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RESEARCH

Assessing pupils' knowledge and attitudes towards Eurasian lynx (*Lynx lynx*) for future conservation actions

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Abstract
Understanding public attitudes toward wildlife is crucial for the success of conservation efforts, particularly for species that might elicit mixed perceptions. For the first time in Slovenia, we conducted a study on attitudes and knowledge about the Eurasian lynx among primary, lower and upper secondary school pupils. Participants between the ages of 9 and 19 took part in the survey (N=1312). The aim of the study was to determine the general acceptance and knowledge of the lynx and identify the key factors that influence the formation of attitudes and knowledge. The survey results show a good acceptance of the species among the younger generation and a high level of support for its conservation. A higher amount of knowledge was positively associated with less fear of the species, more interest in learning and higher support for conservation. Living in a region with a permanent lynx presence was associated with less fear and more interest in learning about the species. No differences in acceptance and support for lynx conservation were detected between regions with or without the permanent presence of the species. Year of education was positively associated with the amount of knowledge about lynx, while gender was partially associated with the amount of fear but mainly with support for conservation. Against this background, we provide guidance for planning future communication and education activities for the long-term conservation of the species.

Keywords Eurasian lynx · Pupils · Attitudes · Knowledge · Education · Conservation

Introduction

As human behaviour is often reflected in various environmental issues (Cheng and Monroe 2012), wildlife conservation, including large carnivores in anthropogenic landscapes, can be very complex (Chapron et al. 2014). Therefore, solutions based on expert and policy decisions alone are often insufficient for long-term conservation (Cheng and Monroe 2012), but they also need to incorporate societal considerations and approaches (Dechner 2021). In this respect, human tolerance is thus one of the most important aspects on which large carnivore conservation must be based (Ripple et al. 2014). Tolerance has been described as a personal value that influences attitudes (Allport 1954), as a moral virtue (Butrus and Witenberg 2013), as a personality trait, and also as a learned competence - and therefore crucial for conservation (Belasheva 2014). It is also defined as passive acceptance, which can be studied in the context of research on human attitudes and behaviour (Bruskotter and Wilson 2014). As attitudes are an important element of behaviour (e.g. Ajzen 1985; Stern and Deitz 1994) and are based on multiple criteria: cognitive, emotional and practical (Asmolov 1998), studying the knowledge and perceptions of wildlife, including large carnivores, is crucial (Lischa et al. 2019).

Most research on attitudes, perceptions, and knowledge of large carnivores focuses primarily on wolves and brown bears and is based on sampling within the general public and key stakeholders. Fewer surveys have focused on assessing attitudes and knowledge about Eurasian lynx (*Lynx lynx*), and even these focused primarily on adult audiences (e.g. Zeiler et al. 1999; Bath et al. 2008; Majić 2008; Liukkonen et al. 2009; Balčiauskas et al. 2010; Lescureux et al. 2011; Bele et al. 2022b; Mavec et al. 2024; Whiley

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and Tzanopoulos 2024). Most studies indicate a higher tolerance for the Eurasian lynx than for wolves or brown bears, which can be attributed to the non-conflict nature of the lynx since conflict situations (e.g. damage to property or injury to humans) are rare compared to wolves and brown bears (Breitenmoser et al. 2000) or larger cat species (e.g. Dechner 2021). A lower acceptance of the Eurasian lynx can be found among small livestock breeders, especially in areas with free grazing and in the absence of other large carnivore species, but in general, the Eurasian lynx is perceived far less as a conflict species compared to wolves or brown bears (Bautista et al. 2019).

In contrast to the less frequent conflicts in agriculture, the lynx is often perceived as a hunting competitor. Hunters are, therefore, widely recognised as an important stakeholder group whose tolerance of lynx is crucial for the long-term conservation of the species (Bautista et al. 2019; Heurich et al. 2018). It is also important to note that negative feelings are deeply rooted in human culture and can persist for centuries after the absence of predatory species in the environment (Kellert et al. 1996). In the past, lynx went extinct in Slovenia and was reintroduced in 1973, with hunters being the main initiators (Breitenmoser et al. 1998). As part of the international lynx reinforcement project LIFE Lynx (LIFE16 NAT/SI/000634, https://www.lifelynx.eu/), which took place between 2017 and 2024, they have been involved in the whole process, from population monitoring, translocations of lynx individuals, to communication in the local environment and more widely. The overall history of hunter involvement in lynx conservation, the high level of acceptance of the species by hunters and their commitment to its conservation in Slovenia (Bele et al. 2022b), is of utmost importance for the long-term conservation of the species.

Although the tolerance of large carnivores is being widely researched, managers still lack information on influencing factors and actions that affect tolerance to develop effective communication strategies and mitigate human-large carnivore conflicts (Gigliotti et al. 2000; Bruskotter et al. 2015). In this regard, continuous studies of attitudes, behaviours, and their influencing factors are crucial (Cheng and Monroe 2012; Ripple et al. 2014). Bruskotter and Wilson (2014) proposed a hazard acceptance model to address better the factors that influence tolerance of large carnivores. The model focuses on cognitive factors and emphasises the perceived costs and benefits of the species as primary drivers. The individual's control over danger, feelings towards the species, and trust in authorities are considered secondary. When people associate large carnivores with high risk, their tolerance towards the species tends to be lower (Treves and Karanth 2003; Eriksson et al. 2015; Knopff et al. 2016). If not maintained and promoted, reduced tolerance can lead to the rejection of the conservation of populations, promoting their reduction and encouraging extreme behaviours such as poaching (Treves and Bruskotter 2014). Management measures associated with maintaining and promoting tolerance can contribute to large carnivores' long-term persistence and conservation (Bruskotter and Wilson 2014). In this regard, conservation education has already been highlighted as an important tool for achieving this goal (Trombulak 2004).

Although a more holistic ecosystem approach is increasingly being adopted in conservation biology, a generalised common approach (especially in communication) to addressing challenges with large carnivores can result in causing problems rather than solving them (Trajçe et al. 2019). Given the different levels of acceptance of species and the different causes of conflict with each species, it makes sense to plan targeted conservation and communication activities for each species (Karlsson and Sjöström 2008; Boitani et al. 2015; Trajçe et al. 2019; Oražem et al. 2022). To plan effective communication and education measures, data on the knowledge, attitudes and influencing factors regarding large carnivores in the younger population, as future decision-makers (Consorte-McCrea et al. 2016) must also be collected, especially to understand young people's behaviours and determine the skills they need to be proactive in the future (Bradley et al. 1999).

To date, few studies have focused on the attitudes and knowledge of primary school children and adolescents towards large carnivores (e.g., Ambarli 2016; Bath et al. 2008; Prokop and Kubiatko 2008; Prokop and Tunnicliffe 2010; Randler et al. 2020; Schlegel and Rupf 2010; Skogen 2001). However, the attitudes and knowledge of this stakeholder group on the Eurasian lynx remain the least researched.

