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Public acceptance of management methods under different human–wildlife conflict scenarios

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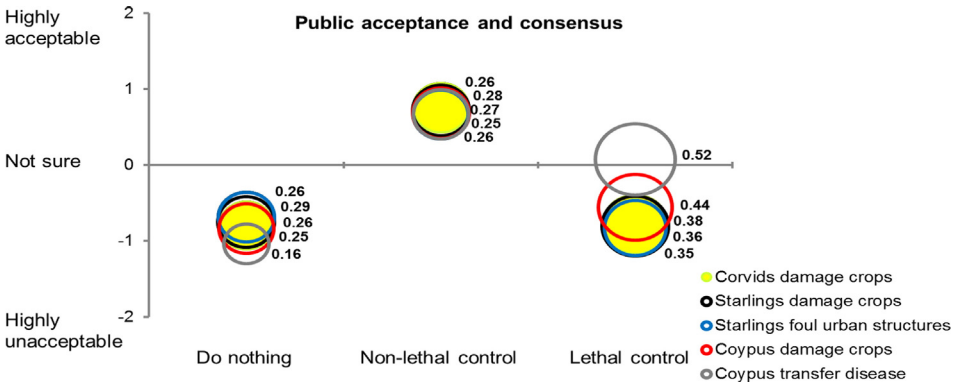
HIGHLIGHTS

- Public preferred non-lethal over lethal and no action options to control wildlife.
- Lethal control was controversial among segments of the public.
- Farmers and hunters were more supportive of lethal control than the general public.
- Support of lethal control increased with increasing threat level.
- Support of lethal control was higher for non-native than for native species.

GRAPHICAL ABSTRACT



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ABSTRACT

Wildlife management seeks to minimise public controversy for successful application of wildlife control methods. Human dimensions research in wildlife seeks a better understanding of public preferences for effective human–wildlife conflict resolution. In face to face interviews, 630 adults in Greece were asked to rate on a 5-point Likert-like scale their acceptance of 3 management methods, i.e., do nothing, non-lethal control, and lethal control, in the context of 5 human–wildlife conflict scenarios: 1) corvids damage crops; 2) starlings damage crops; 3) starlings foul urban structures; 4) coypus damage crops; and 5) coypus transfer disease. Univariate GLMs determined occupation, hunting membership and their interaction as the stronger predictors of public acceptance, generating 4 stakeholder groups: the general public, farmers, hunters, and farmers-hunters. Differences in acceptance and consensus among stakeholder groups were assessed using the Potential for Conflict Index$_2$ (PCI$_2$). All 4 stakeholder groups agreed that doing nothing was unacceptable and non-lethal control acceptable in all 5 scenarios, with generally high consensus within and between groups. The lethal control method was more controversial and became increasingly more acceptable as the severity of scenarios was increased and between non-native and native species. Lethal control was unacceptable for the general public in all scenarios. Farmers accepted lethal methods in the corvids and starlings scenarios, were neutral in the coypus damage crops scenario, whereas they accepted lethal control when coypus transfer disease. Hunters' opinion was neutral in the corvids, starlings and coypus damage crops and starlings foul urban structures scenarios, but they accepted lethal methods in the coypus transfer disease scenario. Farmers-hunters considered lethal control acceptable in all 5 scenarios. Implications from this study could be used for designing a socio-ecological approach which incorporates wildlife management with public interests. The studied species have a wide distribution, therefore present findings might also prove useful elsewhere.

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1. Introduction

Human–wildlife conflict (HWC) occurs "when the needs and behaviour of wildlife impact negatively on the goals of humans or when the goals of humans negatively impact the needs of wildlife" (Madden, 2004, p. 248). HWC can lead to outcomes adversely affecting human societies in varying degree of severity, such as crop damage, damage of private or public property, disease transmission to humans and livestock (Conover, 2002; Treves et al., 2006). Management methods that have been developed and applied for the prevention and mitigation of HWC can be categorised into non-lethal, which do not cause direct harm on wildlife (e.g., exclusion from crops, translocation, contraception) and lethal, which aim at the direct reduction of the population of the species in question (e.g., shooting, poisoning). Conflicts can arise when the level of acceptability of management methods for a species varies between different segments of the public. In addition, the acceptability of a method may vary between different HWC situations.

An understanding of how the public perceives particular management methods can help wildlife authorities minimise controversy when choosing among management alternatives (Decker et al., 2006; Teel and Manfredo, 2010). There are several studies in the literature on the preferences for wildlife management methods, mainly from North America (e.g., Loker et al., 1999; Sponarski et al., 2015; Teel et al., 2002), but also from Europe (e.g., Bremner and Park, 2007; Dandy et al., 2011; Jacobs et al., 2014) and elsewhere (e.g., Akiba et al., 2012; Kaltenborn et al., 2006; Koichi et al., 2013). Jacobs et al. (2014) found that goose management interventions were controversial among Dutch people. However, the acceptance of invasive methods such as 'shake eggs' and 'hunt', increased with increasing severity of the conflict, namely 'geese spoil recreation area' versus 'geese damage crops'. Frank et al. (2015) found that while the general public in Central Italy was in favour of providing preventive measures and compensation for ecological and economic damage of wild boar (*Sus scrofa*), they did not like approaches that directly impacted wild boar numbers. Farmers, the group most impacted by wild boar damages, supported all management tools as long as the approaches selected reduced wild boar economic impacts on agricultural land. Similarly to the general public, hunters were supportive of providing preventive measures and compensation. However, reducing wild boar density represented a controversial topic for this group since these practices subtract game from hunters and affect their ability to hunt. In this article, the acceptance among the Greek public of different management methods is examined in the context of different HWC scenarios to determine differences between stakeholder groups and inform sound wildlife management.

