


# Environmental education for basic education students and perception of the adult rural population about *Crocodylus acutus* (Cuvier, 1807) (Crocodylia: Crocodylidae) in Sinaloa, Mexico

## Educación ambiental para estudiantes de nivel básico y percepción de la población adulta rural sobre *Crocodylus acutus* (Cuvier, 1807) (Crocodylia: Crocodylidae) en Sinaloa, México



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**ABSTRACT.** Due to anthropogenic pressures, wildlife faces

challenges in sharing resources and habitat with humans, which leads to conflicts between them. Environmental education is an accepted resource to shape human behavior and perception towards wildlife, improving a pacific interaction. This study aimed to raise awareness in students from basic education (elementary and middle school), about the biodiversity of Mexico and the American crocodile (*Crocodylus acutus*) biology, as well as studying adults' perception about this crocodile species in three communities from Navolato, Sinaloa, Mexico. Two workshops were designed and conducted in October 2022 to basic education students; and semi-structured surveys were also applied to the adult population. Students demonstrated unsatisfactory knowledge about the biodiversity of Mexico and crocodile biology, reflecting on the lack of knowledge of basic biology concepts. Adults over 62 years old dominated the surveyed population. The 53.5% of respondents considered a risk for crocodiles to live near their homes. However, 71% stated that there are no human-crocodile confrontations. Population from two of the three studied communities expressed a fear of crocodiles due to the impact of floods on their homes, facilitating crocodile invasion. Both, students and adults agreed that crocodiles require protection. It is necessary to strengthen the knowledge about natural resources and the crocodile populations near these human settlements, to create training programs for human-wildlife coexistence, based on the land planning of the area, and to the creation of protected areas for crocodile conservation.

**Key words:** biodiversity; crocodile ecology; ecological workshop; learning

**RESUMEN.** Debido a presiones antropogénicas, la vida silvestre enfrenta retos al compartir recursos y hábitat con los humanos, lo que lleva a generar conflictos entre ellos. La educación ambiental se reconoce como un recurso para cambiar la percepción y la conducta humana hacia la vida silvestre, lo que promueve una interacción pacífica. El objetivo de este estudio fue sensibilizar a estudiantes de educación básica (primaria y secundaria) sobre la biodiversidad de México y la biología del cocodrilo americano (*Crocodylus acutus*), así como conocer las percepciones de las personas adultas sobre la presencia de esta especie en tres comunidades de Navolato, Sinaloa. Dos talleres fueron diseñados e implementados en octubre del 2022 para los estudiantes, y se aplicaron encuestas semiestructuradas a la población adulta. Los estudiantes demostraron tener conocimientos insatisfactorios sobre la biodiversidad de México y la biología de los cocodrilos; reflejado en la falta de conocimiento de conceptos básicos de biología. En la población encuestada predominaron los adultos mayores a 62 años. El 53,5% de los encuestados considera riesgoso que los cocodrilos vivan cerca de sus viviendas. Sin embargo, el 71% afirmó que no existen enfrentamientos entre humanos y cocodrilos. La población de dos de los tres poblados estudiados expresó temor a los cocodrilos debido al impacto de las inundaciones en sus hogares, ya que esto facilita invasión de cocodrilos. Estudiantes y adultos afirmaron que los cocodrilos requieren de protección. Es necesario fortalecer el conocimiento sobre los recursos naturales y las poblaciones de cocodrilos aledañas a estos asentamientos humanos, crear programas de capacitación para la coexistencia de humanos y la vida silvestre, basados en el ordenamiento territorial del área, y también crear áreas protegidas para la conservación de los cocodrilos.

**Palabras clave:** aprendizaje; biodiversidad; ecología del cocodrilo; taller ecológico

## INTRODUCTION

Safeguarding species richness represented in the world's biodiversity is a prior need to achieve sustainable development, according to the Convention on Biological Diversity (CBD, 1992). Part of the environmental crisis originates from the lack of education and knowledge on the environment. Hence, the United Nations (UN) started with biodiversity conservation (CBD COP 16) by creating the UN Environment Programme, which proposes and promotes the implementation of environmental education for sustainable development (Ramírez & Santana, 2019). The environmental education for sustainable development promotes cognitive, socio-emotional, and behavioral learnings, through the development of knowledge, competencies, capacities and values to cope with problems like climate change, biodiversity loss and overexploitation of natural resources, which have negative effects on the environment and human population, as indicated by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2024).

Environmental education plays a determining role in reducing the impacts caused by anthropic activities, achieving sustainable development, and strengthening the connectivity among different landscapes or ecosystems (Boca & Saraçlı, 2019). Ecological literacy is a comprehensive tool from environmental education that develops consciousness, comprehension, and a positive perception toward biodiversity conservation (Yousefpour *et al.*, 2022). It is essential to approach environmental education at every educational level, for better professional formation programs of the future generations (Suárez-López & Eugenio-Gozalbo, 2021; Kowasch *et al.*, 2022; Pan & Hsu, 2022;). On the other hand, non-formal environmental education is a viable option that contributes to the development and practice of values, such as respect, care, tolerance, and preservation of nature, which promote positive attitudes toward environmental conservation (Ninalaya Casallo *et al.*, 2022). The increase in wildlife-human conflicts represents a significant challenge for species conservation (González-Desales *et al.*, 2021; Shankar *et al.*, 2024). In this context, addressing ecological literacy is essential, along with prioritizing communities' perceptions of nature conservation. This approach aims to foster an understanding of the intricate relationship between nature conservation and economic development, ultimately contributing to improved local conservation efforts (Yousefpour *et al.*, 2022). Besides, studies on human perceptions develop sensitization and awareness that lead to actions for species conservation (Ihlow *et al.*, 2015).

