213
year: 2019	0.867	0.264	3.288	0.001
season: spring	0.111	0.412	0.269	0.787
season: summer	0.692	0.265	2.605	0.009
playback: blackcap	0.635	0.216	2.935	0.003
playback: Sardinian warbler	0.683	0.232	2.941	0.003
(d) total species				
intercept	-0.732	0.182	-4.02	<0.001
experiment: playback	0.794	0.148	5.353	<0.001

of playback on heterospecifics are not unprecedented [21,22,44–46] though and using playback with constant mist-netting efforts may lead to estimation biases in population dynamics studies [47].

Our aim here was to draw attention to the appalling bird slaughter in Cyprus by focusing on methods used by poachers and their consequent impacts. In this paper, we reveal that tape lures likely boost capture rates of target species by an order of magnitude. The joint use of non-selective traps with tape lures increases both numbers of individuals and breadth of species caught. Here, species captured included 12 listed as conservation priority under the EU birds directive and/or BirdLife International's list of *European birds of conservation concern* (electronic supplementary material, table S4). These included the breeding endemic Cyprus warbler *S. melanothorax*, whose population is already declining because of land-use change and displacement by a recent colonizer [24].

The tradition of using limesticks to catch migrant birds for a meal is illegal, much because the non-selectivity and extensive use of both limesticks and mist nets have led to the mass killing of birds in the Mediterranean region [11,12,18]. The situation in Cyprus is another example of the conflict between communities over hunting [14], but we believe conservationists should focus on emphasizing how the illegal wildlife trade-driven approach differs from local tradition, and that tape lures magnify the slaughter. We urge conservationists to take

our findings on board [48], bearing in mind the limitations in the number of stimuli used and proximity of playbacks to control nets, and revise their capture rate estimation protocol to account for the over 10-fold increase in bird casualties where lures are used. Also, by targeting the sound source of song broadcasts, authorities can most effectively locate and dismantle traps; the broadcasts are, after all, what attract the birds there in the first place. Minimizing tape lure use would be a significant step in the battle against poaching.

Ethics. The Cyprus Game and Fauna Service provided ringing permits to A.N.G.K. and M.M., which also provided permission for use of playback devices. There is no project number given on these permits.

Data accessibility. Raw data and R code are available in the Dryad Digital Repository (<https://doi.org/10.5061/dryad.905qfth1>) [49]. Peer review accessible link: <https://datadryad.org/stash/share/M6cXbFXz9VZ2JSvuRiyydqQvJyUg8foC5lS7skhFIQw>.

Competing interests. M.M. volunteers as bird ringing officer for BirdLife Cyprus.

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