Abstract

This study examines the survival and adaptation of species identified by four Aboriginal groups and Torres Strait Islanders across regions of Australia, comparing historical records with contemporary data. Utilizing traditional ecological knowledge from rock art and oral histories alongside modern scientific observations, the study highlights how most species have adapted to environmental challenges. Methods involved comparing documented species from ancient art to their status in 2024. Results show that while many species have survived, some, like the thylacine, are extinct. Conservation efforts have successfully reintroduced some species. Future research should involve more Indigenous groups, advanced data collection, and statistical analysis to further understand species adaptation and promote effective conservation strategies.

Introduction

This topic was chosen due to a long-standing concern about wildlife preservation. Since the theme for this year's STS project is "Species Survival – More than just Sustainability," an opportunity arose to research and determine how many animals from different regions of Australia have survived environmental challenges. These challenges include invasive species, predators, habitat loss, and other factors. To find out about animals that existed thousands of years ago in Australia, Aboriginal artworks from that area were scanned. The Aboriginals and Torres Strait Islanders mainly drew what they could see, making their art a trustworthy source far back in history. Although fossil reconstruction was considered as a method for determining prehistoric species, it was not as reliable as analyzing Indigenous artworks, which include stories and tales passed down through generations. While there is some room for human error, it is significantly less compared to fossil recollections, which can be influenced by many more external factors.

Aim

Species survival involves more than just sustainability; it encompasses the ability to adapt and thrive despite environmental challenges. By analyzing Aboriginal and Torres Strait Islander art, we can determine whether the species depicted in historical artworks have managed to endure and adapt over time, continuing to exist in today's environment.

Hypothesis of the study

If species can adapt and evolve, then they will be able to survive environmental changes and challenges, because adaptations and evolutionary changes increase their fitness and ability to cope with predation, habitat loss, and other environmental pressures.