To fill the knowledge gap, the survey aimed to assess the knowledge and attitudes towards lynx among primary, lower secondary and upper secondary school pupils in Slovenia. In addition to obtaining the general information regarding attitudes and knowledge, the survey further explored which factors may be associated with greater support for the conservation of the species. Also, a notable objective of the present study was to find out whether there are differences in participants' attitudes and knowledge depending on where the lynx was permanently present and where it was translocated.

Methods

A survey of 1312 primary and secondary school pupils was conducted to obtain information on knowledge and attitudes towards the Eurasian lynx. First, the data were digitised, and then principal component analyses were carried out to identify different 'attitude dimensions' (principal components).

In addition, we used a multivariate analysis to assess the influence of independent variables on pupils' attitudes towards the Eurasian lynx. Further analyses were conducted using non-parametric (Kruskal-Wallis and Mann-Whitney U test) statistical tests to assess the influence of selected independent variables on pupils' attitudes and knowledge.

Participants

Schools from different regions of Slovenia were invited to participate in a study to assess the attitude and knowledge of pupils on the Eurasian lynx. A total of 1312 pupils (age: 9–19 years with an average difference of one year per grade) from primary school (4th and 5th grade), lower secondary school (6th to 9th grade), and upper secondary school (10th to 12th grade) took part in the study (Table 1). The sample consisted of 24.6% primary school pupils ($n=323$), 39.4% lower secondary school pupils ($n=517$) and 36.0% upper secondary school pupils ($n=472$). The mean age of the total sample was 13.6 (SD=2.70). Broken down by gender, 44.5% were male ($n=584$) and 54.0% female ($n=708$). Twenty pupils (1.5%) did not provide any information on their gender. The sample was evenly distributed between the Alpine and Dinaric regions: 50.8% ($n=666$) of the pupils came from Upper Carniola, and 49.2% ($n=646$) from the statistical region of Southeast Slovenia. Most pupils lived in a house with a garden (64.2%, $n=842$). Half as many pupils, namely 31.4% (412), lived in apartments or houses without a garden, and only 53 pupils (4%) stated that they lived on a farm. At the time of the survey, more than half of the respondents regularly visited the forest: 27.5% of pupils ($n=361$) spent time in the forest several times a week, and 29.1% of pupils ($n=382$) visited the forest once a week. By contrast, many respondents visited the forest only once a month (19.1%, $n=251$) or less frequently (22.2%, $n=291$). Due to the uneven distribution of pupils according to the place of living and seeing lynx in nature, those independent variables were excluded from further analyses.

Table 1 Independent variables (IV) description and the distribution of pupils according to the selected IV

Independent variables	Variable description	f	f (%)
Gender	Female	708	54.0
	Male	584	44.5
	No response	20	1.5
School year (grade)	4	163	12.4
	5	160	12.2
	6	118	9.0
	7	143	10.9
	8	134	10.2
	9	122	9.3
	10	139	10.6
	11	184	14.0
	12	149	11.4
Residence	Alpine	666	50.8
	Dinaric	646	49.2
Place of living	House with a garden	842	64.2
	Apartments or houses without a garden	412	31.4
	Farm	53	4.0
	No response	5	0.4
Frequency of forest visits	Several times per week	361	27.5
	Once a week	382	29.1
	Once a month	251	19.1
	Rarely	291	22.2
	No response	27	2.1
Seeing lynx in nature	Yes	109	8.3
	No	1191	90.8
	No response	12	0.9

Research design

As young people are one of the most important target groups for future conservation and protection activities, we have actively targeted them in the LIFE Lynx project. However, as the attitudes and knowledge about lynx among children and adolescents in Slovenia have not been surveyed, we wanted to fill this knowledge gap. In parallel with the project activities, we carried out an anonymous cross-sectional survey to obtain up-to-date data on knowledge and attitudes towards lynx in two areas: (a) among respondents where lynx is permanently present (the Dinaric area), and (b) among respondents in the Alpine area, where the first lynx specimens were translocated in April 2021.

Measures

A methodologically similar questionnaire (see S1) was previously used to assess attitudes and knowledge about wolves (Oražem in Tomažič 2018; Oražem et al. 2019; Randler et al. 2020) and brown bears (Oražem in sod. 2021), was used to assess pupils' attitudes and knowledge about lynx. The questions for primary school were tailored to the level of reasoning and understanding of this age group, but the content was the same as for secondary schools. In the first part of the questionnaire on attitudes and knowledge about the lynx (LAK-Q), 15 attitude items (statements) were used, covering different attitude dimensions: (1) willingness to learn about the lynx; (2) acceptance (fear) of the lynx; and (3) attitude towards conservation of the species. A 5-point Likert scale was used to express the degree of agreement or disagreement with each attitude statement. The second part of the questionnaire contained questions on knowledge about the Eurasian lynx, which were true/false statements ($n=21$) and multiple-choice questions ($n=9$). A "don't know" option was provided for each question to reduce the

possibility of guessing. The questions were related to the biology of the Eurasian lynx, its management, its conservation and the assessment of factors that might influence the respondents' views and knowledge. In the third part of the questionnaire, the socio-demographic data of the respondents were collected.

Data analysis

First, the raw data from the questionnaires was typed into Microsoft Office Excel and transferred to the SPSS 25.0 program (SPSS, IBM Germany, Ehningen). To reduce the number of dependent variables and group them into individual attitude dimensions (set of variables), principal component analysis (PCA) with direct oblimin rotation was used (see Table 1). The Kaiser–Meyer–Olkin (KMO) test (KMO = 0.843) and Bartlett's test for sphericity ($\chi 2 = 5562.472$, df = 91, $p < 0.001$) (Leech et al. 2005) were applied to test the adequacy of the analysis for the data set. For the final results, an eigenvalue above 1.0 and loadings of at least 0.40 were considered. Cronbach's α coefficients were calculated to test the internal consistency reliability of the extracted principal components (PC); values above 0.6 confirmed the appropriateness of the construct (Leech et al. 2005).