As large predators, crocodiles play a fundamental role in wetland ecosystems by improving structure, function, and biodiversity (Finke & Denno, 2004). They also have restoration potential and confer resilience in the face of climate change and invasive species (Ritchie *et al.*, 2012). Wild populations of top species such as crocodiles, are vulnerable due to their dependence on lower trophic-level organisms for subsistence (Borrvall & Ebenman, 2006). Landscape fragmentation, habitat loss, land use change, and hunting activities are some factors that affect wildlife (Ihlow *et al.*, 2015) besides increasing wildlife-human conflicts (e.g., human-crocodile encounters) (Khan *et al.*, 2020; Chakanyuka & Utete, 2022). There are studies in Mexico about the anthropic impact of crocodiles, for example, human-crocodile conflicts fostered by habitat loss (Cupul-Magaña *et al.*, 2010; Peña-Mondragón *et al.*, 2013; González-Desales *et al.*, 2021;); conservation status of the American crocodile population (López-Luna *et al.*, 2013), and pesticides presence in infertile crocodile eggs from Sinaloa, Mexico (Pérez-González *et al.*, 2024).

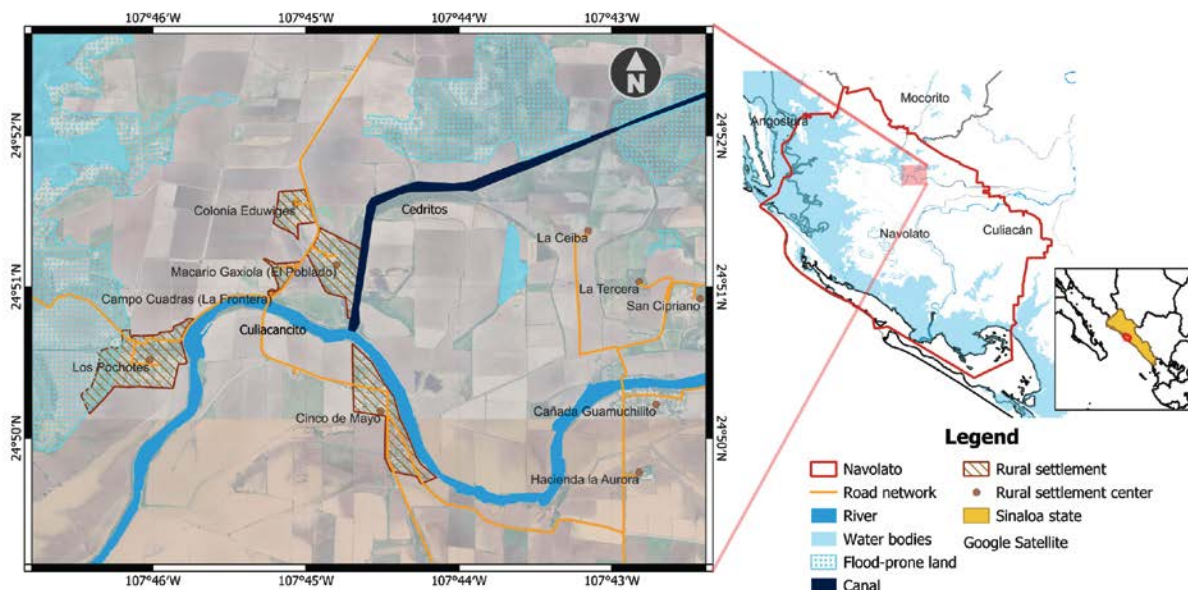
In Mexico, only three crocodilian species are distributed: American crocodile, *Crocodylus acutus* (Cuvier, 1807); Morelet's crocodile, *Crocodylus moreletii* (Duméril & Bibron, 1851); spectacled caiman, *Caiman crocodilus* (Linnaeus, 1758). They all have a conservation category called "special protection" by the Mexican official norm NOM-059-SEMARNAT-2010. This category

aims to promote the recovery and conservation of wild species (SEMARNAT, 2010). Meanwhile, the International Union for Conservation of Nature (IUCN) categorizes these crocodilian species as least concern (*C. crocodilus*, *C. moreletii*), and as vulnerable (*C. acutus*). In Sinaloa State only *C. acutus* is found, and currently it represents the distribution limit of the species in northwestern Mexico (Salomon-Soto *et al.*, 2024), since it was declared extinct in Sonora (Enderson *et al.*, 2009).

To reduce the impact exerted on these living beings, it is imperative to design and implement strategies for crocodile conservation and assess the perception and knowledge of the human communities surrounding crocodiles' habitat (Eniang *et al.*, 2020). In this context, Padilla & Perera-Trejo (2010) assessed the Mayan community's perception of Morelet's crocodiles. Cornejo *et al.* (2021) evaluated the perception and popular knowledge about crocodiles in the naturally protected area of Nichupte, Quintana Roo, Mexico. It is important to note that only one of the three crocodilian species in the country recovered its population after the overexploitation by the leather industry that began in 1970. This study documented basic education students' knowledge about the biodiversity of Mexico and crocodile biology, as well as the perception of local residents regarding the presence of crocodile in human settlements surrounding crocodiles' habitat.