Materials

- Various forms of artworks from Aboriginal and Torres Strait Islanders

I. Arnhem Land group animal depictions:

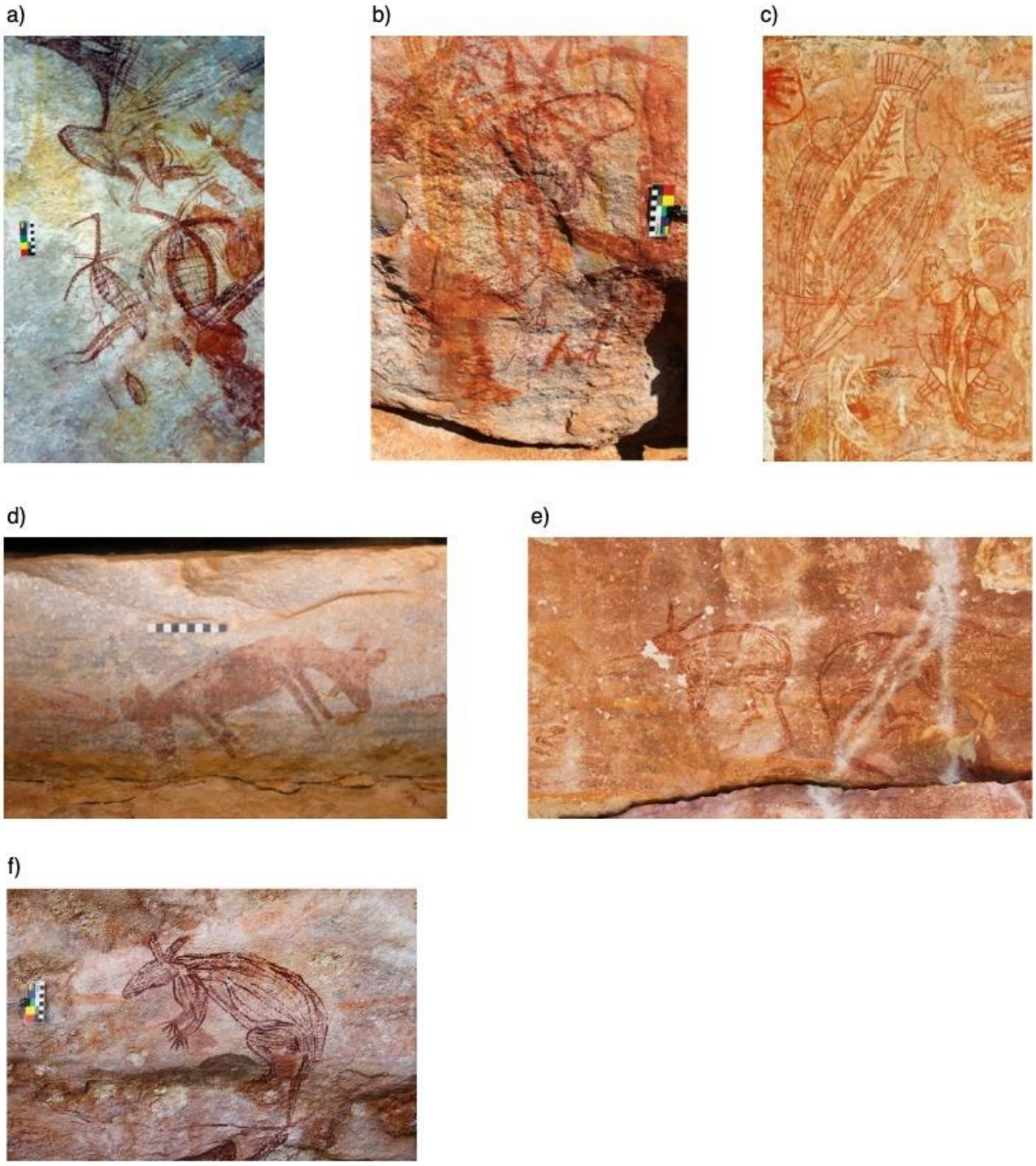

Figure 1: The species from Arnhem Land group

a) Back-to-back birds [1]; b) Dugong [2]; c) Turtle and Barramundi [3]; d) Double headed thylacine looking animal [1]; e) Bilbies [2] and f) Kangaroo [2]