Fourteen out of fifteen statements were categorised into three PCs: Interest to learn (PC 1), fear-acceptance (PC 2), and conservation (PC 3). The three components explained 55.98% of the total variance. The item "*We should spend more money on lynx protection (S8).*" did not load to any principal components and was therefore eliminated from further analysis. For each extracted principal component, means and standard deviations were calculated. The extracted PC scores (see Results) were used as dependent variables to build General Linear Models (GLMs, McCullagh 2019), and we tested their dependence on five independent variables. The independent variables were gender, grade, region of residence, frequency of forest visits, and knowledge. Gender was treated as a binary variable, grade as categorical (nine levels, from 4th to 12th grade), region of residence as binary (Alpine/Dinaric), frequency of forest visits as categorical (four levels), and knowledge as a continuous variable represented by the exam scores (see Table 1). We compiled a set of candidate models for each dependent variable (i.e., PCA score) separately and conducted model selection procedures step wisely, where each model represented a plausible hypothesis (including possible interactions between independent variables). To build a plausible hypothesis, we tested for correlations between the independent variables and performed a PCA including the five independent variables before model selection. We started by building models with a single independent variable and continued by adding variables that showed the most support. Prior to GLM model selections, we selected the best models based on AICc values and their weights (Akaike's Information Criterion, Anderson and Burnham 2004). All analyses were performed using R version 4.4.1 (R Core Team 2024).

The influence of independent variables on pupils' attitudes contained in the GLMs was assessed using Mann-Whitney and Kruskal-Wallis tests. A summed knowledge score was used to categorise pupils' achievements, which were further compared to their attitude scores. The three knowledge categories were calculated: low < M– 1SD, middle = M ± 1SD and high > M + 1SD achievement.

Results

Using Principal Component Analysis (PCA), attitudes toward the Eurasian lynx were categorised into three distinct scores: "Interest in learning," "Fear-acceptance," and "Conservation" (Table 2). "Conservation" did not meet normality assumptions and was therefore considered in GLMs as Gamma distributed. When these three PCA scores were treated as dependent variables, Generalised Linear Models (GLMs) incorporating a majority of the independent variables received strong statistical support for all three attitude dimensions (Table 3). The effects of region, gender, grade, frequency of forest visits and amount of knowledge were further investigated individually (Figs. 1, 2, 3, 4 and 5). Region of living was associated with interest in learning, fear and the amount of knowledge (Fig. 1). Gender differences were reflected in fear and conservation support of the species (Fig. 2). Differences between grades were evident in the interest in learning, conservation, and knowledge (Fig. 3). The frequency of visiting forests affected attitudes and knowledge scores (Fig. 4). The amount of knowledge was related to more positive attitudes of the respondents (Fig. 5).

Principle component analysis of attitudinal items

PCA analysis showed that Both Kaiser–Meyer–Olkin measure of the sampling adequacy test and Bartlett's test for sphericity show the appropriateness of using PCA on this dataset (Table 2). The KMO values exceeded the critical value of 0.70, and item loadings of > 0.40 were found. PC I was named "*Interest to learn*", PC II "*Fear - acceptance*", and PC III "*Conservation*". Cronbach's α for the total scale was 0.78. Cronbach αs for PC I was 0.88 and 0.72 for PC II (satisfactory, both above 0.69). Cronbach α for PC III was lower −0.62. Lower scores (mean values) on the "Fear-acceptance" and "Conservation" dimensions present

Table 2 Principal component analysis (PCA) of attitude statements toward Lynx

Questionnaire attitude items	Principal components (PCs)		
	I	II	III
Interest to learn			
I want to learn about the lynx habitats. (S10)	0.867		
I would like to know more about the evolutionary development of the lynx species. (S13)	0.848		
I want to learn about lynx. (S1)	0.807		
I want to know how lynx prey. (S4)	0.783		
I like to watch popular science shows about lynx. (S7)	0.771		
Fear - acceptance			
I would be afraid to walk in the woods if I knew lynx were present. (S15_R)*		0.841	
I'm afraid of lynx. (S12_R)*		0.754	
I would only camp where there would be no lynx. (S9_R)*		0.725	
I would accept the presence of lynx in the forests nearby. (S3)		0.540	
Lynx do not belong in the vicinity of human settlements. (S6_R)*		0.522	
Conservation			
It would be best to shoot all the lynx. (S2_R)*			0.751
Lynx is not important in the ecosystem. (S5_R)*			0.678
Lynx do not need to be preserved in Slovenia because they live elsewhere in Europe. (S11_R)*			0.659
It is important to preserve lynx in Slovenia for future generations. (S14)			0.563
Kaiser–Meyer–Olkin (KMO)	0.843		
Bartlett's test for sphericity	$\chi 2 = 5562{,}472$, $df = 91$, $p < 0.001$		
Cronbach alphas (for 14 included items was 0.781)	0.878	0.722	0.618
Eigenvalues	3.956	2.373	1.508
Explained variance	28.258	16.951	10.773
Mean	3.41	3.21	4.43
Standard Deviation	1.20	1.29	0.92

Excluded Item: We should spend more money on lynx protection. (S8)

Note: * - *reversed items*

more negative attitudes due to the reversed negative wording items. Detailed description of attitude items is added as supplementary material (see S2).

Multivariate analysis

Gender, knowledge, grade, region of living, and frequency of visiting forest were the five independent variables that were contained in the best ranked models of all three dependent variables (namely, "Interest to learn", "Fear-acceptance", and "Conservation", Table 3). Region of living and grade were weakly, although significantly correlated with each other ($p < 0.05$, $r = 0.25$), similar as were grade and gender ($p < 0.05$, r = -0.18). However, a PCA performed before the GLM fitting resulted in a uniform distribution of proportions of variance among first fives scores, which is why we maintained all five independent variables in our GLM analysis.

For the variable "Interest to learn", the only plausible GLM with the lowest AICc (AICc = 3163.6, Table 3) presented a weight of 0.99 and included all the five independent variables plus an interaction between variables gender and grade. For the variable "Fear - acceptance", three models resulted in sufficient empirical support, where their deltaAICc < 2 (Table 3). The three best supported models for the variable "Fear - acceptance" contained the five independent variables; however, one model also contained an interaction between gender and grade, while the third model contained an interaction between gender and frequency of visiting a forest. It was impossible to distinguish between the best three models for this variable based on AICc, meaning we could not conclude on the importance of the two interaction terms. However, the data strongly supported the additive effects of all five independent variables on "Fear - acceptance", as the three best ranked models contained all the independent variables. Similar holds for the dependent variable "Conservation", where two models resulted in deltaAICc < 2. The two best models for explaining variation in "Conservation" both contained the five independent variables, similar to "Interest to learn" and "Fear-acceptance". However, the model with the lowest AICc (AICC = 2536.6, Table 3) also contained the interaction between gender and grade.