1.1. Potential for Conflict Index$_2$

Research studies in human dimensions of natural resources apply survey and analysis methods to measure and understand complex concepts such as motivations, attitudes and norms, mainly aiming at informing and improving decision making (Vaske, 2008). The Potential for Conflict Index$_2$ (PCI_2) and an associated graphic technique for displaying results were developed to facilitate understanding and interpretation of statistical information (Vaske et al., 2010). A detailed description of the program for calculating, graphing, and comparing PCI_2 values can be found at http://warnercnr.colostate.edu/~jerryv/PCI2/index.htm. PCI_2 ranges from 0.0 to 1.0. The least amount of consensus and greatest potential for conflict ($PCI_2 = 1$) occurs when responses are equally divided between two extreme values on a response scale (e.g., 50% highly unacceptable, 50% highly acceptable). A distribution with 100% at any one point on the response scale yields a PCI_2 of 0.0 and suggests complete consensus and no potential for conflict.

As an aid to understanding and interpretation, survey results can be visualised in bubble graphs (Vaske et al., 2010). Each bubble depicts the evaluation of a particular issue by the public or segments of the public (e.g., farmers, non-farmers). The size of the bubble depicts the magnitude of the PCI_2 and indicates the degree of potential conflict (or consensus) regarding acceptance of that issue. A small bubble represents little potential for conflict (i.e., high consensus) and a larger bubble represents greater potential for conflict (i.e., low consensus). The center of a bubble represents mean evaluative response as plotted on the y-axis. The bubble's location shows whether respondents' average evaluations for a variable are above, below, or at the zero neutral point (i.e., a management action is, on average, acceptable, unacceptable, or neutral). A large bubble that straddles the neutral line suggests that, although the mean evaluation is neutral, an action would be controversial among respondents. On the other hand, a small bubble above or below the neutral line indicates consensus among respondents on the acceptance or rejection of the action.

1.2. Formulation of hypotheses

Human dimensions research posits that important sociodemographic factors that are likely to differentiate public attitudes towards and preferences for wildlife management methods include age and gender (Agee and Miller, 2009; Akiba et al., 2012), occupation and place of residence (Kansky et al., 2014; Naughton-Treves et al., 2003), hunting membership (Brooks et al., 1999; Frank et al., 2015), species' provenance (Bremner and Park, 2007; Olszańska et al., 2016) and familiarity with local wildlife species and knowledge of impacts (Loker et al., 1999; West and Parkhurst, 2002).

Species commonly involved in HWCs in Greece include: a) corvids such as the hooded crow (*Corvus cornix*), the western jackdaw (*Corvus monedula*), and the Eurasian magpie (*Pica pica*); b) the European starling (*Sturnus vulgaris*); and c) the non-native Coypu (*Myocastor coypus*). Based on the literature and local knowledge, the effects of sociodemographic factors (i.e., age, gender, occupation and hunting membership), species' provenance and knowledge of species' presence in the area on the acceptability of three general management methods (i.e., do nothing, lethal control, and non-lethal control) were examined for five HWC scenarios: 1) corvids damage crops; 2) starlings damage crops; 3) starlings foul urban structures; 4) coypus damage crops; and 5) coypus transfer disease. Mean acceptance and PCI_2 were calculated and the following hypotheses were tested:

H1. Segments of the public will differ in mean acceptance of and consensus (i.e., PCI_2) for different management methods.

H2. Species' provenance (native or non-native) will influence mean acceptance of and consensus (i.e., PCI_2) for different management methods.

H3. The severity of HWC will influence mean acceptance of and consensus (i.e., PCI_2) for different management methods.

2. Methodology

2.1. Study area

The study area was in North Greece, in the District of Eastern Macedonia and Thrace, which includes a mosaic of forests, lowland plains and built environments. Agriculture is an important economic sector in the area, including seed producing crops (mainly corn, rice and sunflower), nuts (mainly almonds, walnuts and chestnuts), cotton, olives, fruits (mainly peaches, melons, figs, grapes, kiwis, cherries, apples and berries) and vegetables.

The family Corvidae includes species with widespread distribution, nine of which have been recorded in Greece (Handrinos and Akriotis, 1997). The hooded crow, the western jackdaw and the Eurasian magpie are lowland species resident in the study area. These species will hereafter collectively be referred to as corvids. The European starling, hereafter starling, also has a widespread distribution, being resident in North Greece, with migratory influxes in winter (Handrinos and

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Akriotis, 1997). Corvid and starling populations have increased due to the reduction in the use of toxic chemicals and their ability to exploit new sources of food and shelter in urban and rural areas (BirdLife International, 2004). Local farmers increasingly complain for loss of income because of corvids and starlings raiding their crops. Corvids in the area consume a great variety of seeds, nuts, fruit and vegetables (mainly tomatoes and pumpkins). Starlings mostly consume olives and fruit such as grapes, figs, cherries, and berries, mainly from late summer to late winter when they are most numerous. They will also take grains from sown fields and from livestock feeders. Starlings form huge flocks in winter, increasingly using urban areas in search of warmth and shelter for roosting (Clergeau and Quenot, 2007). In the project area, starlings often form large roosts in buildings or in trees near buildings. Although these roosts vary highly in size, time and space, they raise serious concerns among residents in terms of health risk, filth, noise, odour and corrosive acidity of droppings.

The coypu, also known as nutria, is a semi-aquatic rodent native to southern South America (Parera, 2002), which has been introduced for fur farming into Europe, Asia, Africa and North America (Bertolino and Genovesi, 2007; Carter and Leonard, 2002). Subsequently, the rodent has been accidentally and/or intentionally released into the wild, and several populations have become established along river banks and in wetlands. Coypus have a high reproductive rate, are mobile on land and in water, dig burrows and denude areas of vegetation before moving to another area. These behavioural characteristics of coypus can cause conflicts, such as damage to crops and natural vegetation, burrowing and undermining of riverbanks and irrigation systems and disease transmission with human populations (Panzacchi et al., 2007; Randall and Foote, 2005). For these reasons, coypu is on the list of the 100 World's Worst Invasive Alien Species (Lowe et al., 2004).