## MATERIALS AND METHODS

**Study area.** The study was conducted in three rural communities in Navolato municipality, Sinaloa, Mexico (Fig. 1). The communities where the intervention was carried out were: Macario Gaxiola (El Poblado), Cinco de Mayo, and Los Pochotes, with 130, 318, and 181 inhabitants, respectively. These communities were chosen given their predisposition to flood by the Cedritos drain with wastewater coming from the city of Culiacan, Sinaloa. This water system supports populations of various wildlife species, including crocodiles.



**Figure 1.** Location map of the surveyed rural communities: Macario Gaxiola, Cinco de Mayo, and Los Pochotes, municipality of Navolato, Sinaloa, Mexico.

Two workshops were conducted in October 2022 at General Ignacio Zaragoza elementary school and the "039 Telesecundaria Federalizada" (in Mexico, telesecundaria is a type of middle school where lessons are broadcasted on television and guided by a teacher), located at Cinco de



Mayo village. These workshops entitled "Biodiversity of Mexico" and "Crocodile biology" were carried out with a duration of 4 hours each. Evaluations of the students' knowledge were conducted before and after each workshop in both groups. The assessments included questions on environmental science topics to evaluate their knowledge before and after participating in the workshops. Students involved in the workshops were classified by gender and school grade (Table 1), and the questionnaires related to "Biodiversity of Mexico" and "Crocodile biology" workshops are shown in tables 2 and 3, respectively.

**Table 1.** Students by sex and school grades at Cinco de Mayo village, Navolato, Sinaloa, Mexico.

Grade	Elementary school		Middle school	
	Girls	Boys	Girls	Boys
1	3	0	3	1
2	2	4	2	3
3	1	2	1	4
4	0	7		
5	3	2		
6	2	0		
Total	11	15	6	8

**Biodiversity of Mexico workshop in elementary and middle schools.** The didactic contents and materials for the "Biodiversity of Mexico" workshop were taken from the CONABIO (2022) website. To strengthen the knowledge of biodiversity topics in Mexico, a map of the Mexican republic hosted in the CONABIO website, was used to present different wildlife species and their habitats



**Figure 2.** Teaching aids for learning strengthen; a) representative wildlife species of Mexico; b) practical activity relative to wildlife species distribution in Mexico; c) theoretical reinforcement activity with emphasis on endemic fauna species listed in the NOM 059; d) classroom dynamic activity to reinforce collaborative work: "The planet in our hands".

(Fig. 2a), which was modified with shadowed images of the species and a rectangle to place their names, and as a practical activity kids placed the images and names within their correct shadows (Fig. 2b). During the workshops, emphasis was placed on the endemic species of Mexico and those with an endangered conservation status or listed under a risk category according to the NOM-059-SEMARNAT-2010 (Fig.2c). Finally, a dynamic activity called “The planet on our hands” was held to reinforce the collaborative work (Fig.2d).

**Table 2.** Biodiversity of Mexico workshop questionnaire for elementary and middle school students at Cinco de Mayo village, Navolato, Sinaloa, Mexico.

Elementary school level questions	Middle school level questions
What is biodiversity?	What is the criteria to name a country as megadiverse?
What do coastal ecosystems and oceans provide to us?	Which percentage of atmospheric oxygen is produced by the oceans?
What does a forest provide to us?	Which benefits are provided by the jungles?
Which human actions damage the ecosystems?	Name a top animal in the food chain:
What is an endemism?	What does it happen when herbivores are eliminated from ecosystems?
What is the name given to species introduced into an ecosystem in order to meet the need of humans?	What is the name given to microorganisms that recycle organic matter?
What is the name given to a species found in every place of the world?	What is the name of living organisms that take energy from the sun and turn it into their food?
What does an invasive species cause?	What are those organisms called that need others to feed themselves?
Impact on natural resources when a large quantity of humans lives in a particular region:	Mention an ecosystem from Mexico
How can we conserve our ecosystems?	What is an exotic animal?
	Mention the consequences of greenhouse effect:
	Why is the conservation of a species important?

**Table 3.** Crocodile biology workshop questionnaire for elementary and middle school students at Cinco de Mayo village, Navolato, Sinaloa, Mexico.

Which ecological group do crocodiles belong to?
Which crocodile species lives in Sinaloa?
What is the difference between alligators and crocodiles?
Where are crocodiles born?
What is the eggs nesting and incubation period of crocodiles living in Sinaloa?
What kind of nest do <i>Crocodylus acutus</i> build?
Can crocodiles jump out of the water?
Which body part do crocodiles use to swim?
What are the feeding habits of crocodiles?
Crocodile mothers want to eat their offspring:
Crocodiles are endangered and need help from humans to survive, with actions like avoiding destruction of their habitat.
Male crocodiles fight between them because they are aggressive and strong.

**Crocodile biology workshop on elementary and middle schools.** The theoretical contents used for the “Crocodile biology” workshop belong to PROFEPA (2020) website. The workshop addressed ecological, economic, and cultural topics. The evaluation of this workshop in students from first to

third grade of elementary education consisted in 12 questions, where nine of them were multiple-choice, and three false-true questions. Every answer option had its concept written and represented in color-printed draw to facilitate the understanding. These questions, without draws, were also applied to fourth to sixth elementary education grades, and to middle school education students (Table 3). The workshops were carried out with 100% of attendance in both education school levels. For each workshop, correct and incorrect responses for each ítem were recorded and represented in graphs.