The obtained estimates from the best-chosen model (where one single best model resulted as best) or model averaged estimates (when more than one model resulted plausible) are reported in Table 4. For the Interest to learn, all the

Table 3 Results of general linear models (GLMs) selection procedure to rank the effects of five independent variables (knowledge, gender, grade, frequency of visiting forest, region of living) on pupils' attitudes (Interest, fear, Conservation) toward Eurasian Lynx

Model	df	logLik	AICc	delta	Weight
Interest to learn					
Knowledge + Gender + Grade + Forest + Region + Gender * Grade	8	-1573.74	3163.6	0.00	0.990
Knowledge + Gender + Grade + Forest + Region	7	-1579.77	3173.6	10.02	0.007
Knowledge + Gender + Grade + Forest + Region + Gender * Forest	8	-1579.56	3175.2	11.62	0.003
Gender + Grade + Forest + Region	6	-1619.57	3251.2	87.60	0.000
Grade + Forest	4	-1623.21	3254.5	90.85	0.000
Grade + Forest + Region	5	-1622.26	3254.6	90.97	0.000
Gender + Grade	4	-1640.01	3288.0	124.44	0.000
Grade	3	-1642.68	3291.4	127.78	0.000
Grade + Region	4	-1642.05	3292.1	128.52	0.000
Forest	3	-1724.26	3454.5	290.92	0.000
Region	3	-1729.46	3464.9	301.34	0.000
Knowledge	3	-1730.60	3467.2	303.61	0.000
Gender	3	-1748.88	3503.8	340.17	0.000
Fear - acceptance					
Knowledge + Gender + Grade + Forest + Region	7	-1574.46	3163.0	0.00	0.540
Knowledge + Gender + Grade + Forest + Region + Gender * Grade	8	-1574.24	3164.6	1.58	0.245
Knowledge + Gender + Grade + Forest + Region + Gender * Forest	8	-1574.37	3164.8	1.84	0.215
Knowledge	3	-1595.79	3197.6	34.59	0.000
Gender + Grade + Forest + Region	6	-1600.15	3212.4	49.36	0.000
Grade + Forest + Region	5	-1609.08	3228.2	65.21	0.000
Grade + Forest	4	-1615.38	3238.8	75.78	0.000
Forest	3	-1616.41	3238.8	75.84	0.000
Gender + Grade	4	-1617.02	3242.1	79.07	0.000
Gender	3	-1618.37	3242.8	79.75	0.000
Grade + Region	4	-1619.42	3246.9	83.87	0.000
Region	3	-1621.88	3249.8	86.76	0.000
Grade	3	-1625.06	3256.1	93.12	0.000
Conservation					
Knowledge + Gender + Grade + Forest + Region + Gender * Grade	8	-1260.23	2536.6	0.00	0.565
Knowledge + Gender + Grade + Forest + Region	7	-1262.01	2538.1	1.55	0.261
Knowledge + Gender + Grade + Forest + Region + Gender * Forest	8	-1261.41	2538.9	2.37	0.173
Knowledge	3	-1270.99	2548.0	11.43	0.002
Gender	3	-1305.43	2616.9	80.31	0.000
Gender + Grade + Forest + Region	6	-1303.20	2618.5	81.89	0.000
Gender + Grade	4	-1305.29	2618.6	82.04	0.000
Forest	3	-1309.5	2625.0	88.45	0.000
Grade + Forest	4	-1309.48	2627.0	90.42	0.000
Region	3	-1311.38	2628.8	92.20	0.000
Grade	3	-1311.44	2628.9	92.32	0.000
Grade + Forest + Region	5	-1309.44	2628.9	92.35	0.000
Grade + Region	4	-1311.37	2630.8	94.20	0.000

Note: *df* = degrees of freedom, logLik = logarithm of model likelihood, delta = difference in AICc between the best and current model, Weight = AICc weight

independent variables resulted in significant slopes, where the effects of Gender, Grade and Forest were negative, and Knowledge and Region, were positive (Table 4, upper section). For Fear, three best ranked models were shown plausible, and the model averaged coefficient estimates resulted in significant effects for Knowledge and Region, while the remaining coefficient slopes were not statistically significant (Table 4, middle section). For Conservation, where two best ranked models were shown plausible, only the slope for Knowledge resulted in a significant positive effect (Table 4, lower section), although weak.

Attitudes and knowledge according to region

The overall knowledge score was 51%. The pupils from the "Alpine" region showed more knowledge about (Mann-Whitney: $Z = 4.22$; $p < 0.001$) and were at the same time more afraid of lynx than their counterparts (Mann-Whitney: $Z = 2.88$; $p = 0.004$) (Fig. 1). On the other hand, pupils from the "Dinaric" region were more interested in learning about the species (Mann-Whitney: $Z = 6.31$; $p < 0.001$). Pupils of both areas expressed high pro-conservation attitudes (no

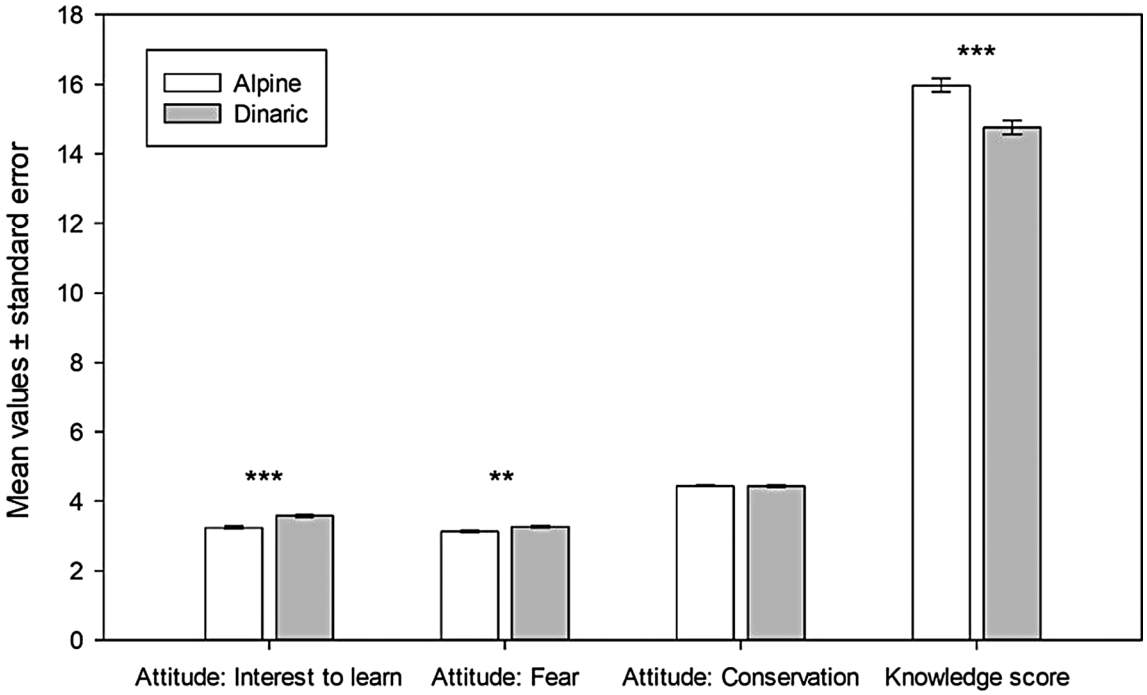

Fig. 1 The bar chart of the mean attitude ratings and knowledge scores according to the region (light bars represent values for the "Alpine" and grey for the "Dinaric" region; **: $p<0.01$, ***: $p<0.001$). Lower scores on "Fear" indicate greater fear