In Greece, coypus are present in rivers, lakes and irrigation canals, mainly in the north mainland, but also further south and on islands (Corfu, Lefkada), however their exact distribution and abundance is not known. The local populations are escapees from fur farms in Greece and adjacent countries (i.e., Bulgaria and F.Y.R.O.M.). Coypu sightings have been reported in riverbanks and irrigation canals throughout the project area. Local authorities increasingly receive complaints from farmers, mainly corn producers whose fields are located near water bodies, but also fruit and vegetable producers. Livestock farmers view the intruder as a 'big rat' and fear disease transmission from the rodent to their animals and ultimately to people through the food chain, mainly via fecal contamination of food and water.

2.2. Questionnaire design

A two-part questionnaire was developed. The first part of the questionnaire contained four sociodemographic questions: 1) gender (female or male); 2) age (aggregated into three classes: young: 18–34 yo, middle: 35–54 yo, old: 55+ yo); 3) occupation (recorded as farmer or non-farmer); and 4) hunting membership (recorded as hunter or non-hunter); and one question on the knowledge of species' presence: participants were asked if corvids, starlings and coypus occur in the places where they live and work (possible answers: yes, no, do not know).

The second part of the questionnaire contained five HWC scenarios: 1) corvids damage crops; 2) starlings damage crops; 3) starlings foul urban structures; 4) coypus damage crops; and 5) coypus transfer disease. Under each of these conflict scenarios, three general management methods were offered, varying in degree of harm to wildlife: 1) do nothing; 2) use non-lethal control; and 3) use lethal control. Survey questions were structured as, using scenario 1 as an example, 'Corvids are lowland species that often feed on agricultural crops. When they cause significant damage, how acceptable or unacceptable would be for you to: 1) do nothing; 2) use non-lethal control; 3) use lethal control'. Participants were then asked to rate each management method on a 5-point Likert-like scale as: "highly unacceptable" (−2), "unacceptable" (−1), "neither" (0), "acceptable" (1); or "highly acceptable" (2). The same rating scale was used for all HWC scenarios.

2.3. Sampling protocol and sample composition

The sample was collected in face to face interviews with Eastern Macedonia and Thrace residents, between October 2015 and February 2016. Cities, towns and villages were visited in all the District's Prefectures (i.e., Drama, Kavala, Xanthi, Rodopi, and Evros) during open market hours in an effort to assemble a sample representative of the area's gender and age structure. It took respondents 15 min on average to orally complete the questionnaire with the assistance of the interviewer. A total of 630 questionnaires were completed, with 54 refusals, yielding a response rate of 92.1%.

The study area's population of 608,000 has a 51% female/49% male gender ratio, whereas the age ratio, after excluding those under 18, is 30%/35%/35% in the 18–34, 35–54 and 55+ yo age classes respectively (ELSTAT, 2011). The sample's gender and age structure was not different to that of the population's (Table 1; gender: $\chi^2 = 0.028$, df = 1, $p = 0.836$, age: $\chi^2 = 1.811$, df = 2, $p = 0.404$).

2.4. Data analysis

The effects of gender, age, occupation, hunting membership and knowledge of species' presence on the mean response to each of the three management methods in the five scenarios were tested with univariate General Linear Models (GLMs). Effect size was calculated by partial Eta-squared (η_p^2) with $\eta_p^2 = 0.01$–0.059 being interpreted as a small effect, $\eta_p^2 = 0.06$–0.139 as medium and $\eta_p^2 > 0.14$ as a large effect (Cohen, 1988). Significant differences among groups were determined with pairwise Tamhane post hoc tests to account for heteroscedasticity. Repeated-measures ANOVA was used to compare mean responses within each management method across the five scenarios for each stakeholder group (general public, farmers, hunters, farmers-hunters). PCI_2 was also calculated for each of the three management methods in the five scenarios and differences were tested with pairwise *d* tests (Vaske et al., 2010).

Repeated-measures ANOVAs and GLMs were performed in SPSS 21 statistical package (IBM Corp.) and PCI_2 statistics were calculated using free online software (http://warnercnr.colostate.edu/~jerryv/PCI2/index.htm). Significance level was set at $\alpha = 0.05$.

3. Results

Overall results revealed consistent patterns in the level of acceptance of the 3 management methods by the participants, across the 5 HWC scenarios (Table 2). On average, survey participants considered the 'do nothing' management method unacceptable in all the scenarios: 'corvids damage crops' (scenario 1, mean response $\bar{x} = -0.80$), 'starlings damage corps' (scenario 2, $\bar{x} = -0.75$), 'starlings foul urban structures' (scenario 3, $\bar{x} = -0.69$), 'coypus damage corps' (scenario 4, $\bar{x} = -0.84$), 'coypus transfer disease' (scenario 5, $\bar{x} = -1.04$). Furthermore, participants were positive towards using 'non-lethal control' methods for resolving conflict in all the scenarios ($\bar{x} = 0.67$–0.76), while they rejected 'lethal control' as a management tool for scenarios 1 through 4 ($\bar{x} = (-0.83)$–(-0.56)), with their opinion being neutral when 'coypus transfer disease' (scenario 5, $\bar{x} = 0.07$).

Univariate GLMs tested for the effects of age, gender, occupation (farmer, non-farmer), hunting membership (hunter, non-hunter) and knowledge of species occurrence on the mean level of acceptance for each management method within each scenario (Table 2). Results suggested higher differences among segments of the public in the acceptability of 'lethal control' than the other methods in all the scenarios. Effect sizes were minimal or unimportant for all control variables in the 'do nothing' and 'non-lethal control' models in all the scenarios ($\eta_p^2 = 0.00$–0.05). Occupation and hunting membership had a stronger

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Table 1
Frequencies for sociodemographic and knowledge of species' occurrence groups of the survey participants ($N = 630$).