**Adult perceptions about crocodiles' presence.** Surveys were conducted with participants of the three rural communities to understand adults' perceptions on the presence of crocodiles in wetland ecosystems near their homes. As recommended by Eniang *et al.* (2020), only one person over 18 years of age per household was interviewed; also, the interviewee was informed about the objective of the project and verbal consent was requested to continue with the questionnaire. We applied 86 surveys, and the number of surveys was calculated with the finite population formula according to Aguilar-Barojas (2005):

$$n = \frac{NZ^2 pq}{d^2 (N - 1) + Z^2 pq}$$

Where:

**n** = sample size

**N** = population size

**Z** = z-score calculated from normal distribution tables. It is also named level of confidence (1.96)

**d** = absolute precision level. The desired confidence level width is 0.05

**p** = approximated proportion of the phenomenon under study in the reference population

**q** = proportion of the reference population that does not present the phenomenon under study (1 -p)

Note: the sum of p and q should always be 1. For example, given p=0.8 and q=0.2.

**Table 4.** Perception survey on the knowledge and presence of crocodiles, applied to adult locals from three rural communities in Navolato, Sinaloa, Mexico.

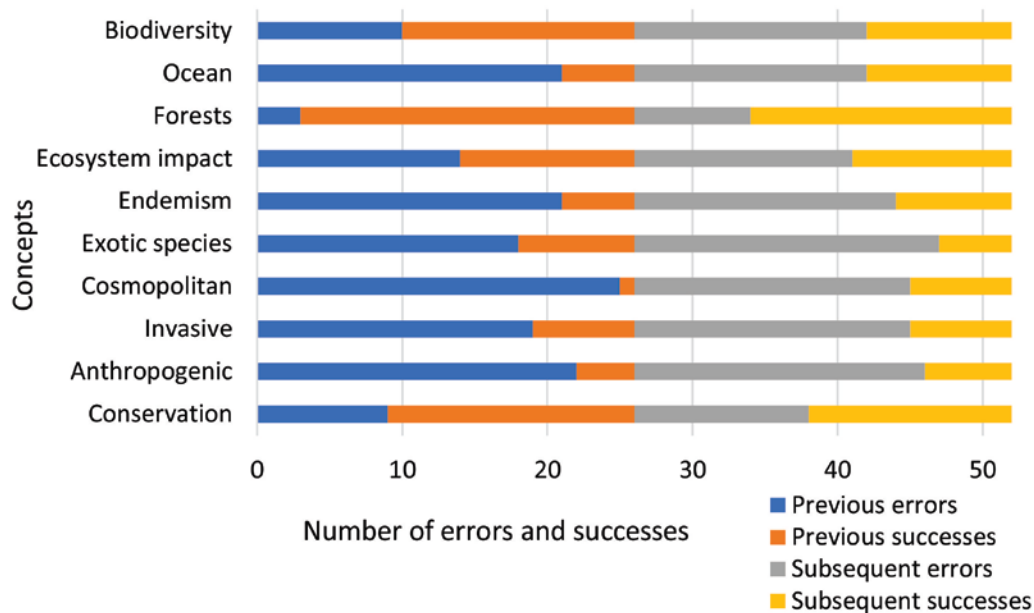
Items	Scale 1 to 4
What do you know about crocodiles in this area?	Nothing, A little, Some, A lot
Have you seen crocodiles?	Yes, No
Where have you seen crocodiles?	
Were the crocodiles alive?	Yes, No
	Wild, Captivity
When was the last time you saw crocodiles around the area?	
How many crocodiles did you see?	
Have you had contact with crocodiles in this area?	Never, Rarely, Frequent, Very, frequent
Knowledge about biology crocodiles?	Nothing, A little, Some, A lot
Do you know about human-crocodile conflicts?	None, rarely, frequent, very frequent
Do you know of any community where crocodiles are hunted or killed?	None, Few, Some, Many
Do you know support crocodile conservation?	No, A little, I don't know, Some, A lot
Do you consider crocodile conservation important?	No, Very important
Does crocodile conservation benefit the community?	Nothing, Little, I don't know, Some, Very much
Do you know laws for that protection of crocodiles?	None, Few, Some, Many
Would you like to learn about crocodile conservation and ecology?	No, A little, Some, Very much

The first four questions gathered data for social statistics purposes (sex, age, occupation, and educational level), no names and personal data were asked. An 18 questions semi-structured survey was conducted. Every item had response options based on the Likert scale (1 indicates a full positive response, and 4 a full negative response), and specific questions (Table 4). The questions focused on: a) sightings and frequency of crocodiles observed; b) perception on the crocodiles' presence; c) confrontations between humans and crocodiles; d) degree of interest in conservation and the laws that protect crocodiles (van der Ploeg *et al.*, 2011; Eniang *et al.*, 2020; Cornejo *et al.*, 2021).

The obtained results were entered into a database (Microsoft Excel®) where descriptive statistics (*n*, frequency percentages) were performed and categorized by respondents' age, sex, and educational level.