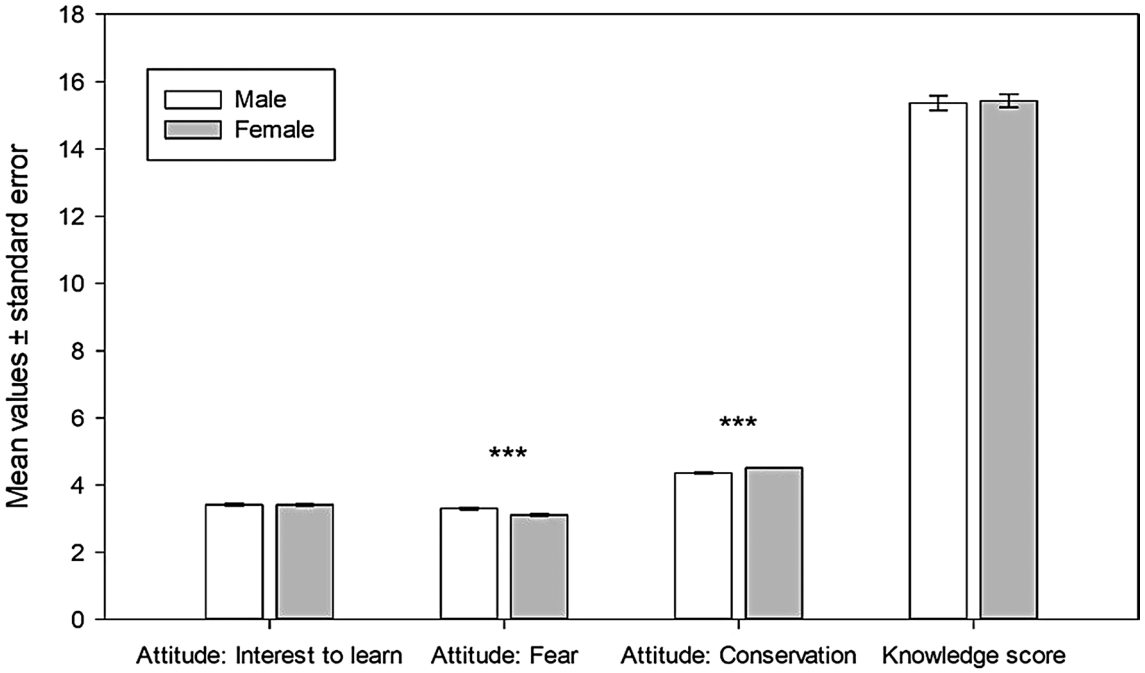

Fig. 2 The bar chart of the mean attitude ratings and knowledge scores according to gender (light bars represent values for males and grey for females; **: $p<0.01$, ***: $p<0.001$). Lower scores on the "Fear" indicate a greater degree of fear

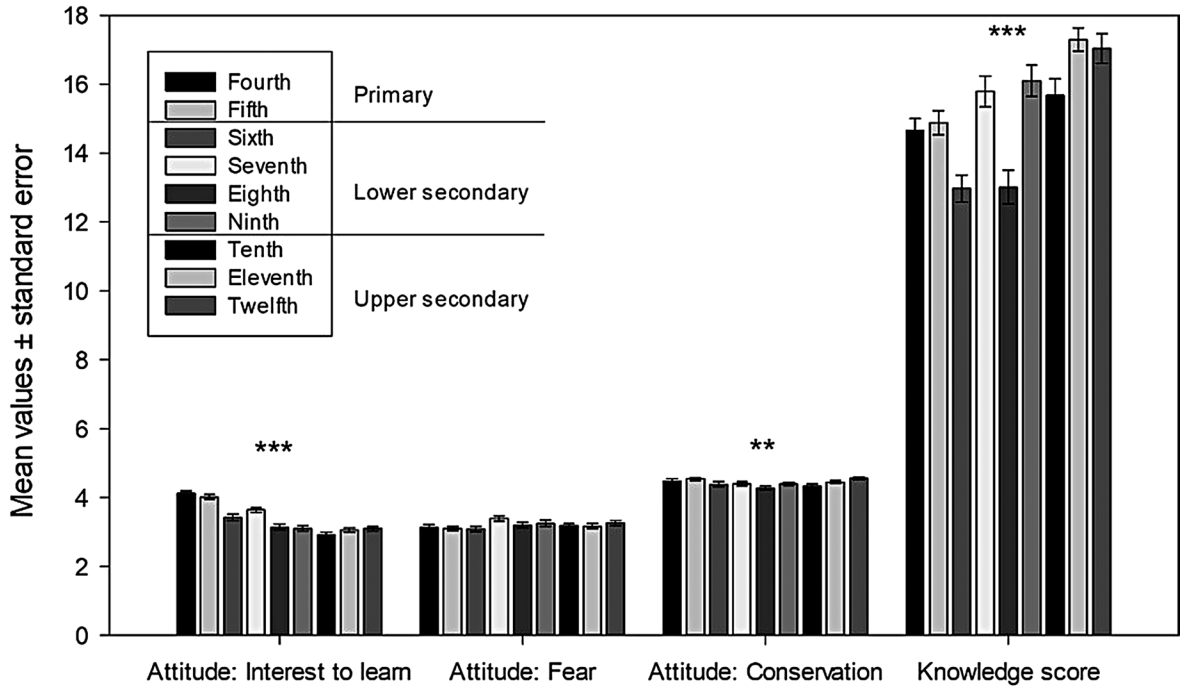

Fig. 3 The bar chart of the mean attitude ratings and knowledge scores according to school grades (bars for individual grades are presented in different shades of grey; **: $p<0.01$, ***: $p<0.001$)

