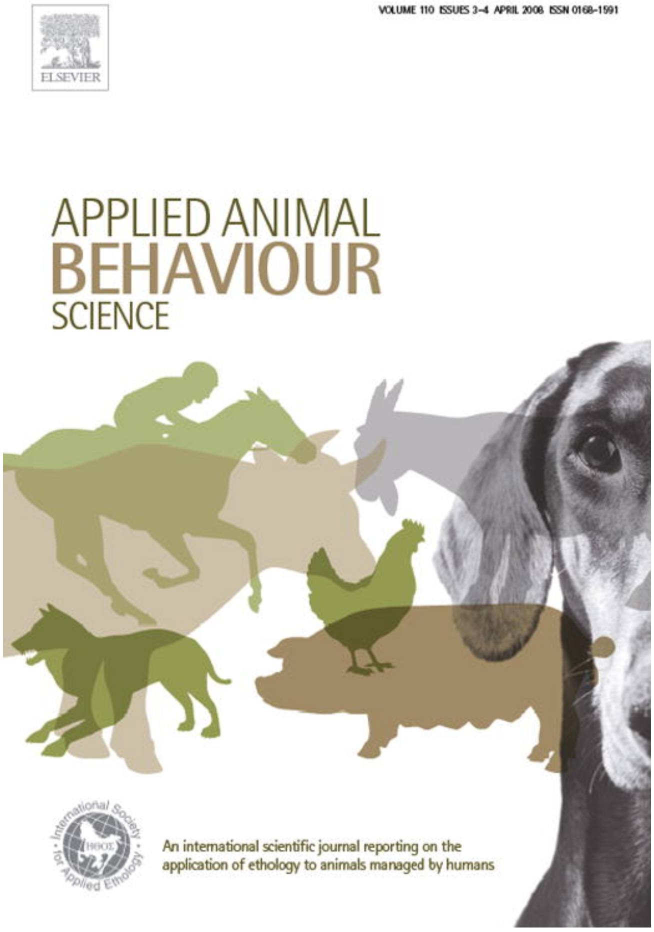
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Testing the efficacy of deterring systems in two gull species

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Abstract

During recent decades, populations of some gull species have dramatically increased causing management problems; as a result of this, a number of deterring systems have been implemented. In this study, three commonly used scaring methods (visual, acoustic, falconry) were tested at a refuse dump. In order to evaluate the efficacy of the methods and, in particular, habituation occurrence, an index was developed that can be used for comparing such methods and for evaluating their employment in an integrated management protocol. Although the tests lasted for a few weeks, the analytical methodology revealed that the employed methods were effective only for short periods of time.

Keywords: Anthropogenic food; Gull; Habituation; *Larus michahellis*; *Larus ridibundus*; Refuse dump; Non-lethal deterrent; Pest management

1. Introduction

The environmental problems caused by superabundant animal species, particularly ''bird pests'' have become increasingly acute during the past decades (Feare, 1991). Owing to their high ecological adaptability, their competitive behaviour and their abundance, gulls are often considered pests (Vidal et al., 1998). The feeding and roosting habits of gulls drawn by the new

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trophic resource available in refuse dumps are often considered a nuisance or responsible for damage to personal property, or else they affect human activities (Blockpoel, 1976; Benton et al., 1983; Belant, 1997; Raven and Coulson, 1997; Dolbeer and Eschenfelder, 2002; Rock, 2005).

A management policy to reduce access to anthropogenic resources, at least during the pre-laying period, could have an effect on the presence of gulls and on their reproductive success (Pons, 1991; Bosch et al., 1994; Kilpi and Ost, 1998; Duhem et al., 2002; Duhem et al., 2003). In the long-term, preventing access to a constant and highly predictable food source could result in a reduction in the presence of gulls in the area, favouring the reduction of economic impacts on human activities affected by gulls.