## RESULTS

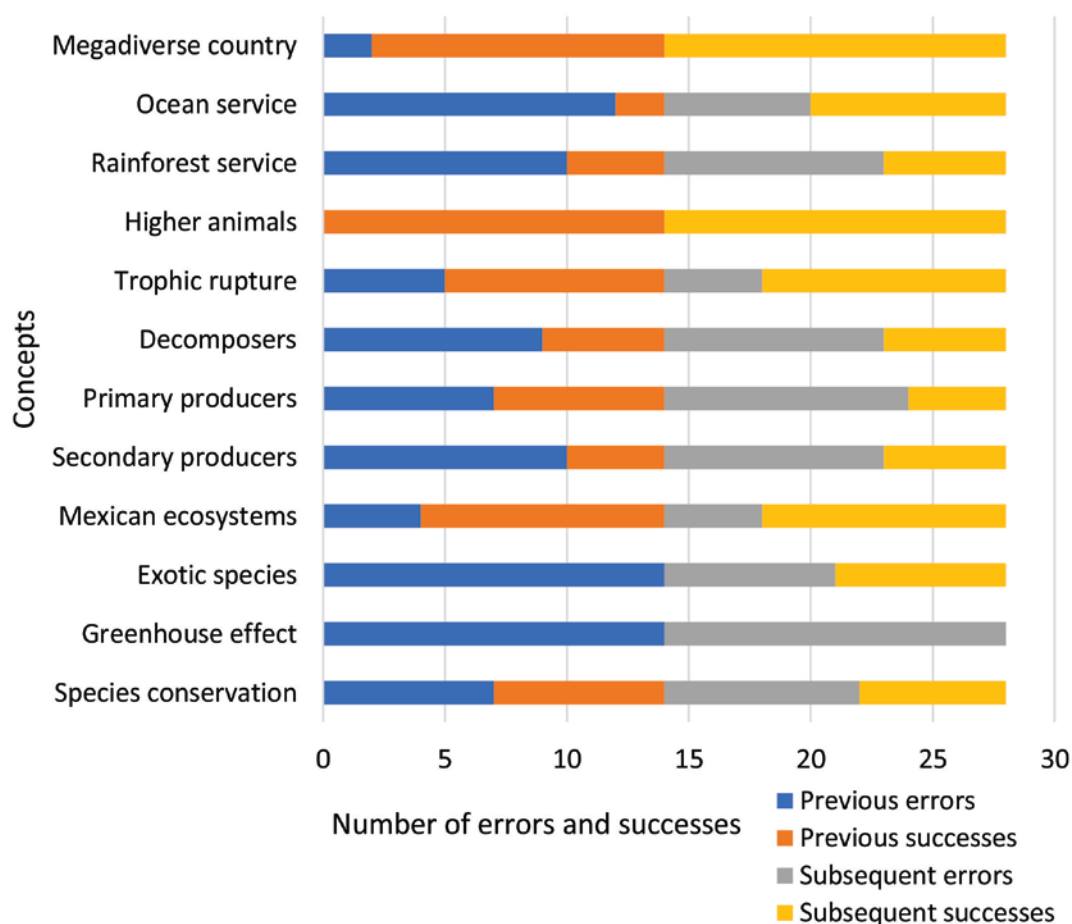
**Biodiversity of Mexico workshop in elementary and middle schools.** The evaluation results before and after to the biodiversity of Mexico workshop in the elementary school, including number of errors and correct answers for each question are shown in figure 3. The sum of correct answers was slightly higher before (98) the workshop than after (96), equivalent to less than 40% success rate.



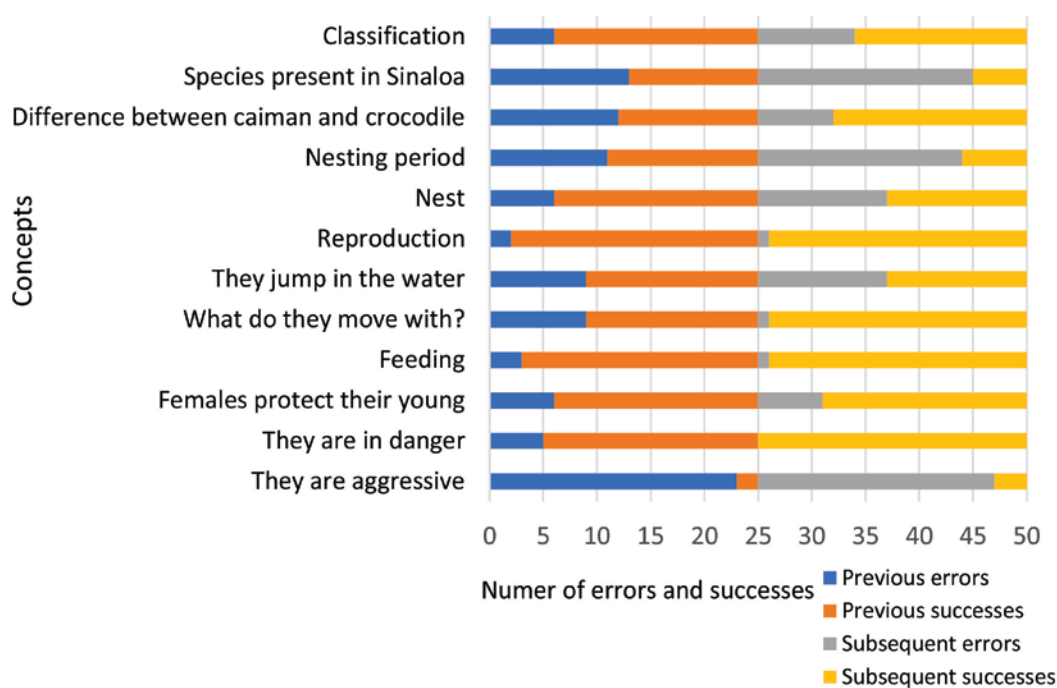
**Figure 3.** Evaluation results before and after the biodiversity of Mexico workshop for elementary school students at Cinco de Mayo village, Navolato, Sinaloa, Mexico.