II. The Kimberley animal depictions:

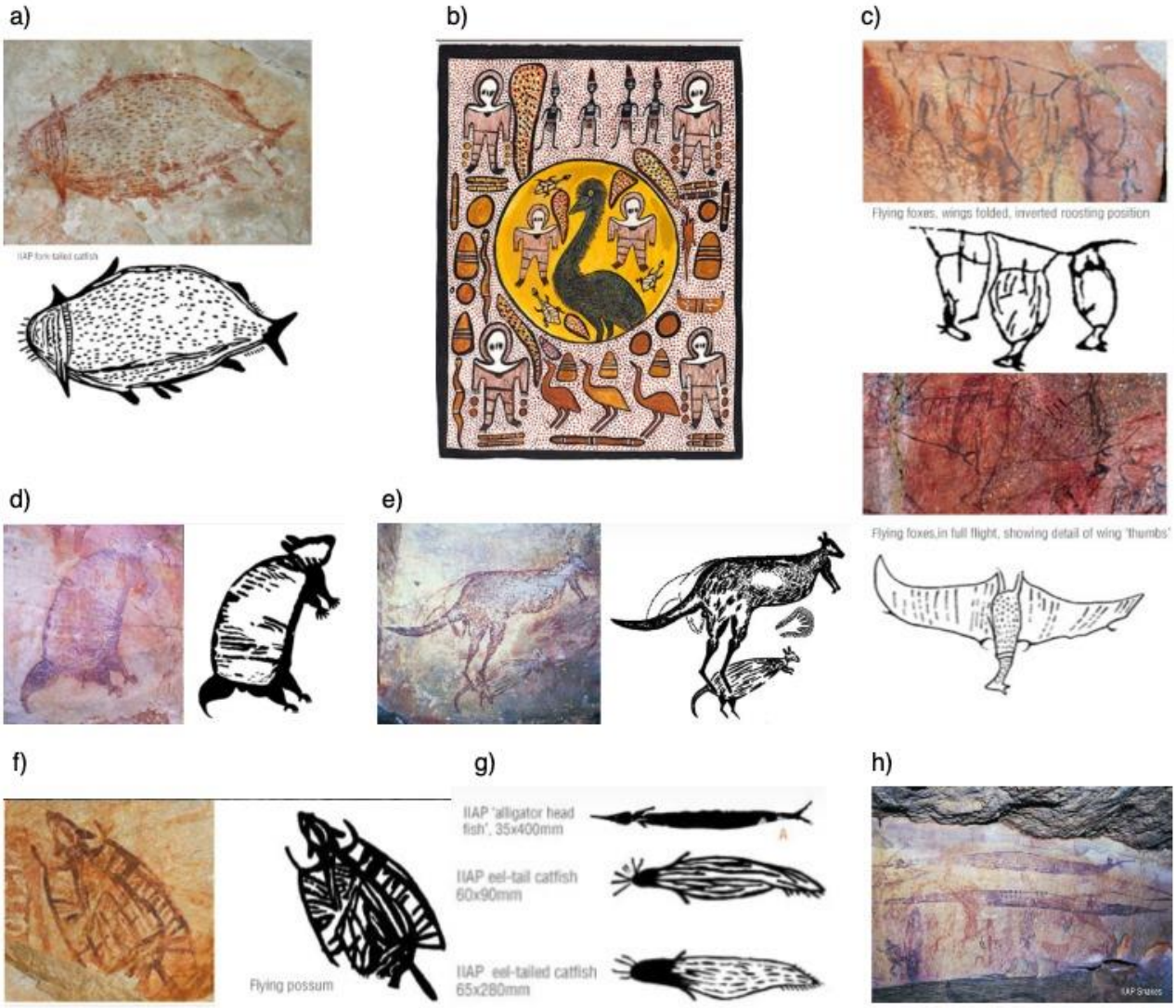

Figure 2: The animals depicted in art from The Kimberley

a) Fork-tailed catfish [4]; b) Emu, turtle, turkey, goanna and snake depiction [5]; c) Flying foxes [4] d) Ring-tail rock-haunting possum [4]; e) Wallaby/rat-kangaroo [4]; f) Flying possum [4]; g) “Alligator head fish” [4] and h) Snakes [4]

III. Pilbara Animal depictions:

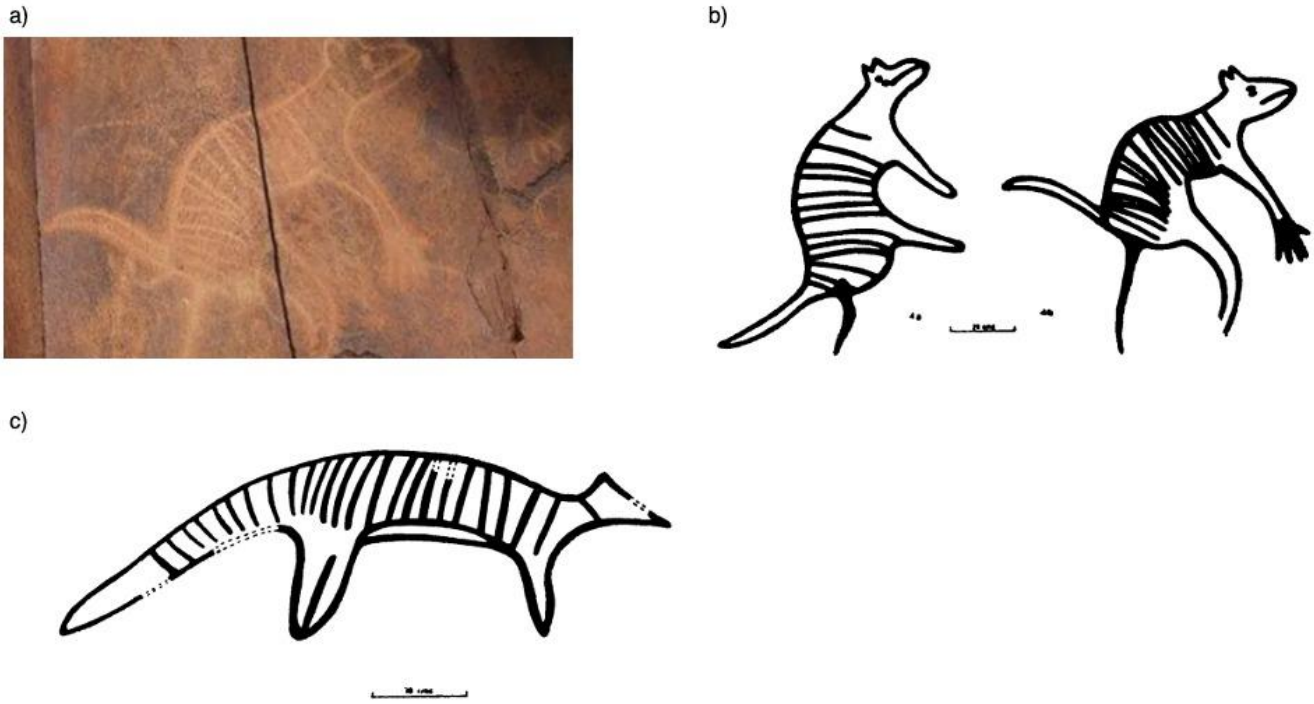

Figure 3:
a) Thylacine/Tasmanian Tiger [6]; b) Banded hare-wallaby [7] and c) Possible depiction of numbat [7]