Dissuasive devices are used in integrated wildlife damage management to reduce the impacts of animals, but the effectiveness of such devices is often variable (Belant and Ickes, 1997; Blackwell et al., 2002; Baxter, 2000; Stevens et al., 2000). Non-lethal and non-chemical techniques are to be preferred in creating an environment unattractive to birds (Haag-Wackernagel, 2000). Although physical barriers can permanently exclude birds from a site, they may not be economical or compatible with the purpose or design of the facility. Visual and acoustical devices to scare and repel birds are often the methods for managing bird problems. However, the efficacy of most of these devices has not been objectively tested in the field (Stewart, 1984; Griffiths, 1988). Devices with ultrasonic (i.e., >18 kHz, the upper frequency level heard by humans) output are most appealing because they are not conspicuous or distracting and do not produce annoying sounds. The utility of ultrasonic sounds for repelling birds has no apparent biological foundation because most birds do not hear higher frequencies than humans can hear (Frings and Frings, 1967; Dooling et al., 2000). Pest birds such as starlings, *Sturnus vulgaris*, and house sparrow, *Passer domesticus*, have hearing ranges from 0.2 to 18 kHz (Brand and Kellogg, 1939; Summers-Smith, 1963), while those of pigeons, *Columba livia*, go from 0.1 to 10 kHz (Necker, 1983). In addition, even if birds could detect ultrasonic sounds, they generally become quickly used to sounds, and this would make the devices ineffective for long-term control (Murton and Wright, 1968; Bourdeau, 1975; Blockpoel, 1976; Murton and Westwood, 1976). Many other methods have been tested, such as eye devices (Woronecki, 1988), mylar flags (Belant and Ickes, 1997), bio-acoustic (Bridgman, 1969; Brough, 1969; Iljichev, 1986), pyrotechnics, chemical repellents (Belant et al., 1996, 1997a, b; Blackwell et al., 1999), laser beams (Blackwell et al., 2002) and integrated bird hazing systems (Stevens et al., 2000).

Due to the peculiar areas where dissuasive devices can be used (such as airports, mills, landfills, crops, etc.) and to the response of different species, the efficacy of the methods should be tested in advance and calibrated in order to obtain better results. We assumed that the test of a method, or the comparison of more than one, if carried out in a highly attractive place, and conducted with standardized methodology would give important information on their efficacy and applicability. Based on data obtained from experimental work, we propose the use of two new indexes that may be combined in evaluating the efficacy of deterring systems. As refuse dumps are highly attractive foraging sites for gulls, they were selected as testing sites.

2. Material and methods

2.1. Animals

We studied the response of the two most abundant species of *Laridae* in refuse dumps in Italy: the yellow-legged gull, *Larus michahellis* (Naumann, 1840), and the black-headed gull, *Larus ridibundus*

(Linnaeus, 1766). These species were chosen firstly because of their abundance in Italy and then because they are easy to test in the wild.

2.2. The test arena

Commonly used deterring methods were compared during a seven-week test period (six days per week) at a landfill in San Donà di Piave (45.63N 12.57E, Venice, Italy) in November–December 2003. The operating area was 1600 m^2, where the refuse is stocked and compacted by machines; non-operative portions of the area are covered by plastic.

2.3. Tested devices

2.3.1. Acoustic device

We used one AT-MU unit of the Aviotek Bird Guard System (Aviotek Engineering, 2000). This unit is made up of a group of wide spectrum and high output power noise generators; a matrix of highly efficient piezoelectric loud speakers is used as an element of electro-acoustic transduction. These allow the reproduction of sounds ranging from medium frequencies to ultra-sound (including distress calls and electronic sounds).

The unit generates random acoustic signals on frequency spectra that range from 2 to 45 kHz (130 dB measured at 1 m) creating an elliptical cone of acoustic signals that reaches a horizontal distance of 150 m and a vertical one of 100 m (the typology of ground and prevailing winds might influence these figures).

2.3.2. Visual scare

Two persons were equipped with white suits (workers habitually wear green suits), bright orange caps, shirts and flags (1 m^2). They were also equipped with a dummy pistol.

2.3.3. Falconry

A falconer (authorized by the Hunting and Fishing Office of the Province of Venice) used alternatively two hybrid falcons (*Falco peregrinu–Falco cherrug*) and applied falconry techniques to make them scare the gulls present in the dump area. They were used as game birds, not being allowed to hunt.

The AT-MU unit was positioned at one side of the study area; the two persons with flags and the falconer operated all around the area and could enter it if necessary.

2.4. Experimental plan, field work and data collection

Gulls were counted daily, each hour from 7.00 a.m. to 4.00 p.m., by one person (responsible only for counting but not taking part in the tests) using binoculars and a telescope (zoom 20–60×). Birds were counted hourly (and before and after the trials see 2.5 Behaviour recordings) and numbers were separately recorded in the inside (feeding) and outside (roosting) areas; for the outside area we took a 200-m strip all around the landfill. An average error of 10% was considered in the counting, that we considered constant since the counter was always the same person.