For the case of the middle school, the evaluation results, including the number of errors and correct answers for each question are shown in figure 4. Concept learning is observed, such as megadiverse country, top animal in the food web, the effects of removing a trophic level from the food web, and types of ecosystems in Mexico. Incomplete comprehension of the greenhouse effect was observed. Pre- and post- evaluations to the workshop show 44% and 52% of correct answers, respectively.





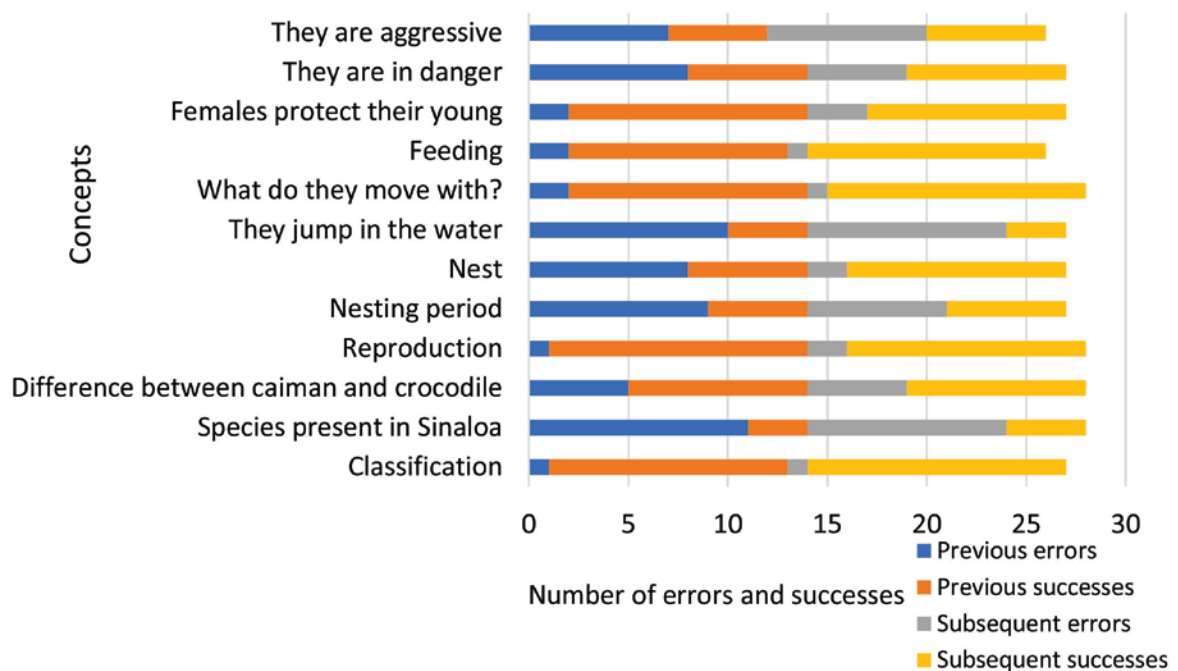
**Figure 4.** Evaluation results before and after the biodiversity of Mexico workshop for middle school students at Cinco de Mayo village, Navolato, Sinaloa, Mexico.



**Figure 5.** Evaluation results before and after the crocodile biology workshop for elementary school students at Cinco de Mayo village, Navolato, Sinaloa, Mexico.

**Crocodile biology workshop in elementary and middle schools.** The elementary school's pre- and post-crocodile biology workshop evaluation results are shown in figure 5. The students demonstrated comprehension of specific topics such as distinguishing between crocodiles and alligators, reproduction, swimming appendages, and feeding habits. It is important to note that the perception of these animals as aggressive is prevalent; nevertheless, 76% of the students agreed that it is necessary to protect crocodiles. A general analysis showed that 40% and 57% of correct answers were obtained in the pre- and post-workshop evaluations, respectively.

Pre- and post- evaluation results of students from the middle school are shown in figure 6. It is observed that there are no significant differences between, with 59% and 64% of correct answers, before and after the workshop, respectively.