IV. Torres Strait Islander animal depictions:

Figure 4:
a) Sharks [8]; b) Turtle [9]; c) Turtles, Stingrays, Dugong, Geese, Snake, Sword shark (saw shark), Octopus, Crocodile, Pig, Bat, Flying foxes, Seserre birds [10] and d) Dugong [11]

Method

1. **Identify the Region:**

   Use an Australian map to identify the region of study. Focus on areas with significant Aboriginal and Torres Strait Islander populations and historical records.

   The groups were majorly distributed around the north east/west shore line.

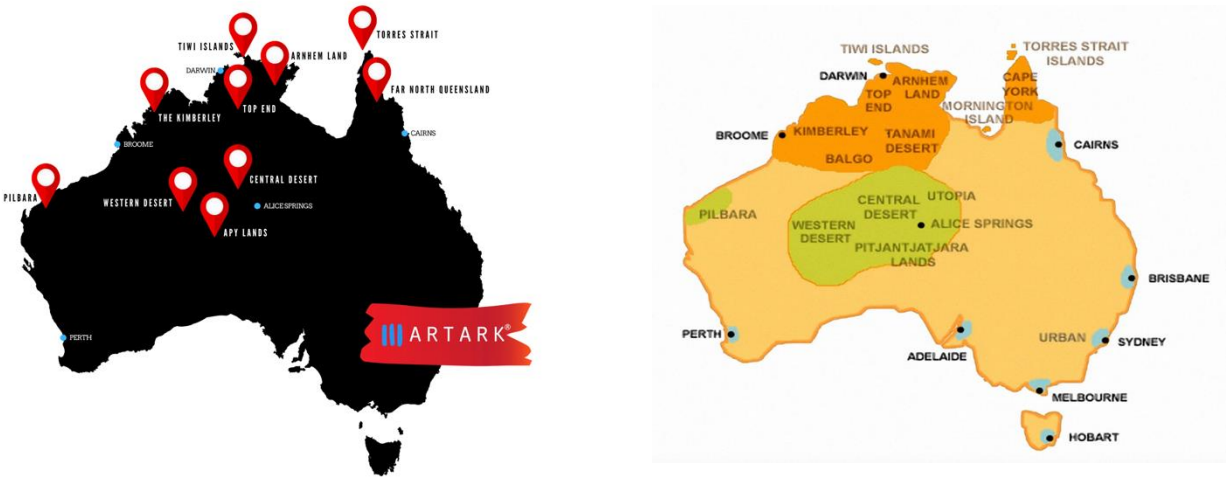

Fig 5: Distribution of Aboriginal groups with identified artworks across the Australian landscape. (Source: https://artark.com.au/pages/aboriginal-art-regions; https://creativenative.com.au/pages/art-regions)

2. **Choose Aboriginal Groups:**

   Select Aboriginal groups that cover the entire marked region, ensuring an even distribution to capture maximum diversity.
   Based on the above maps we identified the following aboriginal groups:

   i. Arnhem Land: Northern Territory
   ii. Anangu Pitjantjatjara Yankunytjatjara (APY) Lands: South Australia
   iii. Central: Northern Territory
   iv. Central Desert: Northern Territory
   v. Eastern Desert: Northern Territory
   vi. Far North Queensland: Queensland
   vii. Kimberley: Western Australia
   viii. Outback: South Australia, New South Wales And Queensland
   ix. Tiwi: Northern Territory
   x. Torres Strait Islands: Queensland
   xi. West Coast: Western Australia
   xii. Pilbara

3. **Collect information about the Groups by Literature Search:**

   Conduct a comprehensive literature search to gather information about the chosen Aboriginal groups. This search should include:
   a. Historical and anthropological texts.
   b. Research papers and studies on Aboriginal art and culture.
   c. Documentation of oral histories and traditions.

   Specifically look for:
   a. The time periods when these groups existed.
   b. The methods they used to represent and pass information, particularly through art.
   c. Detailed descriptions and analyses of their artworks.