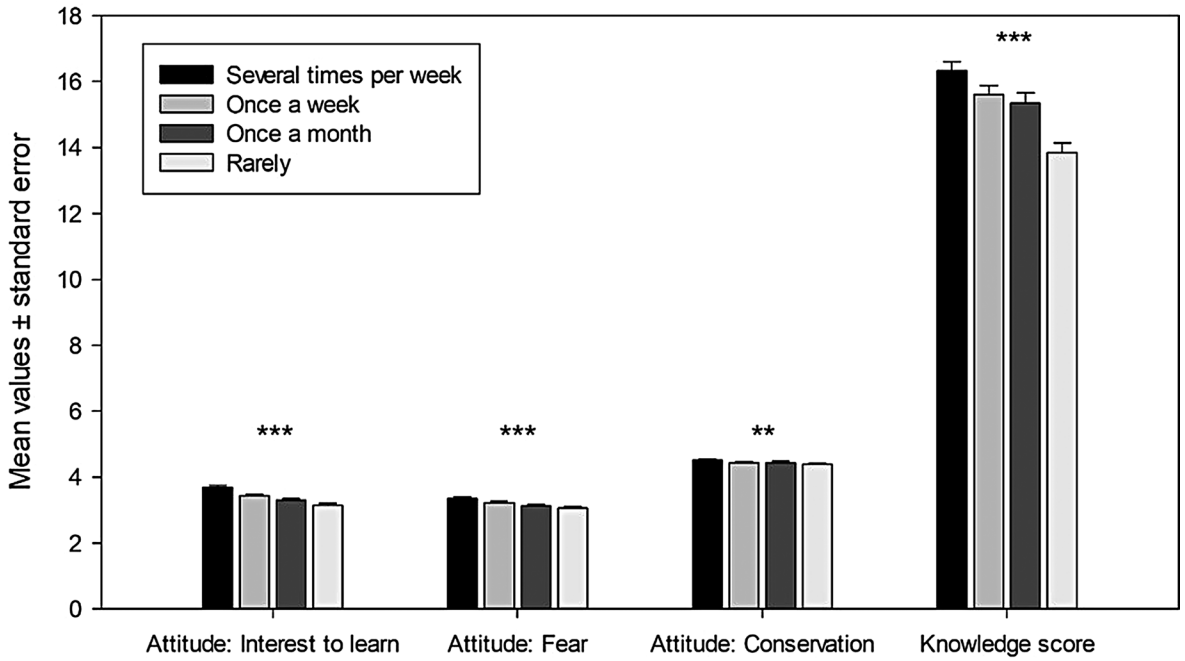

Fig. 4 The bar chart of the mean attitude ratings and knowledge scores according to the frequency of visiting forests (bars for individual grades are presented in different shades of grey; **: $p<0.01$, ***: $p<0.001$). Lower scores on the "Fear" indicate a greater degree of fear

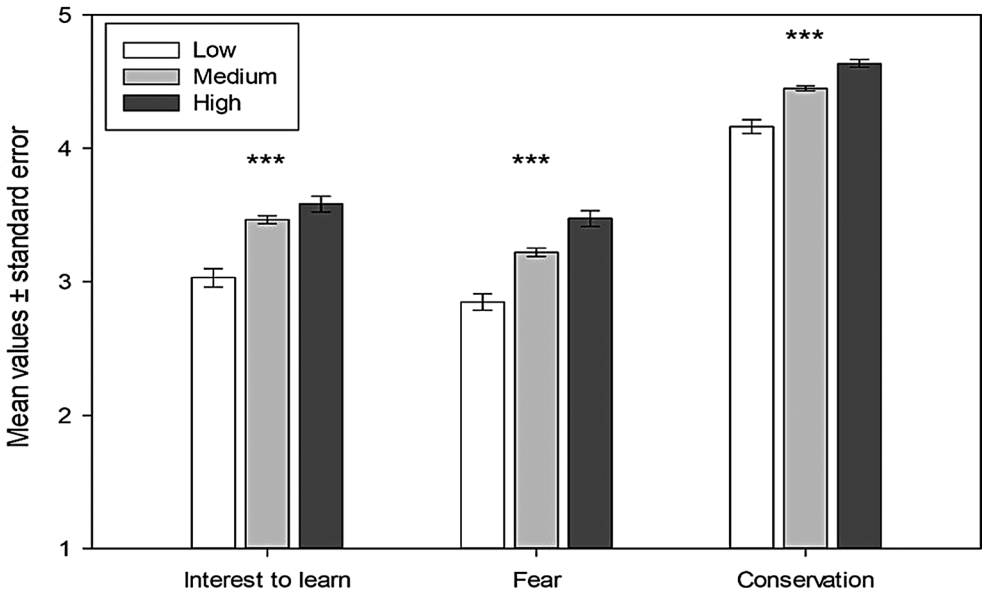

Fig. 5 The bar chart of the mean attitude ratings according to the level of achievement (light bars represent values for low achievers, light grey bars for medium achievers and dark grey bars for high achievers; **: $p<0.01$, ***: $p<0.001$). Lower scores on the "Fear" indicate a greater degree of fear

Table 4 Coefficient estimates, their standard errors and significance tests for best ranked models shown in Table 3. The results were model-averaged whenever more than one model was plausible

Interest to learn and Model(s)	Intercept	Knowledge	Gender	Grade	Forest	Region	Gender * Grade	Forest * Gender
Model(s)								
Knowledge + Gender + Grade + Forest + Region + Gender * Grade								
Estimate	4.621	0.046	-0.385	-0.255	-0.103	0.104	0.065	
SE	0.273	0.005	0.156	0.031	0.022	0.053	0.019	
t-value	16.925	9.323	-2.466	-8.283	-4.660	1.984	3.470	
Pr(>t)	**0.000**	**0.000**	**0.014**	**0.000**	**0.000**	**0.047**	**0.001**	
Fear (after model averaging)								
(a) Knowledge + Gender + Grade + Forest + Region; (b) Knowledge + Gender + Grade + Forest + Region + Gender * Grade; (c) Knowledge + Gender + Grade + Forest + Region + Forest*Gender								
Estimate	2.599	0.035	-0.171	0.026	-0.066	0.220	-0.012	-0.019
SE	0.220	0.005	0.108	0.019	0.040	0.052	0.019	0.043
z-value	11.794	7.197	1.578	1.329	1.638	4.189	0.662	0.428
Pr(>z)	**0.000**	**0.000**	0.115	0.184	0.101	**0.000**	0.508	0.669
Conservation (after model averaging)								
(a) Knowledge + Gender + Grade + Forest + Region; (b) Knowledge + Gender + Grade + Forest + Region + Gender * Grade								
Estimate	1.401	0.008	0.001	-0.010	-0.001	0.000	0.006	
SE	0.051	0.001	0.031	0.006	0.003	0.008	0.003	
z-value	27.599	10.347	0.018	1.684	0.193	0.015	2.087	
Pr(>z)	**0.000**	**0.000**	0.986	0.092	0.847	0.988	**0.037**	

statistically significant differences detected; Mann-Whitney: $Z=0.81$; $p=0.420$).

Attitudes and knowledge according to gender

Even though females express more fear toward lynx (Mann-Whitney: $Z=3.33$; $p=0.001$), they tend to have higher pro-conservation attitudes toward the species than males (Mann-Whitney: $Z=3.81$; $p<0.001$) (Fig. 2). Surprisingly, when dividing the sample according to the region of residence, the trend mentioned above was only detected in the "Alpine" subsample (Mann-Whitney$_{fear}$: $Z=3.67$; $p<0.001$); Mann-Whitney$_{conservation}$: $Z=3.07$; $p=0.002$). No same gender-specific differences were found in the "Dinaric" subsample, where females expressed more positive attitudes toward conservation than males only (Mann-Whitney: $Z=2.33$; $p=0.020$).