Treatment weeks were alternated with non-treatment ones, in a randomly assigned order. The ordinary activity of the gulls in the area was first monitored during an undisturbed pre-treatment week, U1; then the Acoustic device, A, Visual scare, V, and Falconry, F, treatments followed, each succeeded by one undisturbed week, respectively U2-3-4.

The acoustic device operated at regular intervals, following a random order of On/Pause timing six hours per day. The operator always counted the number of birds present before stimuli were deployed. The stimulus was always composed of random frequencies (2–45 kHz).

People in charge of the visual scare intervened simultaneously, walking into the treatment area, jumping up and down, waving their arms, shooting off pyrotechnics or noisemakers, or acting in a threatening manner each time the gulls attempted to land. The falconer operated by releasing the falcon in the middle of the gull feeding area and leaving it to fly above it.

The objective was to have the falcon fly among the gulls, threatening and scaring them. On occasions, the falcon would try to catch a bird that had flown away from the test area, but then the falconer would call the falcon back by whistling, shouting and gestures.

2.5. Behaviour recordings

During scaring treatments the number of birds was determined by additional counting before, during and after the stimulus. To establish a behavioural inventory, we chose behavioural patterns considered to be accurately measurable (Brémond and Aubin, 1990; Aubin, 1991):

- initial number of birds (*N*): the total number of birds counted prior to the treatment;
- first departure (FD): the time from the stimulus to the moment when the first individuals left the flock, flying overhead (in seconds);
- in addition, we considered three other behavioural patterns;
- first return (FR): first arrival back inside the disturbed area (in seconds) following the initial disturbance stimulus;
- number of departures (*n*FD): total number of birds that took off in response to the signal;
- number of returned birds (*n*R): number of birds back in the area after the trial; birds were counted when the flock of landed birds was almost stable and the birds started looking for food.

Supplemental observations of gulls' behaviour were made and the presence of ringed birds was recorded during the whole study period.

2.6. Statistical analysis

During the experimental period, we recorded meteorological data and the daily input of refuse recorded by the landfill operators, testing throughout the seven-week test period whether those factors had influenced the occurrence of gulls. The daily average temperature, recorded at the refuse dump, was correlated with the daily amount of refuse and with daily average numbers of gulls inside the test area.

2.6.1. Analysis of quantitative aspects

To perform descriptive analyses, daily and weekly presence data were summarized ($\bar{x} \pm$ S.D.). Runs test procedure was performed on daily numbers of the two species inside and outside the refuse dump in order to test dependence in the data set. Correlations between species and between species and different bird locations (inside and outside the study area) were tested using the Spearman rank test. We considered the average inside and outside numbers, and the sum of these, as dependent variables and time as an independent variable in Pearsons correlations. Multiple regression analysis was used to determine trends throughout the experimentation period. To perform trend analyses, an exponential smoothing model was used. This procedure smoothes out irregular components of time-series data, while the model assumes a linear trend and has no seasonality effect.

Non-parametric analyses on total daily numbers were computed to compare stimuli effects. First, we determined whether differences between control and stimuli periods were significant, using a Mann–Whitney test; then we used a Kruskall–Wallis test to compare these differences. These differences were compared (previous control-stimulus) to detect whether differences were significant and which was the most effective stimulus among the three proposed; for that, a Kruskall–Wallis test was computed.

2.6.2. Analysis of behavioural patterns

Behavioural elements documented the reaction of the gulls to different scaring devices. Two indexes are proposed for the determination of stimuli effect and their comparison.