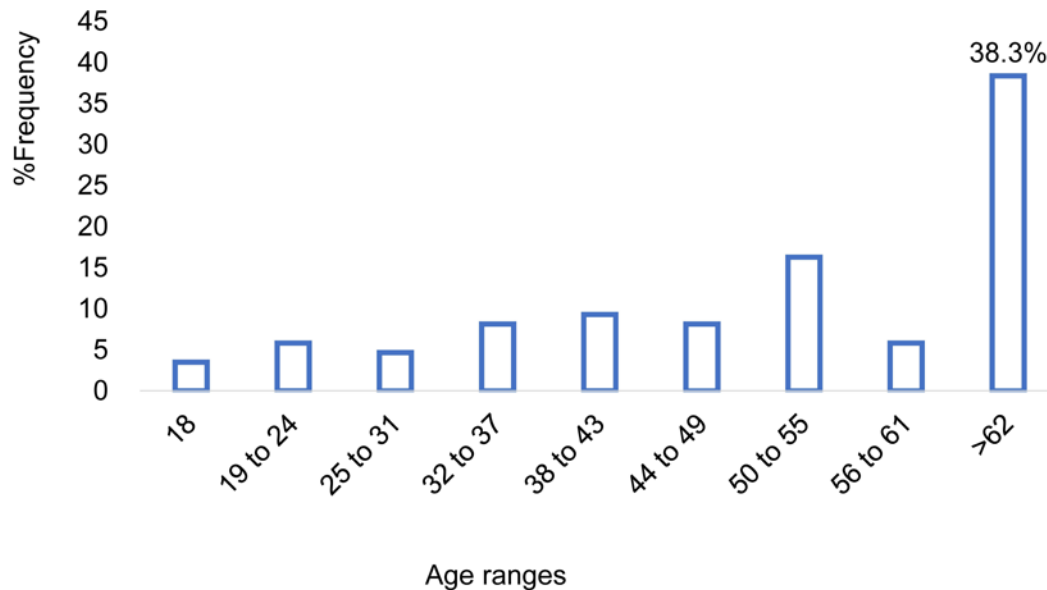


**Figure 6.** Pre- and post- evaluation results of the crocodile biology workshop for middle school students at Cinco de Mayo village, Navolato, Sinaloa, Mexico.

**Adult population surveys.** Out of 89 surveys (14% of the total adult population of the communities), 54% involved women, and 46.0% men. Most respondents (69%) were over 44 years old, including a high proportion (38.3%) of individuals older than 62 years (Fig. 7).

Housewives corresponded to 46.5% of the surveyed population; 44.7, 24.1, 17.6, and 5.9% had primary, secondary, high school, and university schooling, respectively; one person mentioned to have a master's degree, and two had no studies at all.

From the surveyed population, 53.5% perceived the presence of crocodiles in the area as dangerous or bad; 26.0% did not know how they perceived them, 20.0% answered that crocodiles' presence is good. The majority (80.0%) stated that they have mainly observed crocodiles in aquatic environments such as rivers, drain channels and lagoons around their villages. Most (88%) respondents said that they have seen crocodiles wild and alive near their communities, while 2% have seen them dead, and the remaining 10% have seen them in captivity; one person answered having seen them in a crocodile farm. Crocodile sightings is frequent in the communities, 48% of the respondents stated have seen from 1 to 3 crocodiles less than a month ago.



**Figure 7.** Age ranges of adults who responded to the survey relative to perception and knowledge on crocodiles, in rural communities in the municipality of Navolato, Sinaloa, Mexico.

Regarding human-crocodile encounters, 47.7% said they had no contact with crocodiles in their communities. The 12% expressed having a lot of knowledge about crocodiles; most of the surveyed population (55%) expressed having regular too little knowledge, 33% indicated not having any knowledge about crocodile biology. In addition, 71% affirmed that they did not know of human-crocodile confrontations; 76% were unaware of cases involving haunting or killing crocodiles within communities; while the rest mentioned that these practices are carried out in some communities. The 9% know many people or social groups that support crocodile conservation. Some (23%) consider crocodile conservation very important, 50% regular too little important, and 27% do not.

Regarding the surveyed population perceptions on crocodile conservation in the communities, 38% consider it very beneficial, 19% view it as little to regular benefit, while most respondents (43%) said they see no benefit from it. In terms of legislation, 16% stated to have a high knowledge of crocodile protecting laws, while 41% regular too little, and 43% do not know any law. Moreover, 27% are willing to learn about crocodiles' ecology and conservation, 47% stated regular too little willingness, 26% remaining do not have any willingness.

## DISCUSION

The understanding of biodiversity issues in Mexico in basic education students in the study area is scarce, and the problem is more notable in elementary school first grades, knowledge appropriation was not observed during post- workshop evaluations. This suggests that students required previous knowledge to effectively assimilate new concepts. It is noted that the workshop lasted four hours and included theoretical instruction, practical and dynamic activities. In developing countries, there are difficulties in teacher trainings to address biodiversity topics (Luvison Araújo & Dos Santos Alitto, 2021; Beach, 2023). Education basic level students did not reach a satisfactory level of knowledge about the benefits provided by different ecosystems in Mexico, this evidences the need to improve environmental education. Awareness-raising

campaigns and outdoor activities for biodiversity conservation are effective in improving learning (Tesfai *et al.*, 2016). Practical actions involving services provided by ecosystems, such as the construction of ponds and their associated biodiversity, have demonstrated an improvement in students learning and attitudes (Sousa *et al.*, 2016). Biodiversity loss has been addressed internationally since 1972 at the Stockholm conference; UNESCO and the UN Environment Programme was launched in 1977 (Kassas, 2002), but those efforts have not been reflected locally.

Understanding and creating awareness about species richness of megadiverse countries at basic education levels should be an educational priority. Essential concepts such as organic matter recycling, primary producers, exotic animals, invasive species, endemism, cosmopolitan species and greenhouse effect, still need to be understood. Creative ways of fostering learning like posing questions for children and young people, and exposing individuals to a sensory, emotional, and aesthetic experience in nature, favor an understanding and significant learning of the environment (Matos *et al.*, 2022).