Attitudes and knowledge according to grade (age)

The school grades (age) influenced pupils' interest in learning about the species and their pro-conservation attitudes toward lynx (Fig. 3). The amount of knowledge differed between years, but its' dynamic was not linear. Pupils from

6th and 8th grade showed the least knowledge of the species. In general, knowledge of the upper secondary school pupils tends to be higher than that of primary and lower secondary pupils. Regarding the fear of lynx, only minor differences between school years in the "Alpine" subsample have been detected (Kruskal-Wallis: $p = 0.039$).

Attitudes and knowledge according to the frequency of visiting forests

More frequent visits to the forest had a positive effect on all dimensions of attitudes (Kruskal-Wallis$_{interest}$: $p < 0.001$; Kruskal-Wallis$_{fear}$: $p < 0.001$; Kruskal-Wallis$_{conservation}$: $p = 0.001$) and also on the level of knowledge (Kruskal-Wallis: $p < 0.001$), (Fig. 4).

The effect of knowledge on attitudes

The amount of knowledge influenced all attitudinal dimensions (Kruskal-Wallis; all $p < 0.001$) regardless of the living region (Fig. 5). Pupils with a higher level of knowledge were less afraid of lynx expressed higher Interest in learning about the species and were more inclined to conserve it. All except one pairwise comparison within individual attitudinal dimensions resulted in statistically significant differences (at a level $p < 0.001$). Namely, no significant difference was found between medium and high achievers within the Interest to learn attitudinal dimension ($p = 0.337$).

Discussion

The present study has shown a high level of support for the Eurasian lynx among younger generations, which is crucial for the long-term conservation of the species. The study results are consistent with previous studies conducted on a sample of adults in Slovenia (Bele et al. 2022b; Oražem et al. 2022). The study also observed the impact of various variables on pupils' attitudes and knowledge of the species. The results of GLMs strongly support the additive effects of all five independent variables (knowledge, region of residence, grade, frequency of visiting forest, and gender, Table 3). To build on these findings, we analysed the impact of individual independent variables on pupils' attitudes and knowledge, detailed in the final section of the results. The discussion is organised around these findings.

The effect of gender on attitudes and knowledge

In the study, the results show an overall neutral position of the respondents concerning the fear of the Eurasian lynx, as the species is not generally perceived as a conflict species (Červený et al. 2019). Statistical analysis using non-parametric tests showed gender-specific differences (see Fig. 2). Girls remained more neutral when expressing fear of the Eurasian lynx, while boys expressed less fear of the species. After a more in-depth exploration of the observed phenomenon, it was shown that the difference between genders emerged only in the "Alpine" subsample, which could result from the long absence of the species in this area. Despite their more neutral position concerning fear, girls expressed more support for conserving the species, consistent with the previous research among adolescents regarding brown bears (Oražem et al. 2021). This is expected, since girls usually express more moralistic values related to protecting species and nature (Kellert and Berry 1987). Also, previous studies reported greater fear of animals among girls than boys (e.g. Arrindell 2000), and linked greater fear levels among females to lower species knowledge (e.g. Trajçe et al. 2019; Oražem et al. 2022). Besides, greater fear among girls was also found compared to adult women (e.g. Kellert and Berry 1987; Røskaft et al. 2003), which can be, besides gender-related differences, also linked to evolutionary conditioning (Hawkes et al. 1991; Treves and Naughton-Treves 1999).

In contrast to previous studies among adult audiences (e.g. Trajçe et al. 2019; Oražem et al. 2022), in the present study, we did not detect differences in the amount of knowledge between boys and girls that could account for gender-related differences in conservation support. To better understand the impact of gender, further studies should be conducted to follow changes longitudinally or clinically. This is considered a limitation because we cannot directly explain the incidence of fear in this study. From the perspective of educating young people and building tolerance in future generations, it is crucial to investigate the differential impact of fear on pro-conservation attitudes between the genders and further age-related differences within the genders.

The effect of region of residence on attitudes and knowledge

Concerning the long-term conservation of the species, a key finding of the study is the strong support of participants from both regions, with and without the presence of Eurasian lynx (see Fig. 1). In this respect, no statistically significant differences were found between respondents, which is in line with previous research among the adult public in Slovenia (Bele et al. 2022b; Mavec et al. 2024; Oražem et al. 2022) and also in other countries, e.g. Germany (Whiley and Tzanopoulos 2024) and Norway (Røskaft et al. 2003), which can be due to lesser conflicting nature of the species compared to wolf and brown bear. Since we did not detect a lower acceptance of the species in the area with a longer absence of lynx, it is very

encouraging information for species conservation. Usually, in areas of longer absence of the species (e.g. Randler et al. 2020 for the wolves), greater differences also occur between rural and urban environments, which we could not confirm in the present study due to the uneven sample. Although the lynx died out in Slovenia at the end of the 19th century and was reintroduced just over 50 years ago, we can say that strong support for the species has still been maintained. However, when analysing the attitudes according to the region of residence, some interesting differences still emerged. Pupils from the "alpine" region showed more knowledge (approx. 4% of the total score) about the lynx and were somewhat more fearful of the animals. More knowledge about the species among respondents in the Alpine part could result from the intensive sensitisation to the species and its introduction as part of the LIFE Lynx project. As the species has not been permanently present in this part of Slovenia for more than a century, the newly acquired knowledge might not yet translate into a lower fear of the species. Conversely, pupils from the "Dinaric" region were more interested in learning about the species and less fearful. A similar result between living in an area with a constant presence of the species and lower fear and higher motivation to learn was also found in a survey on young people's attitudes and knowledge about wolves (Oražem et al. 2019) and about brown bears in Slovenia (Oražem et al. 2021). The lower fear among pupils in the "Dinaric" area could be related to the longer duration of the species' presence in this area, as it has been reintroduced before, and thus, at least a minimal tolerance towards the species is maintained. A similar trend was observed in a study of youth attitudes towards wolves in Germany, where the species is returning (Randler et al. 2020). More fear was also found among the adult public in the same areas, but only of potential damage to human property caused by the species (Bele et al. 2022a).