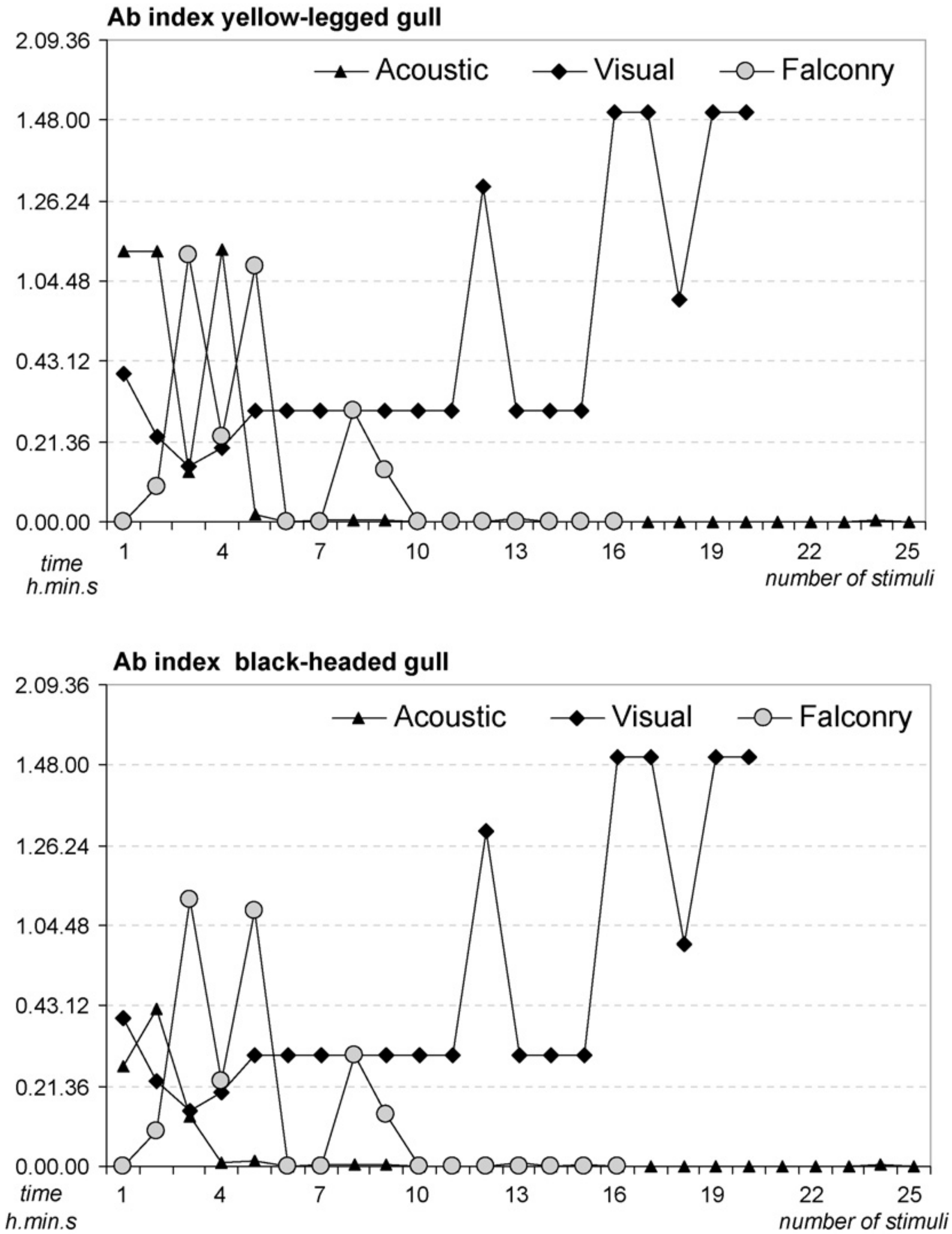

Fig. 1. Ab Index calculated for yellow-legged and black-headed gulls. The time of absence is reported in the *y* axis (h/min/s).

Absence (Ab) is determined by the time gulls take before coming back to the test area after they had been scared and flown away: Ab = (FR-FD) (Fig. 1).

Effect (E) describes the effect the scaring devices have on bird movements and their approach to the test area: $E = [(N - n\mathrm{FD}) - (n\mathrm{FD} - n\mathrm{R})]/N$ (Fig. 2). We did not calculate this second index for visual scaring because the actions were taken before the bird landed and N, nFD, nR were too approximate.For a better interpretation of the E index we could summarize:

- $E \geq 1$ no reaction (in the case of $E > 1$: more gulls arrived in the study area than were present at the start of the stimulus);
- $0 \leq E < 1$ weak reaction (the whole flock or a small part of it takes off and comes back again. Total numbers are unchanged);
- $1 \leq E < 0$ strong reaction (the whole flock flies away and none, or only a part, comes back).