4. **Identify Species Information:**

   Within the literature, identify references to animal species depicted in the artworks of these groups.
   Catalog the species information, including:

   a. Species names.
   b. Descriptions of the species' appearances in the artworks.
   c. The context in which the species are depicted (e.g., hunting scenes, spiritual representations).

5. **Select Groups for Detailed Study:**

   Based on the literature search, select groups that have a sizeable number of reported species in their artworks. Ensure that the selected groups represent a diverse range of species to provide a comprehensive understanding of historical biodiversity.

6. **Analyze Artworks:**

   a. Collect and analyze the artworks from the selected groups.
   b. Document the species depicted, noting any patterns or common themes.
   c. Cross-reference the species identified in the artworks with current conservation status and historical records.

7. **Data Compilation and Analysis:**
   a. Compile the data collected from the literature and artwork analyses.
   b. Analyze the data to determine how the identified species have survived and adapted over time.
   c. Consider environmental challenges such as invasive species, predators, habitat loss, and other factors affecting species survival.

Observations and results

Based on the gathered information, four Aboriginal groups were chosen to proceed with the hypothesis:

1. The Arnhem Land Group:
2. The Kimberley: Western Australia
3. Pilbara
4. Torres Strait Islanders

These groups are distributed across the northern and western/eastern shorelines of Australia.

Group 1. Arnhem Land Group:

The species identified in the Arnhem land were presented in Table 1

Table 1 presents the comparison of identified species reported by the 4 aboriginal and Torres Strait groups studied, and compared to how many of those still exist in current times, and how close they are to extinction. Comparison of the presence of various animal species depicted in Arnhem Land group rock art from ancient times ("Reported by Arnhem") with their status ("Reported in 2024"). This comparison helps to understand the survival and conservation status of these species over time.

S.No	Species	Reported by Arnhem	Reported in 2024
1.	Kangaroo	Yes	Yes [12]
2.	Birds	Yes	Yes [12]
3.	Snakes	Yes	Yes (Oenpelli Pythons - endangered) [14]
4.	Bilbies	Yes	Yes (vulnerable) [14]
5.	Dugongs	Yes	Yes (vulnerable) [14]
6.	Flying foxes	Yes	Yes (endangered) [15]
7.	Barramundi	Yes	Yes (there's two links for barramundi, I'll show one) [13]
8.	Turtle	Yes	Yes (most species are vulnerable or worse but the one mentioned in the link is okay) [14]
9.	Thylacine	Yes	No

Analysis on the species survival

1. Kangaroo: Present both in ancient times and now, indicating successful adaptation and survival.
2. Birds: Consistently present, showing resilience across time.
3. Snakes: Continued existence demonstrates their adaptability to changing environments.

4. Bilbies: Though still present, they are now considered vulnerable, indicating a decline in their population and habitat stability.
5. Dugongs: Remain present but are vulnerable, highlighting the impact of environmental challenges on their populations.
6. Flying foxes: Currently endangered, reflecting significant threats to their survival despite their historical presence.
7. Barramundi: Continues to thrive, showing successful adaptation over time.
8. Turtle: While still present, most species are now vulnerable or worse, indicating severe conservation concerns.
9. Thylacine: No longer present, marking a complete extinction of the species.

This table illustrates the varying degrees of success in species survival and highlights the importance of conservation efforts to protect vulnerable and endangered species. The comparison emphasizes the resilience of some species while also drawing attention to the urgent need to address the threats faced by others.

Group 2: The Kimberley: Western Australia

The species identified by the Kimberley's in Western Australia were presented in Table 2

Table 2 presents a comparison of animal species depicted in the rock art of the Kimberley Aboriginal group with their status as of 2024. This comparison helps in understanding the continuity, changes, and conservation status of these species over time.

S.No	Species	Reported by Kimberley	Reported in 2024
1.	Emu	Yes	Yes [16]
2.	Turtle	Yes	Yes [17]
3.	Turkey	Yes	Yes [18]
4.	Goanna	Yes	Yes [16]
5.	Fork-tailed catfish	Yes	Yes [19]
6.	Eel-tailed catfish	Yes	Yes (Endangered) [20]
7.	Long-necked tortoise/turtle	Yes	Yes [21]
8.	"Alligator head fish"	Yes	?
9.	Belonostomus	Yes	?
10.	Platypterygius	Yes	No (all ichthyosaurs are extinct) [22]
11.	Ring-tail rock-haunting possum*	Yes	Yes [23]
12.	Wallaby/rat-kangaroo like creature	Yes	Yes (there are wallabies and kangaroos but no rat-kangaroos) [16]
13.	Flying possum	Yes	? (couldn't find any evidence after the thorough literature search)

14.	Flying foxes	Yes	Yes [16]
15.	Snakes	Yes	Yes [16]

* The ring-tail rock-haunting possum is also called the rock ringtail possum. This alternative name is used in some references.