This research revealed that involved students support crocodile conservation. Ecosystems conservation for the development of top species such as crocodiles, promotes energy flow throughout the trophic web. Nevertheless, crocodile biology is poorly understood in the coastal communities of the study area; students with basic knowledge ranged between 9 and 14 years old, categorized crocodiles as reptiles, knew their body shape and appendages, reproduction, and feeding habits. The workshops did not improve the knowledge about the species but it is suggested that the adjustment of the intervention strategies could provide the students with better knowledge acquisition, such as attending natural history museums (Uppin & Timoštšuk, 2022) or implementing community museums. Educational projects that integrate conservation, economic development, and a sustainability vision under community management can improve species conservation (Jiménez *et al.*, 2017).

Environmental education significantly improves knowledge and positive attitudes towards charismatic fauna after annual interventions; however, it is not enough for behavioral changes (Grúňová *et al.*, 2017). Integrating people into their natural environment promotes interest in protecting ecosystems (Padua, 2010). Continuous educational interventions with environmental topics like the ecological functions of species improve assimilation and understanding of new concepts, and develops awareness towards conservation (Andresen *et al.*, 2020).

The limitations of this study were due to a lack of previous knowledge needed to understand new concepts. Another factor could be that the intensity of the workshop methodologies affected the willingness to learn and focus during for the post-workshop evaluations. It is suggested that the evaluations should be applied on days other than the execution of the workshops. Improving the understanding of the environment is necessary to achieve sustainability. In addition, continuous activities with students, inhabitants of rural areas, and decision-makers on the species ecological value and ecosystem functions favors the achievement of sustainable development on coastal communities.

The lag in environmental education evidenced in this study is currently being addressed in the “New Mexican School” (implemented in the 2023-2024 cycle), which is founded on eight principles. One of these principles emphasizes respect for nature and environmental care, promoting awareness of environmental protection, conservation, climate change prevention, and sustainable development. These principles and values are fostered through the educational journey, from birth to 23 years of age.

The adult population with low schooling expressed poor availability to learn about crocodile conservation. A previous study correlates higher educational level with a better

knowledge of the species studied herein, and a willingness to support conservation efforts (Cornejo *et al.*, 2021). It has also been reported that a low socioeconomic level tends to demotivate people due to the lack of economic resources to cover basic needs such as food, clothing, and transportation before acquiring learning materials (Ögeyik, 2016). A similar situation was observed in this study.

The opinions and perceptions of people about crocodiles allow to understand the types of interactions between the inhabitants with these reptiles. Interviewed people were familiar with the presence of crocodiles, although the low frequency of sightings (1 -3 specimens per month), suggests a low density of crocodile's population in the study area. Studies indicate that the higher the density of organisms, the greater the competition for food and space, which may result in conflicts (Chakanyuka & Utete, 2022). According to Eniang *et al.* (2020), perceptions and attitudes toward crocodiles are in function of the experiences to which locals have been exposed. In this study, inhabitants expressed fear of the invasion of crocodiles to their homes during the floodings of rainy or hurricane seasons. Another study revealed that fear to species was the main reason for the killing of *Varanus flavescens* (Ghimire *et al.*, 2014). The killing of crocodiles by humans can be attributed to human-crocodile conflicts, and perceptions on crocodiles as a threat (Chakanyuka & Utete, 2022; Wallace *et al.*, 2011).

Although most inhabitants involved in the study were aware of the presence of crocodiles, their knowledge about these species' biology is poor. They differentiated two species, acknowledging that only *C. acutus* is present in the study area. A better understanding of the ecological functions of species in the ecosystems will contribute to promote the development of conservation attitudes towards the environment (López del Toro *et al.*, 2009). Interaction with crocodiles is rare, with no records of attacks or human-crocodile confrontations in the studied communities. Studies in Africa report up to 98 attacks in a decade, and more than half of the cases ended in fatal outcomes; where conflict or illegal hunting exists, it is necessary to address the negative attitudes of the population towards wildlife with effective programs to safeguard the well-being of both humans and wildlife (Wallace *et al.*, 2011). The permanence of people in these areas refers to their capacity for community resilience in the face of extraordinary events such as floods or when human-crocodile interaction occurs, or both (Robertson *et al.*, 2021).

In this study, the population knew the concept of species conservation and favored the preservation of biological resources. The inhabitants of the area support the conservation of crocodiles; in other sites of Mexico, conservation programs have led to the recovery of crocodile's populations, which currently allows the sustainable use of *C. moreletii* (Cedeño-Vázquez *et al.*, 2006; Platt *et al.*, 2010; Sánchez & Álvarez-Romero, 2006). Furthermore, *C. acutus* and *C. crocodilus* continued to recover in Mexico after the ban imposed in the 1970s due to overexploitation of the three crocodilian species (SEMARNAT, 2016).

## CONCLUSIONS

Elementary and middle school students in this study, have an unsatisfactory to poorly knowledge and learning on the biodiversity of Mexico and crocodile biology topics. Students at higher grades showed better achievement. Nevertheless, the students showed interest and were motivated by the covered topics in the workshops, which presents an opportunity to integrate environmental education topics effectively. The adult population perceives the presence of crocodiles in their community as a danger; however, they still support the conservation of these organisms.



Formulation of training programs for wildlife-human coexistence and the creation for protected areas are required for crocodile conservation. These actions should always be based on the land use planning of a natural protected area.

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