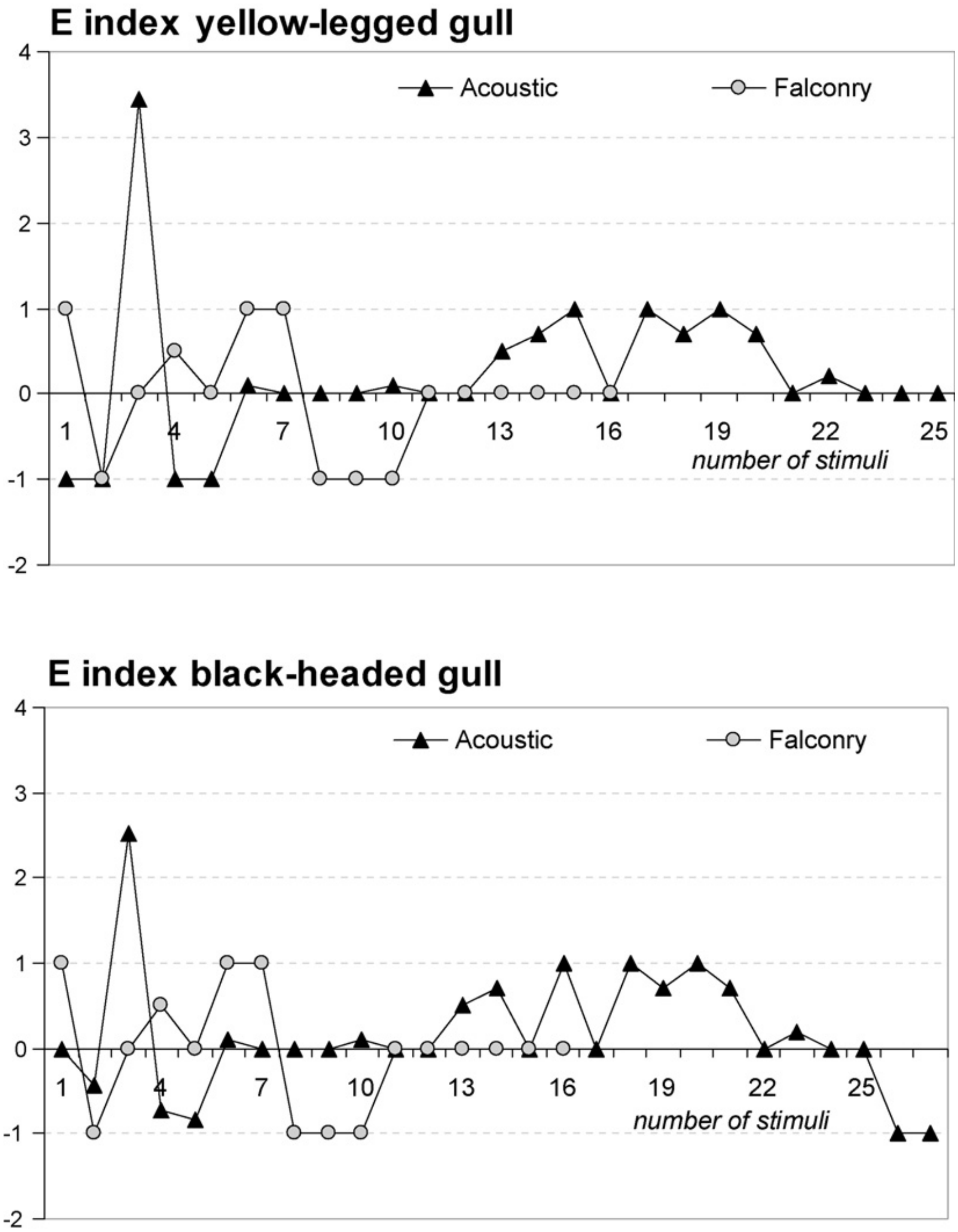

Fig. 2. *E* index calculated for yellow-legged and black-headed gulls, summarizing the effect the scaring devices have on bird movements and approach to the test area.

3. Results

3.1. Quantitative aspects

No correlation was found between bird occurrence, temperature or input of refuse. During the whole period of 37 days, we recorded a daily average number of 556 ± 394.05 yellow-legged gulls (max 1973.75–min 125.75) and 536 ± 228.81 black-headed gulls (max 981.25–min 41.25) (Table 1). The proposed treatments affected the average daily occurrence of both species inside the refuse dump (Table 1).