Analysis on the species survival

1. Emu: Present both historically and currently, showing successful adaptation and survival.
2. Turtle: Continuously present, indicating resilience over time.
3. Turkey: Remains present, showing adaptability to changing environments.
4. Goanna: Continues to exist, reflecting stability in their population.
5. Fork-tailed catfish: Consistently reported, showing survival across time.
6. Eel-tailed catfish: Although still present, now endangered, indicating significant threats to their population.
7. Long-necked tortoise/turtle: Remains present, showing stability.
8. "Alligator head fish": Current status is unknown, suggesting a gap in the existing knowledge or possible extinction.
9. Belonostomus: Current status is unknown, indicating a lack of recent documentation.
10. Platypterygius: Extinct, consistent with the extinction of all ichthyosaurs.
11. Ring-tail rock-haunting possum: Also known as the rock ringtail possum, remains present, showing survival.
12. Wallaby/rat-kangaroo like creature: Wallabies are present, but no rat-kangaroos, indicating partial survival of the species group.
13. Flying possum: Current status is uncertain due to lack of evidence after thorough literature search.
14. Flying foxes: Continues to exist, indicating resilience.
15. Snakes: Continuously present, reflecting adaptability to environmental changes.

This comparison table illustrates the varying degrees of survival and adaptation among the animal species depicted in the Kimberley Aboriginal group's rock art. It highlights the importance of continuous conservation efforts, especially for endangered species. The unknown statuses suggest areas for further research to fill in gaps in the existing knowledge.

Group 3: The Pilbara

The species identified in the Pilbara land were presented in Table 3.

Table 3 presents a comparison of animal species depicted in the rock art of the Pilbara Aboriginal group with their status as of 2024. This comparison sheds light on the survival, extinction, and conservation status of these species over time.

S.No	Species	Reported by Pilbara	Reported in 2024
1.	Thylacine	Yes	No
2.	Numbat	Yes	Maybe but too rare to determine because it's endangered. There's only less than a thousand of these alive. [24]
3.	Barred bandicoot	Yes	Yes [26] & [27]
4.	Banded hare-wallaby	Yes	Yes [25] (was extinct, but it was re-introduced in 2017)

Analysis on the species survival

1. Thylacine: Historically reported by the Pilbara Aboriginal group but currently extinct. This highlights the significant environmental changes and challenges that led to the extinction of this species.
2. Numbat: Although reported by the Pilbara group, it is currently extremely rare, with its status listed as endangered or vulnerable. This indicates a severe decline in population, requiring critical conservation efforts to prevent its extinction.
3. Barred Bandicoot: The Western Barred Bandicoot may exist in the Pilbara region, but there's very few left. Its national conservation status is endangered and has been successfully re-introduced onto Faure Island in 2005. It still hasn't been re-introduced to mainland Australia, but it's better to take it step by step, than have it extinct due to a rushed process. The Eastern Barred Bandicoot is either endangered or extinct in the wild, so it's not possible to tell if it exists in the Pilbara region. The driving cause for the critical conservation status of the Easter and Western Barred Bandicoot species is their loss of grassland habitat, and predation from cats and foxes.
4. Banded Hare-wallaby: Reported historically and present again today after being reintroduced in 2017. This indicates a successful conservation and reintroduction effort, showcasing the potential for recovery of endangered species.

The comparison highlights varying outcomes for different species:

- **Endangered**: Both the Eastern and Western variation of the Barred Bandicoot are nationally classified as endangered.
- **Extinct Species**: The Thylacine's extinction underscores the importance of historical records and artwork in understanding past biodiversity.
- **Critically Endangered and Vulnerable Species**: Numbats face severe threats and require ongoing conservation efforts to ensure their survival.
- **Successful Reintroduction**: The Banded Hare-wallaby's and the Western Barred Bandicoot's reintroduction success story illustrates how targeted conservation initiatives can help recover populations of endangered species.