Sociodemographic variable		General public	Farmers	Hunters	Farmers-hunters	x^2	Cramer's V
	N	432	95	51	52		
	%[a]						
Age						15.11*	0.11
18–34	204	35.7	22.1	27.4	28.8		
35–54	211	34.7	29.5	31.4	32.7		
55+	215	29.6	48.4	41.2	38.5		
Gender						123.24**	0.44
Female	317	61.8	51.6	0.0	0.0		
Male	313	38.2	48.4	100.0	100.0		
Corvid occurrence						63.10**	0.22
Species present	414	56.0	82.1	86.3	96.2		
Presence unknown	159	32.9	10.5	13.7	0.0		
Species absent	57	11.1	7.4	0.0	3.8		
Starling occurrence						101.70**	0.28
Species present	310	36.1	72.6	74.5	90.4		
Presence unknown	196	40.5	15.8	9.8	1.9		
Species absent	124	23.4	11.6	15.7	7.7		
Coypu occurrence						136.90**	0.33
Species present	175	14.3	52.6	51.0	71.2		
Presence unknown	238	47.5	22.1	17.6	5.8		
Species absent	217	38.2	25.3	31.4	23.0		

[a] Column percentages within each control variable.
* $p < 0.05$.
** $p < 0.001$.

effect than age, gender and species occurrence on all 'lethal control' models. Effect sizes were minimal or medium for occupation ($\eta_p^2 = 0.03–0.08$) and hunting membership ($\eta_p^2 = 0.03–0.10$), and medium for their interaction ($\eta_p^2 = 0.06–0.10$). Age, gender and species occurrence had a small or unimportant effect on 'lethal control' models ($\eta_p^2 = 0.00–0.05$). The interaction between occupation and hunting membership generates 4 stakeholder groups: the general public, farmers, hunters and farmers-hunters. Chi-squared analysis of frequencies indicated important interrelationships between stakeholder and age, gender and species occurrence groups (Table 1). In particular, older participants were more likely to be farmers (48.4%), hunters (41.2%), or farmers-hunters (38.5%) than members of the general public (29.6%), whereas all hunters and farmers-hunters were male. Furthermore, those aware of the presence of corvids, starlings, and coypus in their area were to a higher degree farmers-hunters (71.2–96.2%), hunters (51.0–86.3%), or farmers (52.6–82.1%) than members of the

Table 2
Results from univariate GLMs testing for the effects of categorical factors on the mean responses for 3 management methods within 5 human–wildlife conflict scenarios.

Method/scenario	Mean score ± SD	Age		Gender		Occupation[a]		Hunting[b]		Occupation: hunting		Species occurrence[c]	
		F	η_p^2	F	η_p^2	F	η_p^2	F	η_p^2	F	η_p^2	F	η_p^2
Scenario 1 – corvids damage crops													
Do nothing	−0.80 ± 1.08	0.15	0.00	1.45	0.00	*10.65***	0.02	*4.65**	0.01	*5.65***	0.01	*4.40****	0.01
Non-lethal control	0.76 ± 1.09	0.09	0.00	2.35	0.01	0.59	0.00	0.22	0.00	0.82	0.00	1.89	0.01
Lethal control	−0.78 ± 1.28	*3.50**	0.01	*4.47**	0.01	*33.46****	0.05	*53.10****	0.08	*53.22****	0.08	*3.24**	0.01
Scenario 2 – starlings damage crops													
Do nothing	−0.75 ± 1.09	0.26	0.00	2.88	0.00	1.09	0.00	2.54	0.00	*2.96**	0.01	*8.70****	0.03
Non-lethal control	0.72 ± 1.08	0.34	0.00	*5.44**	0.01	0.18	0.00	1.19	0.00	1.28	0.00	*5.77***	0.02
Lethal control	−0.80 ± 1.27	*3.19**	0.01	*5.84**	0.01	*21.24****	0.04	*49.42****	0.07	*55.04****	0.10	*6.03***	0.02
Scenario 3 – starlings foul urban structures													
Do nothing	−0.69 ± 1.12	0.68	0.00	0.94	0.00	1.61	0.00	1.13	0.00	0.74	0.00	*5.34***	0.02
Non-lethal control	0.67 ± 1.10	0.53	0.00	0.48	0.00	0.08	0.00	0.23	0.00	0.22	0.00	*5.05***	0.02
Lethal control	−0.83 ± 1.26	*3.33**	0.01	*5.88**	0.00	*14.33****	0.03	*64.60****	0.10	*54.26****	0.08	*7.07****	0.02
Scenario 4 – coypus damage crops													
Do nothing	−0.84 ± 1.09	2.57	0.00	0.95	0.00	*8.11***	0.01	*4.53**	0.01	*4.88***	0.01	1.84	0.01
Non-lethal control	0.68 ± 1.09	0.04	0.00	*4.56**	0.01	3.24	0.01	1.65	0.00	0.25	0.00	1.74	0.01
Lethal control	−0.56 ± 1.39	*5.87***	0.02	*8.55****	0.01	*53.01****	0.08	*16.16****	0.03	*64.35****	0.09	*17.41****	0.05
Scenario 5 – coypus transfer disease													
Do nothing	−1.04 ± 0.98	0.14	0.00	1.41	0.00	*8.90***	0.05	2.82	0.01	*3.68**	0.01	1.04	0.00
Non-lethal control	0.67 ± 1.10	0.90	0.00	*10.97****	0.02	0.02	0.00	0.04	0.00	0.87	0.00	1.13	0.00
Lethal control	0.07 ± 1.49	*6.19***	0.02	*7.76***	0.01	*25.90****	0.04	*15.06****	0.03	*38.93****	0.06	*6.43***	0.02

All GLM models are significant ($p < 0.001$), except 'non-lethal control' in Scenario 1; significant effects (F values) are given in italics; effect sizes (partial Eta-squared, η_p^2) are also given.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
[a] Two-group factor: farmer, non-farmer.
[b] Two-group factor: hunter, non-hunter.
[c] Three-group factor: species present, species absent, presence unknown.

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general public (14.3–56.0%), suggesting that awareness was rather attributable to social identity than to knowledge of the species. Based on these findings we further investigate variation among stakeholder groups in the acceptability of management methods, and not among other demographic variables, to avoid bias in the interpretation of results.