Data collected were randomly ordered; movements of the two species of gulls proved to be significantly correlated with each other both inside and outside the refuse dump (inside $r_s = 0.81$

Table 1
Average number of yellow-legged and black-headed gulls during each week of treatment counted at the San Donà di Piave refuse dump, in November–December 2003

	Gull-counting results						
	U1	A	U2	V	U3	F	U4
Yellow-legged gull							
In							
Mean	555.62	272.51	153.96	0.0	232.50	100.41	169.37
S.D.	27564	19191	17516	0.0	48.50	74.58	71.59
Range	210.6–957.5	87.5–625	0–474	0–0	157.5–275	0–193.7	118.7–220
Out							
Mean	520.33	458.44	432.67	295.10	279.75	200.62	218.21
S.D.	380.39	396.44	247.08	215.04	102.00	62.51	145.96
Range	111.7–1016.2	0–1090	206.2–910	125.7–712.5	172.5–425	100–280	115–321.4
Black-headed gull							
In							
Mean	272.54	191.83	145.83	0.0	303.75	151.35	283.12
S.D.	98.01	48.73	108.65	0.0	110.71	98.98	138.77
Range	146–411.2	126–250	0–318.7	0–0	137.5–400	0–287.5	185–381.2
Out							
Mean	160.29	509.52	503.54	201.48	431.25	443.96	480.13
S.D.	78.10	209.95	186.16	152.28	137.64	144.06	391.75
Range	43.4–250	200–802.5	225–750	41.2–487.5	250–587.5	393.7–670	203.1–757.1

U1, U2, U3, U4: control weeks, no dissuasive method applied; A, V, F: devices testing weeks, A, acoustic, V, visual, F, falconry.

$P < 0.05$; outside $r_s = 0.42$ $P < 0.05$), while no significant correlation was found between inside and outside numbers of each species considered separately ($P < 0.05$). We found a significant negative correlation of bird numbers with number of days after the beginning of the experiment (for the whole testing period) only for the yellow-legged gull ($P < 0.01$ all cases), while the black-headed gull showed a non-significant correlation with time ($P > 0.05$ in all cases). Taking the period as a whole, we observed a significant decreasing trend for the yellow-legged gull (inside $r = -0.57$ $P < 0.05$; outside $r = -0.47$ $P < 0.05$; and EXSMOOTH: inside trend = -9.395 $P < 0.05$; outside trend = -21.840 $P < 0.05$). There was no correlation between inside and outside numbers of this species ($r = 0.03$ $P > 0.05$). Whereas, with respect to the black-headed gull, our results demonstrated that there was no evidence of a trend (inside $r = -0.12$ $P > 0.05$; outside $r = 0.21$ $P > 0.05$; and EXSMOOTH inside trend = 5.659 $P > 0.05$; outside trend = -1.302 $P > 0.05$) and no correlation between inside and outside numbers ($r = -0.08$ $P > 0.05$). In fact, this species seemed to be less affected by the scaring devices in general: the average numbers were fairly constant considering the whole period (see Table 1).

The three methods yield significant decreases (‘‘decline’’) in inside numbers compared to the week prior to scaring (U), with the exception of U1-A and U3-F considering the black-headed gull (Mann–Whitney test, respectively, yellow-legged gull: U1-A: U = 4.0 $P = 0.025$, U2-V: U = 3.0 $P = 0.007$, U3-F: U = 4.0 $P = 0.045$; black-headed gull: U1-A: U = 6.0 $P = 0.055$, U2-V: U = 3.0 $P = 0.007$, U3-F: U = 8.0 $P = 0.20$). Comparing the magnitude of the ‘‘decline’’, we found that inside the refuse dump the three methods were significantly different for the yellow-legged gull (Kruskal–Wallis ANOVA by ranks, $P = 0.05$) and we can summarize the result: U2-V > U1-A > U3-F. The greatest ‘‘decline’’ came with the visual method/second scaring, V.

Regarding the black-headed gull, we found no significant differences in declines yielded by the three methods inside the refuse dump (Kruskal–Wallis ANOVA by ranks, $P = 1.25$). For both species we also considered total numbers, inside and outside the refuse dump, a non significant difference in ‘‘declines’’ being observed in the number of yellow-legged gulls (Kruskal–Wallis ANOVA by ranks, $P = 0.18$) and a highly significant one in that of black-headed gulls (Kruskal–Wallis ANOVA by ranks, $P = 0.001$).