This observation table provides valuable insights into the historical and status of animal species associated with the Pilbara Aboriginal group, emphasizing the need for continued conservation actions to protect vulnerable and endangered species

Group 4: The Torres Strait Islanders

The species identified by the Torres Strait Islanders were presented in Table 4

Table 4 presents an overview of the species observed by the Torres Strait Islanders and their current status. The comparison helps in understanding how these species have fared over time and highlights the adaptability and survival of different species amidst environmental challenges.

S.No	Species	Reported by Islanders	Reported in 2024
1.	Turtles	Yes	Yes [28]
2.	Dugongs	Yes	Yes [29]
3.	Sword shark (saw shark)	Yes	No
4.	Seabirds	Yes	Yes [30]
5.	Saltwater crocodiles	Yes	Yes [31]
6.	Stingrays	Yes	Yes [32]
7.	Geese	Yes	Yes [33]
8.	Snakes	Yes	Yes [34]
9.	Octopus	Yes	Yes [35]
10.	Crocodile	Yes	Yes [31]
11.	Pig	Yes	Yes [36]
12.	Bat	Yes	Yes [37]
13.	Flying foxes	Yes	Yes [38]
14.	Seserre birds	Yes	?

It shows that the majority of the species reported by the Islanders are still present in 2024. Notably, the Sword shark (saw shark) is no longer reported, and the status of Seserre birds is uncertain, indicating a need for further investigation. The saw shark still exists in other water bodies today, but not in the Torres Straits. There may have been a decrease in food source, water quality or many other external factors, but as of today, the saw shark has migrated to other areas. This comparison highlights both the continuity and changes in species presence over time, reflecting the impacts of environmental and conservation efforts.

Analysis of Animals Across Different Aboriginal Groups in Australia

The Kimberley:

Located in Western Australia (WA), the Kimberley Aboriginal group is renowned for its rock paintings and rock art. These artworks were created during the Irregular Infill Animal

Period (IIAP) or Naturalistic period, depicting animals at life-size [39]. Although no scientific methods can precisely date the application of paint to the rocks, it is estimated that the IIAP occurred between 17,000 to 13,000 years ago [39]. The Kimberley is also notable for housing some of Australia's oldest rock art. A distinctive style of Aboriginal art, called X-Ray art, which originated in Arnhem Land, is also featured in their rock art.

The Pilbara:
The Pilbara Aboriginal group, also located in Western Australia, depicted various animals in their rock art, including the Thylacine (Tasmanian tiger). This is particularly significant as the Thylacine went extinct approximately 11,000 years ago, indicating that the Pilbara's rock art must have been created before the species' extinction [6].

Arnhem Land Group:
The Arnhem Land group is primarily known for its X-Ray art, a unique rock art style depicting animals and the interiors of their bodies, such as spinal cords. Arnhem rock art started around 20,000 years ago [3].

Torres Strait Islanders:
The Torres Strait Islanders are indigenous people distinct from mainland Aboriginal Australians. Their art includes various forms such as painting and weaving rather than rock art. Due to the unique styles and the lack of historical rock art, it is challenging to track and date these pieces precisely. However, contemporary artworks from the NSW Art Gallery depict animals from ancient times, based on stories, tales, and legends passed down orally through generations.

The Torres Strait was named after the sailor Luís Vaz de Torres, who was the first European to navigate the straits over a century before Captain Cook [40]. Over 8,000 years ago, a land bridge connected Papua New Guinea and Australia, facilitating human migration south towards Australia and the Torres Strait Islands [40]. This connection is evident in the similarities between animal species in Papua New Guinea and northern Queensland. Rising water levels eventually isolated the Torres Strait Islands from Australia and Papua New Guinea. Evidence indicates human existence in the Torres Strait Islands at least 2,500 years ago [40]. Therefore, the art produced from this region likely dates from 2,500 years ago to the present. Due to their relatively recent history compared to mainland Aboriginal Australians, it is difficult to find old animal depictions by the Torres Strait Islanders. The Torres Strait campsites were mainly located near the shoreline at a time when the water levels were lower [40]. So, it is speculated that most of their ancient art has been lost to erosion and submersion. Another line of evidence shows that the first people to habit Torres Strait Islands have migrated from the Indonesian archipelago 70,000 years ago [41].