The effect of the school year on attitudes and knowledge

The negative effect of increased age on attitudes has been reported repeatedly for large carnivores (e.g. Johnson 1974; Williams et al. 2002; Prokop and Kubiatko 2008; Binngießer and Randler 2015), including Eurasian lynx (e.g. Roskaft et al. 2007). The research among children and adolescents aged 10 to 15 (Prokop and Tunnicliffe 2010) pointed out that even if familiar with the species, pupils can nevertheless express more negative attitudes towards the species if classified as unpopular, e.g., predators. The results of this study showed some differences across the school years regarding interest in learning, support for Eurasian lynx conservation, and knowledge of the species. The knowledge scores of the high school pupils were the highest. Although some studies have reported a correlation between higher support for lynx and higher levels of education, special attention is needed here, as a higher education level does not necessarily imply more knowledge of the Eurasian lynx (Trajçe et al. 2019; Oražem et al. 2022), but may only indicate a stronger concern for the environment and nature in general. 6th and 8th -grade pupils showed the least knowledge of the species since their learning topics in biology class are plants and humans, respectively. Pupils from 7th grade showed more knowledge of Eurasian lynx, which is expected since the main learning topic in science classes is animals. We argue that the main link with the amount of pupils' knowledge is related to the amount of content covered in lessons rather than the influence of age per se, and suggest that the topic should be represented at all levels of formal education in Slovenia, not just to a limited extent.

Attitudes and knowledge according to the frequency of visiting forests

The results show that pupils who visit the forest several times per week express more interest in learning about the species, less fear, and more support for its conservation. They also know more about the species than pupils who visit the forest less often or only occasionally. Direct experiences with nature are positively related to environmental actions, especially positive behaviours regarding biodiversity (Soga and Gaston 2024). As the Eurasian lynx is generally a non-conflict and less feared species compared to the brown bear and the wolf (e.g. Johansson et al. 2012), we propose to include as many as possible school visits to the forests and the implementation of communication activities in schools to reduce fear of the species (Johansson et al. 2016 for the brown bear) and promote positive development of other attitudinal aspects. As previous research has found no age-related differences in the positive effects of nature experiences on pro-environmental behaviour (Soga and Gaston 2024), we assume that the results of this study will be very informative not only for the work with younger generations but also for work with adults.

The effect of knowledge on pupils' attitudes

The study results show that the mean pupils' achievement score was 51%. The amount of knowledge (classified as low, medium or high) significantly influenced all attitudinal dimensions, particularly reducing fear of Eurasian lynx, and promoted interest in learning about the species and its conservation. Also, other studies regarding attitudes toward Eurasian lynx (e.g. Lescureux et al. 2011; Trajçe et al. 2019) indicate hunters as more knowledgeable than other stakeholder groups (Trajçe et al. 2019; Bele et al. 2022b; Mavec et al. 2024). Since scarce knowledge can result in irrational fear of the species (Lescureux et al. 2011), adequate public information is crucial. Previous educational studies on

wolves and brown bears in Slovenia (Oražem et al. 2018, 2019, 2022) also showed comparable results to this study, and we suggest that knowledge has a decisive influence on children's and young people's attitudes towards the Eurasian lynx. Although we did not check how many respondents have a hunter in their family, which we recognise as a limitation of the study, we can speculate that the influence of a hunter has a positive effect on children's attitudes towards lynx. This is based on the knowledge gained from previous studies, where we found a positive impact of a hunter on reducing fear of wolves (Oražem et al. 2018), Interest in learning about the species (Oražem et al. 2019), and promotion of knowledge about bears (Oražem et al. 2021). Lescureux et al. (2011) argue that avoidant behaviour and, thus, the invisibility of the species to most residents in the Eurasian lynx area can result in negative opinions of the species. As hunters were actively involved in the whole lynx monitoring and translocation process within the LIFE Lynx project, they are the ones who are well aware of the nature of the species and its non-conflict nature. Therefore, they could effectively disseminate their knowledge to the local population, especially younger generations.

Conclusions

The study provides important information for planning future communication and education activities on Eurasian lynx. Like previous surveys in Slovenia, this one also showed a high level of support for the conservation of the species, this time from the perspective of the younger generation. As we did not detect differences in support for lynx according to their presence in the environment, we highlight this as an advantage for long-term conservation, as the past absence of the species does not reflect a negative attitude towards the protection of the species. We found some differences between areas of permanent presence of the species and areas where the first lynx individuals were translocated at the time of the survey. Children and adolescents from areas where the species is permanently present expressed less fear of the species, reflecting the importance of experience with the species or simply awareness that the species is present in the wider home environment. Respondents from areas where the species is permanently present also showed more interest in learning about the species, while children and adolescents from areas where the species has been absent for a long time showed slightly more knowledge. As the survey data were collected independently of the LIFE Lynx project, we consider this a limitation, as we could not directly link the contribution of the project's communication activities, which were part of the lynx migration, to the pupils' knowledge. However, the indirect perceived impact of the communication efforts shows that children and pupils in the lynx reintroduction area have received some information. As the results show a correlation between a higher amount of knowledge about the species and more favourable attitudes of adolescents, we suggest that awareness raising about the species should be ongoing. We have also observed a rapid increase and decrease in knowledge between school years, which we attribute in part to the treatment of the topic in a given period of education, and we encourage a more sustainable approach that would systematically regulate the provision of key information on large carnivores and tolerant coexistence with them, including the lynx, at all levels of education, as ensuring tolerance among future adults is key to the conservation of these species.

Regarding the perceived impact of gender, we propose that special attention should be paid to providing information for girls and women, as their opinions of the Eurasian lynx are more uncertain. We also suggest that communicators and educators focus on first-hand activities to reduce fear of the species. If we conclude based on past pedagogical research related to large carnivores, these are, for example, direct experience through observing a species (e.g., in a zoo) and working with biological materials. Although in the field of nature conservation and also in teaching, the use of the so-called holistic or ecosystem approach, based on a review of the existing literature and newly obtained results, we recommend species-specific planning of concrete communication and educational measures to avoid generalising the perception of conflicts with different large carnivore species. However, since the Eurasian lynx is well-received in Slovenia, it would make sense to raise a general awareness of large carnivores and their importance in the environment using lynx as an example species.

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Author contributions Both authors contributed equally to the conception and design of the study, material preparation and data collection. Analysis was performed by I.T. The first draft of the manuscript was written by V.M.O. I.T. reviewed and edited the manuscript. Both authors read and approved the final manuscript.

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Data availability The data presented in this study are available on request from the corresponding author.

Declarations

Ethical approval The study was anonymous and was conducted according to the Slovenian legislation—Personal Data Protection Act (Official Gazette of the Republic of Slovenia), No. 94/07 and 177/20 official consolidated text, therefore an ethical committee approval was not needed. In Slovenian schools, parents or caretakers give a general informed consent at the beginning of each school year that they allow their children to participate in educational research. Pupils that do not have a signed informed consent, are not included in such studies. In the present study, all pupils were informed verbally and with text on the survey. They had the option to decline participation.

Competing interests The authors declare no competing interests.

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