3.2. Behavioural aspects

The acoustic (A) and the falconry (F) methods showed habituation effects at the end of the testing period. Thus we decided to analyse behavioural data calculating Absence and Effect indexes. The absence index (Ab) gave the same results for both species (Fig. 1). This index gives us a projection of the habituation process to the three tested devices summarizing and explaining in detail bird number fluctuations (Table 1). Actually, as we observed that larger gulls usually wait for black-headed gulls to land and start feeding before approaching the test arena after a trial, this could produce a similar trend in the two species when considering the absence period duration. Although Acoustic and Falconry initially evoked a clear response from the gulls, we observed mobbing behaviour oriented towards the device and the predator and longer time dispersion, compared with the effects of other two methods. However, after a few stimuli (5 and 6, respectively) responses were less evident. In fact, although there was some variable response initially to A and F, any effect was soon lost because birds became habituated. Consequently, absence periods have close to zero values, meaning no evident reaction (Fig. 1).

The Effect index (E) shows little difference between the yellow-legged gull and black-headed gull reactions (Fig. 2), probably due to the tendency of the yellow-legged gull to wait for the black-headed gull to land before approaching the test area. For both species, the first day of a test produced more evident reactions, and E tended to -1 more frequently. In the second part of the week of treatment, E values were between 1 and 0 denoting habituation to the stimuli.

4. Discussion

Our analyses indicated a slight difference between the two species throughout the testing period. The yellow-legged gull exhibited a negative trend in numbers and no correlation between inside and outside numbers, meaning that birds once scared disperse and move to quieter roosting and feeding areas. On the other hand, no trend was found in numbers of black-headed gull and no correlation between inside and outside numbers, meaning that birds move while waiting for the disturbance to stop, but in general, do not leave the area. Actually, we found that tested stimuli did not always produce significant differences in numbers of the two species compared to the week prior to scaring (U). Generally the outside numbers did not differ significantly, while the inside numbers were significantly different. Between the three tested deterring systems the most effective was visual scaring, confirming that only the on-demand deterrent system significantly reduces the probability of birds landing, as found for several bird guilds by Ronconi and St. Clair (2006).

Our behavioural analyses did not show differences between the two species, so while the proportion between species may change, their reactions are similar. Under natural conditions birds generally respond to a scaring situation by emitting distress calls and by a mobbing behaviour oriented towards the predator (Curio, 1978). The response of the gulls to the scaring stimuli on the first occasion that they were used was mostly to take off within a few seconds, to fly towards the source of the disturbance, to circle above and while gaining height to disperse. Later the reaction was less and less evident: they became habituated in periods shorter than a week. The newly proposed indexes (Figs. 1 and 2), and in particular the *E* index, proved useful to describe habituation occurrence and to evaluate simultaneously the two species reactions in terms of behavioural response. Of course, numerical comparisons give a quantitative description, but the use of the *E* index simplifies evaluation of the overall effects, standardizing in terms of bird abundance and enhancing reaction descriptors such as reaction duration.

As found in other studies (Bourdeau, 1975; Woronecki, 1988; Belant and Ickes, 1997; Blackwell et al., 2002; Haag-Wackernagel, 2000; Stevens et al., 2000; Baxter and Allan, 2006; Gagliardi et al., 2006; Ronconi and St. Clair, 2006), scaring devices do not work for long. Our analyses indicated that habituation arises quite rapidly, although the integration of more scaring methods might delay it. The Ab and *E* indexes may be used in preparing and validating protocols including a wide variety of scaring methods, the effectiveness of each of which may be monitored by calculating the Ab and *E* indexes to determine habituation occurrence and effects.

We probably selected the most difficult test scenario in terms of repelling birds from a site. In fact, we chose highly social and intuitive bird species and we tested scaring devices in a refuse dump (a highly attractive food resource) in wintertime, the most difficult period in terms of finding food supply. The reason for this was to have a close-to-limit-condition test field in order to test the efficacy of newly developed indexes in describing behavioural patterns. This should be the preference in terms of device selection, even when used in different areas (i.e., airports), in order to define trial duration and alternation of methods with a view to reducing the occurrence of habituation.

A wider knowledge of deterrence systems can be valuable, but ineffective if not supported by an effective refuse management policy. Preventing the access of gulls to anthropogenic resources may be the key to management policies in terms of pest control.

5. Conclusion

We suggest scaring methods should be tested in a close-to-limit-condition test field, determining the timing of habituation occurrence. This information may then be employed when preparing a dissuasive protocol including different scaring methods. Knowledge about scaring methods efficacy and bird habituation to them is essential for a more effective timetable in dissuasive protocols.

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