Discussion

The results of this study indicate that most species have adapted to their surroundings to combat environmental challenges within Aboriginal and Torres Strait Islander groups across Australia. Predation and habitat loss have primarily affected endangered or extinct animals. However, conservation efforts have saved a few species, such as the Eastern and Western Barred Bandicoots, by relocating them to predator-free sanctuaries on islands and then reintroducing them to mainland Australia after successful repopulation. Other species, such as the Thylacine and Platypterygius, went extinct long before conservation efforts existed.

The validity of the results obtained from comparing species identified by different Aboriginal groups and the Torres Strait Islanders with their status in 2024 is well-supported by the consistency and reliability of the data sources. Traditional ecological knowledge, documented through rock art and oral histories, provides a rich and accurate historical record of species presence, while modern scientific methods offer precise, standardized observations. Despite some discrepancies, such as the absence of the sword shark and the uncertain status of certain species, the overall consistency between ancient and contemporary data underlines the robustness of these findings. Environmental changes, habitat loss, and human impact explain many of the observed differences, highlighting the dynamic nature of ecosystems over time. The integration of traditional knowledge with modern science not only enhances the validity of these results but also emphasizes the critical role of Indigenous expertise in biodiversity conservation and the need for ongoing research to fill existing data gaps.

Overall, most species have managed to adapt to challenging environments and ensure their survival, corroborating the initial hypothesis of this experiment. This aligns with Darwin's theory of natural selection, where species that adapt best to their environment survive and reproduce, often referred to as the "survival of the fittest" (Darwin, 1859) [42]. Evolution and adaptation have played crucial roles in the persistence of these species.

Several challenges were encountered throughout the research, such as finding a wide variety of animal depictions in Aboriginal art and determining the timeline of the existence of certain Aboriginal and Torres Strait Islander groups. Documented and identified animal depictions were scarce due to limited public knowledge on the topic. Understanding the timeline of the four Indigenous groups was crucial because if they all existed simultaneously, it would have negated the threat of migration between groups, which could cause overlap in culture and language.

As this project is rooted in historical analysis, greater potential for error exists the further back in time it explores. A possible error in the above observations and results is the potential misidentification or ambiguity in species identification between historical records and modern observations. For example, the "Alligator head fish" and "Belonostomus" have uncertain current statuses due to unclear identification or lack of recent documentation. Additionally, there may be an oversight in recognizing the extinction status of certain species, such as the thylacine, which could lead to incorrect conclusions

about their historical presence. Furthermore, environmental and geographical changes over time may have been insufficiently accounted for, impacting the accuracy of the comparison between ancient and contemporary data.

Also, potential sources of error include the possibility that more animals existed in the studied areas but were not documented due to a lack of adequate literature or the absence of artworks depicting these animals. Additionally, it is possible that Indigenous groups created artworks based on pure imagination or depicted animals from outside their territory, leading to assumptions about the animals' presence in their region.

This project presents a proof of principle for species survival and has the potential to be expanded over a broader region of Australia. More sophisticated and established data collection methods could be employed in the future. Similarly, the experimental design could be improved to include the statistical significance of the reported findings. A greater variety of Indigenous groups would be included in the study to show more diversity. With more time, a broader range of artworks and additional sources of information would be utilized to gain deeper insights into this topic.

Overall, the findings of this study support the hypothesis that species have survived and adapted to environmental changes and challenges over the years. It was anticipated that many species would have existed in older times and still be present today, and it was reassuring to see that most of them have survived despite challenges. However, the extinction of a few species despite conservation efforts suggests that some species could not adapt to the changing environments, reflecting the ecological principle of "survival of the fittest" (Darwin, 1859) [42].

Discovering that multiple species have been saved from complete extinction through conservation efforts demonstrates how humans can positively impact the world by promoting species survival. This underlines the importance of continued and enhanced conservation strategies to support the ongoing survival and adaptation of species in the face of environmental challenges.

Conclusion

The analysis of Aboriginal artworks from the Pilbara, Kimberley, Arnhem Land, and Torres Strait Islander groups provides valuable insights into the historical presence and survival of various animal species. These artworks serve as a crucial resource for understanding species adaptation and survival over thousands of years, despite significant environmental challenges. Based on this study, it can be concluded that most species are able to adapt, evolve, and survive environmental challenges. As a next step, it is proposed to conduct a statistically significant study to quantify the actual number of each species that have survived across a broader range of areas. This would provide a more comprehensive understanding of species survival and adaptation in response to environmental changes.

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