3.1. Differences among stakeholder groups, within scenarios

3.1.1. Scenario 1 – 'corvids damage crops'

On average, all stakeholder groups agreed that 'do nothing' was unacceptable when 'corvids damage crops' (general public: $\bar{x} = -0.71$; farmers: $\bar{x} = -0.95$; hunters: $\bar{x} = -0.76$; farmers-hunters: $\bar{x} = -1.31$; Fig. 1a). Mean response from farmers-hunters significantly differed from the general public and hunters ($p < 0.05$). All 4 stakeholder groups agreed that 'non-lethal control' was an acceptable management method in scenario 1 ($\bar{x}$ range = 0.71–0.97). 'Lethal control' was unacceptable for the general public ($\bar{x} = -1.12$), moderately unacceptable for farmers ($\bar{x} = -0.47$), hunters were neutral ($\bar{x} = -0.08$), whereas farmers-hunters considered 'lethal control' as an acceptable method ($\bar{x} = 0.81$). Mean response from farmers and hunters significantly differed from the general public and farmers-hunters, with the two latter groups also significantly differing ($p < 0.05$). Level of consensus was moderate to high (i.e., low PCI_2 values) with no significant differences among stakeholder groups for the 'do nothing' (PCI_2 range = 0.14–0.27) and 'non-lethal control' methods (PCI_2 range = 0.25–0.31). Consensus for 'lethal control' varied among groups (PCI_2 range = 0.20–0.52), being significantly higher for the general public ($PCI_2 = 0.20$) than for farmers ($PCI_2 = 0.52$) and hunters ($PCI_2 = 0.40$; $p < 0.05$).

3.1.2. Scenario 2 – 'starlings damage crops'

On average, all stakeholder groups agreed that 'do nothing' was unacceptable when 'starlings damage crops' (general public: $\bar{x} = -0.68$; farmers: $\bar{x} = -0.79$; hunters: $\bar{x} = -0.86$; farmers-hunters: $\bar{x} = -1.13$; Fig. 1b). Mean response was significantly different between farmers-hunters and the general public. Level of consensus was moderate to high (PCI_2 range = 0.12–0.28), being significantly higher for the general public ($PCI_2 = 0.12$) than for farmers ($PCI_2 = 0.28$). The 'non-lethal control' method was acceptable by all 4 stakeholder groups in scenario 2 ($\bar{x}$ range = 0.59–0.91) with similar levels of consensus (PCI_2 range = 0.25–0.28). 'Lethal control' was unacceptable for the general public ($\bar{x} = -1.16$), moderately unacceptable for farmers ($\bar{x} = -0.46$), hunters were neutral ($\bar{x} = 0.02$), whereas farmers-hunters

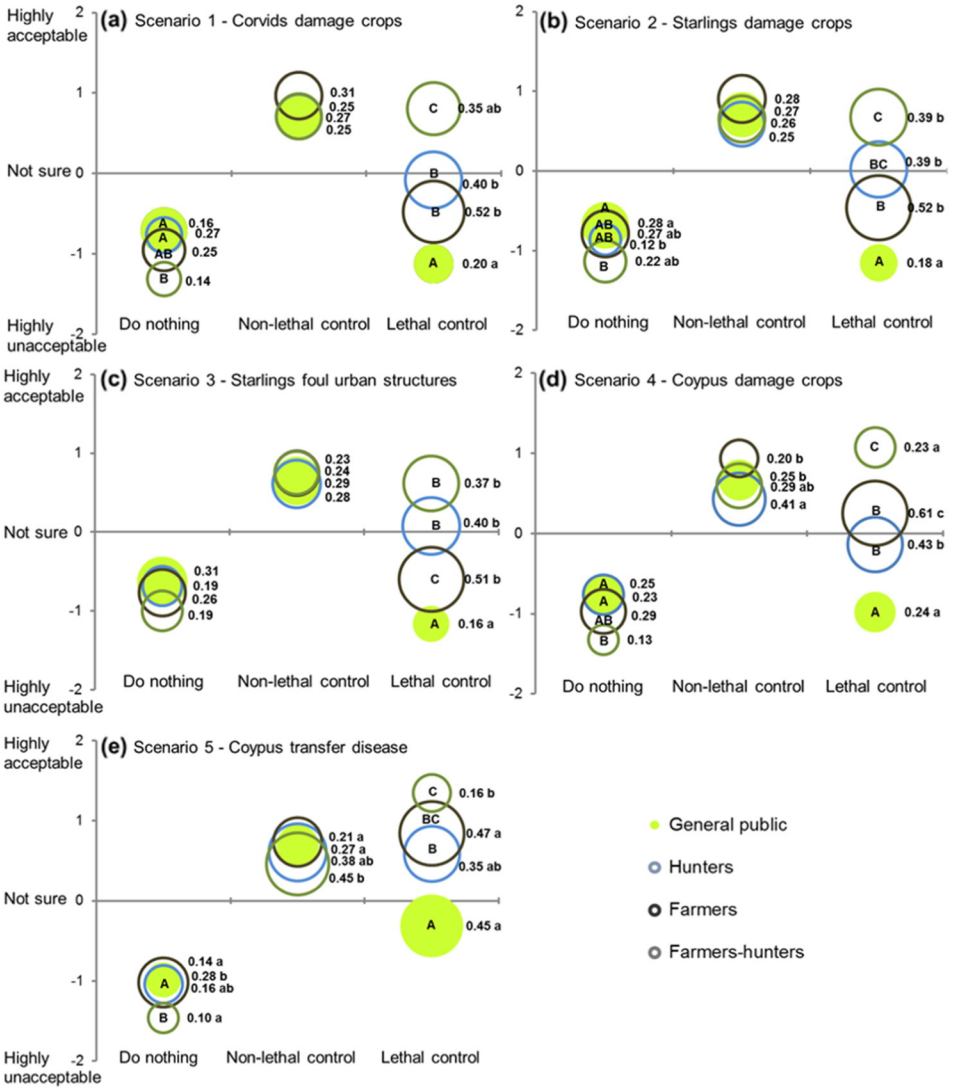

Fig. 1. Mean response scores with potential for conflict indices (PCI_2) by stakeholder group, regarding the acceptability of 3 management methods for 5 human–wildlife conflict scenarios of the survey participants ($N = 630$). In each management method, mean responses (bubble position) and PCI_2 values (bubble size) not sharing an uppercase (A, B, or C) or lowercase (a, b, or c) letter respectively, are significantly different ($p < 0.05$).

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considered 'lethal control' as a moderately acceptable method ($\bar{x}$ = 0.67). Mean response from the general public was significantly different than this from all other groups, with farmers' also being significantly different from farmers-hunters'. Level of consensus for 'lethal control' was significantly higher for the general public (PCI_2 = 0.18) than for farmers (PCI_2 = 0.52), hunters (PCI_2 = 0.39), and farmers-hunters (PCI_2 = 0.39).

3.1.3. Scenario 3 – 'starlings foul urban structures'

All stakeholder groups agreed that 'do nothing' was unacceptable with mean responses ranging from −1.00 to −0.63, and that 'non-lethal control' was acceptable ($\bar{x}$ range = 0.61–0.75). when 'starlings foul urban structures' (Fig. 1c). Level of consensus was moderate to high with no significant differences among stakeholder groups for the 'do nothing' (PCI_2 range = 0.19–0.31) and 'non-lethal control' methods (PCI_2 range = 0.23–0.29). 'Lethal control' was unacceptable for the general public ($\bar{x}$ = −1.16), moderately unacceptable for farmers ($\bar{x}$ = −0.60), hunters were neutral ($\bar{x}$ = 0.08), whereas farmers-hunters considered 'lethal control' as a moderately acceptable method ($\bar{x}$ = 0.62). Mean response from the general public was significantly different than this from all other groups, with farmers' also being significantly different from hunters' and farmers-hunters'. Level of consensus for 'lethal control' was significantly higher for the general public (PCI_2 = 0.16) than for farmers (PCI_2 = 0.51), hunters (PCI_2 = 0.40), and farmers-hunters (PCI_2 = 0.37).

3.1.4. Scenario 4 – 'coypus damage crops'

All stakeholder groups agreed that 'do nothing' was unacceptable when 'coypus damage crops' (general public: $\bar{x}$ = −0.76; farmers: $\bar{x}$ = −0.97; hunters: $\bar{x}$ = −0.76; farmers-hunters: $\bar{x}$ = −1.33; Fig. 1d). Mean response from the general public significantly differed from hunters and farmers-hunters. Level of consensus was moderate to high with no significant differences among stakeholder groups (PCI_2 range = 0.13–0.29). The 'non-lethal control' method was acceptable for all 4 stakeholder groups in scenario 4 ($\bar{x}$ range = 0.43–0.94). Level of consensus was significantly higher for farmers (PCI_2 = 0.20) and the general public (PCI_2 = 0.25) than for hunters (PCI_2 = 0.41). 'Lethal control' was unacceptable for the general public ($\bar{x}$ = −0.98), farmers ($\bar{x}$ = 0.25) and hunters ($\bar{x}$ = −0.14) were neutral, whereas farmers-hunters deemed 'lethal control' acceptable ($\bar{x}$ = 1.08). Mean response from farmers and hunters significantly differed from the general public and farmers-hunters, with the two latter groups also significantly differing. Consensus for 'lethal control' was significantly higher for farmers-hunters (PCI_2 = 0.23) and the general public (PCI_2 = 0.24) than for hunters (PCI_2 = 0.43) and farmers (PCI_2 = 0.61).

3.1.5. Scenario 5 – 'coypus transfer disease'

All stakeholder groups agreed that 'do nothing' was unacceptable when 'coypus transfer disease' (general public: $\bar{x}$ = −0.99; farmers: $\bar{x}$ = −1.02; hunters: $\bar{x}$ = −1.04; farmers-hunters: $\bar{x}$ = −1.46; Fig. 1d). Mean response from farmers-hunters significantly differed from all other groups. Level of consensus was significantly higher for farmers-hunters (PCI_2 = 0.10) and the general public (PCI_2 = 0.14) than for farmers (PCI_2 = 0.28). The 'non-lethal control' method was acceptable for all 4 stakeholder groups in scenario 5 ($\bar{x}$ range = 0.46–0.74). Level of consensus was significantly higher for farmers (PCI_2 = 0.21) and the general public (PCI_2 = 0.27) than for farmers-hunters (PCI_2 = 0.45). 'Lethal control' was moderately unacceptable for the general public ($\bar{x}$ = −0.31), acceptable for farmers ($\bar{x}$ = 0.84) and hunters ($\bar{x}$ = 0.59), and highly acceptable for farmers-hunters ($\bar{x}$ = 1.35). Mean response from the general public was significantly different than this from all other groups, with farmers-hunters' also being significantly different from hunters'. Level of consensus for 'lethal control' was significantly higher for farmers-hunters (PCI_2 = 0.16) than for the general public (PCI_2 = 0.45) and farmers (PCI_2 = 0.47).

Level of consensus for all stakeholder groups was generally higher for the 'do nothing' and non-lethal control' than for the 'lethal control' methods in all the scenarios. The differences in the mean acceptability of and consensus for the 3 management methods found among stakeholder groups support Hypothesis 1.

3.2. Differences within stakeholder groups, across scenarios

The 'do nothing' method was significantly less acceptable in scenario 5 than in scenario 3 for the general public and hunters (Table 3; $p < 0.001$). This method was also significantly less acceptable in scenario 5 than in scenarios 2, 3 and 4 for farmers-hunters, being also less acceptable in scenario 4 than in scenario 3 ($p < 0.001$). 'Doing nothing' was not significantly different among farmers across scenarios. Differences across scenarios in the acceptability of the 'non-lethal control' method were not significant for any of the stakeholder groups.

The 'lethal control' method became increasingly more acceptable as the severity of scenarios was increased and between non-native and native species. 'Lethal control' was significantly more acceptable in scenario 5 than in the other 4 scenarios for all the stakeholder groups ($p < 0.001$). It was also significantly more acceptable in scenario 4 than in scenarios 1, 2 and 3 for the farmers and farmers-hunters groups ($p < 0.001$).

Differences in the mean acceptability of and consensus for the 3 management methods were observed between scenarios involving native and non-native species and with increasing severity of conflict. These results support Hypotheses 2 and 3.

4. Discussion

4.1. Stakeholders' views towards the management of HWCs: the role of farmers, hunters and the general public

In general, doing nothing was unacceptable and non-lethal control acceptable as a management method for all stakeholder groups in all scenarios. Lethal control was deemed acceptable, unacceptable, or neither, with acceptability varying considerably among stakeholder groups in all scenarios. This general trend has also been reported by other similar studies (Jacobs et al., 2014; Kaltenborn et al., 2006; Sponarski et al., 2015). Doing nothing was becoming more unacceptable and lethal control more acceptable with increasing severity of the conflict, i.e., crop damage and fouling of urban structures versus disease transmission. The findings in this research are complementary to other findings where the general public preferred non-lethal actions and has also shown that acceptability ratings for wildlife management strategies vary by situational context (e.g., Decker et al., 2006; Don Carlos et al., 2009; Reiter et al., 1999; Wittmann et al., 1998; Zinn et al., 1998). In particular, they found a higher level of support for lethal management in situations involving higher incident severity (human and animal health and safety) than in situations of lower severity (economic damage, aesthetic deterioration, and nuisance).

Farmers and farmers-hunters supported lethal control of non-native coypus when they damage crops more than of scenarios involving native species, even when involving similar impacts. Coypus are large rodents that become highly invasive outside their native areas due to their high reproductive rates and expansive feeding behaviour, thus causing damage to agricultural crops (Bertolino and Genovesi, 2007). Invasive species control is highly controversial and research has suggested that the public was more supportive of the eradication of 'hated invasives', such as rats, than of 'attractive invasives' (Bremner and Park, 2007; Olszańska et al., 2016; Veitch and Clout, 2001). Greek farmers might well view these newly established alien animals as unattractive 'big rats'. This attitude, combined with the perceived threat to their livelihoods, might has raised farmers' support of lethal control options.

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Table 3
Repeated measures analysis of variance of mean acceptability scores within 5 human–wildlife conflict scenarios for each of 3 management methods and between stakeholder groups of the survey participants ($N = 630$). In each management method and stakeholder group, scenarios' scores not sharing a superscript letter (A, B, or C) are significantly different ($p < 0.05$, Tamhane post hoc tests).

Method/scenario[a]	General public	Farmers	Hunters	Farmers-hunters	Multivariate Wilks' λ	Within-subject Greenhouse-Geisser	Partial Eta squared (η_p^2)
Do nothing							
Scenario 1	-0.71^{AB}	-0.95	-0.76^{AB}	-1.31^{AB}	*9.70*[*]	*21.31*[*]	0.06
Scenario 2	-0.68^{AB}	-0.79	-0.86^{AB}	-1.13^{AC}			
Scenario 3	-0.63^{A}	-0.77	-0.69^{A}	-1.00^{C}			
Scenario 4	-0.76^{AB}	-0.97	-0.76^{AB}	-1.33^{A}			
Scenario 5	-0.99^{B}	-1.02	-1.04^{B}	-1.46^{B}			
Non-lethal control							
Scenario 1	0.72	0.97	0.71	0.71	2.14	4.21	0.01
Scenario 2	0.71	0.91	0.59	0.65			
Scenario 3	0.65	0.75	0.61	0.75			
Scenario 4	0.67	0.94	0.43	0.60			
Scenario 5	0.69	0.74	0.61	0.46			
Lethal control							
Scenario 1	-1.12^{A}	-0.47^{A}	-0.08^{A}	0.81^{A}	*38.08*[*]	*43.93*[*]	0.20
Scenario 2	-1.16^{A}	-0.46^{A}	0.02^{A}	0.67^{A}			
Scenario 3	-1.16^{A}	-0.60^{A}	0.08^{A}	0.62^{A}			
Scenario 4	-0.98^{A}	0.25^{B}	-0.14^{A}	1.08^{B}			
Scenario 5	-0.31^{B}	0.84^{C}	0.59^{B}	1.35^{C}			

[*] $p < 0.001$.
[a] Human-wildlife conflict scenarios are specified in Table 2.

Stakeholder groups showed similar support of non-lethal control. Farmers-hunters were the least supportive of the do nothing option, and at the same time the most supportive of lethal management. Lethal control was the most controversial option, with the general public showing the least support, as opposed to farmers-hunters. The higher preference of farmers and hunters for lethal management methods has been reported in many studies. Farmers have been found to be more positive towards lethal control compared to other methods and to the preferences of the general public, especially when wildlife species threaten their livelihoods (Frank et al., 2015; Naughton-Treves et al., 2003; West and Parkhurst, 2002). Hunters are consumptive users of wildlife resources sharing a utilitarian disposition towards animals (Kellert, 1980), and as such they are generally more supportive of lethal control of problem wildlife than other interest groups (Brooks et al., 1999; Naughton-Treves et al., 2003). However, they also have a long tradition of helping to conserve game animals and their habitat in many countries (Holsman, 2000; Loveridge et al., 2007). Research has shown that hunters' willingness to accept lethal control often varies by situational context. Black bear (*Ursus americanus*) hunters in Central Georgia (Agee and Miller, 2009) and wild boar hunters in Central Italy (Frank et al., 2015) did not accept lethal control of their game to reduce negative impacts. On the other hand, black bear hunters in Wisconsin supported lethal control of grey wolves (*Canis lupus*) when they attacked their hunting dogs (Naughton-Treves et al., 2003). The negative impacts caused by the high numbers of corvids and starlings in Greece have been recognised and these species are allowed to hunt during the hunting season, a largely unsuccessful measure as they are non-game species not targeted by local hunters. Corvids and starlings, but also coypus, are known to predate on birds' eggs and young, including gamebirds (Bertolino et al., 2012; Olsen and Schmidt, 2004; Tapper et al., 1996), a fact possibly contributing to the negative attitude of Greek hunters observed in this study.

4.2. Social conflict resolution for effective wildlife management

The analysis of public opinion, as extended by the PCI method, offered insights on the variation in the acceptance of wildlife management methods within and between groups. Differences between PCI_2 values showed that, although pest control was selected over the no action alternative, consensus was missing within and between groups regarding the management of HWCs. Lethal control was perceived as more controversial than non-lethal control, both within and between groups, a result similar to those reported in other studies (Akiba et al., 2012; Frank et al., 2015; Koichi et al., 2013; Sponarski et al., 2015). Such 'human–human conflicts' have been recognised to precede and reside within HWCs, owing to different interests and values between stakeholder groups (White and Ward, 2010). Conflicts between people need to be firstly resolved to achieve effective HWC management.

Although crows and starlings are allowed to hunt as a population control measure, it is considered as a temporary solution, as nearby conspecifics readily fill vacant space (Webb et al., 2012). On the other hand, a number of non-lethal techniques, including deterrents and repellents, have been applied and proved to be most effective (Honda, 2012; Peterson and Colwell, 2014; Seamans et al., 2001). Non-lethal techniques were supported by all stakeholder groups, with little controversy within and between them, and could be implemented by those most affected, the farmers. Lethal techniques were controversial among individual members of farmers and hunters. On the other hand, the general public formed the least supportive and most homogenous in opinion group. The short-term effectiveness of lethal control should be communicated to those groups. Population reduction could be selected for cases of extreme damage, and implemented by the farmers-hunters group, which was the most positive and cohesive towards such measures.

The provision of alternative food by planting river and canal banks has been proposed as a non-lethal measure for the reduction of crop damage by coypus. However, it needs to be implemented to a large area, it is very expensive, and ultimately ineffective (Bertolino and Genovesi, 2007). Given their high reproductive outcome and their linear expansion along waterbodies, the eradication of invasive coypu populations before they become established is considered as the most effective management method and has been successfully implemented in the UK (Gosling and Baker, 1989). In Italy, where coypu populations have been established and their eradication seems unfeasible, the reduction of coypu numbers through trapping and humane killing has been proved cost-effective in reducing crop damage (Panzacchi et al., 2007). Non-lethal control was supported by all groups, being more controversial among hunters and farmers-hunters. Lethal control was most controversial among farmers, whereas farmers-hunters formed a more supportive and homogenous in opinion group. The general public held the most negative attitude regarding lethal control, being more controversial when coypus transfer disease. The acceptance of non-lethal methods and the high controversy over the lethal methods indicate that public opinion is not well informed on the effective management

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of coypus. The opinions of farmers and hunters are rather based on their interests and values than being informed decisions. Once the potential for damage has been established and the most suitable management method selected, appropriate education programmes should aim at the communication of information and the reduction of conflict among segments of the public. After resolving the 'human–human conflict', lethal control could be implemented with the help of farmers-hunters, the most supportive and cohesive group regarding such methods.

5. Conclusions

The findings of this survey gave insights on the acceptability of and consensus for wildlife management methods by segments of the public, under different HWC scenarios. As such, they can be used to guide wildlife managers to select from an array of acceptable measures, minimise social conflict, and ultimately achieve effective pest management:

- Occupation and hunting membership were the stronger predictors of public acceptance.
- Stakeholder groups opposed to doing nothing as a management method with generally high consensus within and between groups.
- Stakeholder groups accepted non-lethal management methods with generally high consensus within and between groups.
- Farmers and hunters were the most supportive of lethal management methods, a highly controversial option, divisive within and between groups.
- Support of lethal control was increasing with increasing severity of the HWC scenario; fouling of urban structures, crop damage, and disease transmission.
- Support of lethal control was higher for non-native species (i.e., coypus) than for native species (i.e., corvids and starlings), even when the same HWC scenario was considered (i.e., crop damage).
- Based on acceptance and consensus ratings, farmers should be used for the support and implementation of non-lethal management of corvids and starlings, and farmers-hunters for lethal management of coypus.

Public preferences for wildlife management were controversial and not always directed at the methods considered as the most effective for reducing conflict. District authorities, such as the Forest Service, responsible for the management of wildlife and hunting, and the Directorate of Agricultural Economy, should develop and implement tailored education and outreach programmes to communicate effective wildlife damage management strategies. Farmers, hunters and the general public need to be provided with detailed information on the species involved in the conflict, the extent of the incurred damage and economic costs. They should also be provided with descriptions of available management methods and the rationale behind selecting specific methods for controlling wildlife species. This information should be communicated through the social media (e.g., Facebook), local media (newspapers, TV and radio stations), lectures in public meetings, and other educational means (e.g., pamphlets, posters). Clarifying the issues involved in specific HWCs is necessary to direct public preferences towards most effective management methods, thus reducing human–human conflict and allowing for the adoption of a socio-ecological approach which incorporates wildlife management with public interests.

The HWCs studied in Eastern Macedonia and Thrace involve species with a wide distribution (corvids, starlings; BirdLife International, 2004) or introduced to many countries (coypus; Carter and Leonard, 2002). Therefore, their associated types of damage are pertinent to other areas in Greece and other countries, and implications from this study might also prove useful for these other areas. Additional studies should investigate public preferences for specific non-lethal (e.g., crop covering, scaring, provision of alternative food) and lethal (e.g., trapping and euthanising, shooting, poisoning) management methods. Farmers, which are more exposed to economic loss from agricultural pests, and hunters, which are more utilitarian in attitude, are generally more supportive of lethal management methods than the general public (Frank et al., 2015; Naughton-Treves et al., 2003; this study). Research should further determine whether the public's preferences for wildlife management methods are based on their knowledge of conflicts and suitability of methods, or they are solely based on the interests, values and beliefs of different stakeholder groups.

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