

TAPROBANICA, ISSN 1800–427X. Vol. 14, No. 02 (2025): pp. 214–229.
Published by Research Center for Climate Change & Faculty of Mathematics & Natural
Sciences, Universitas Indonesia, Depok 16424, INDONESIA.
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<http://www.taprobanica.org>
<https://doi.org/10.47605/tapro.v14i2.374>



OPEN ACCESS

DECODING ARCHAEOFAUNAL BIODIVERSITY IN THE KARMA VIBHANGA (*KARMAWIBHANGGA*) RELIEFS OF BOROBUDUR TEMPLE – INDONESIA, AND ITS IMPLICIT MEANINGS

Submitted: 20 January 2025, Accepted: 22 September 2025, Published: 30 October 2025
Subject Editor: Anne-Marie Moigne

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Abstract

Borobudur Temple in Indonesia is one of UNESCO's World Heritage sites, renowned for its exquisite architecture, adorned with intricate reliefs, sculptures, and stone outcrops. A notable aspect that has not been exhaustively examined is the presence of diverse forms of archaeofauna depicted in the carvings of the Karmawibhangga relief. By employing the methodologies of intra-, inter-, and extratextuality, the examination of these reliefs as ecological and cultural texts unveils the broader implications associated with the incorporation of fauna within the narrative of the Karmawibhangga. The examination of 160 panels of Karmawibhangga reveals 52 species of archaeofauna, classified into the following taxonomic groups: mammals, birds, reptiles, fish, and molluscs. The archaeofauna functions as a valuable indicator of temporal, natural, and symbolically meaningful expectations related to the designated aspects, particularly human behaviour. These conditions serve to underscore the fact that Karmawibhangga reliefs serve as a means of conveying natural scientific principles and cultural critique in a manner that is more accessible to readers.

Keywords: Buddhist monument, Central Java, Syailendra Dynasty, UNESCO World Heritage

Introduction

The Borobudur Temple is a religious edifice with a rectangular configuration consisting of 1,460

panels securely attached to the vertical surfaces in the Borobudur subdistrict, Magelang, East Java, Indonesia (Puspitasari *et al.* 2010). Santiko

& Nugrahani (2012) delineate three discrete categories of relief sculptures present on the walls of the Borobudur Temple. The first of these categories comprises reliefs that function as visual storytelling, communicating a range of stories. This initial category encompasses beautifully engraved panels that depict sequential pictures, effectively conveying narratives of considerable length, such as the Lalitavistara, Gandawyuha, and Gandawyuha-Bhadracarī. The second category comprises panels that convey sequential narratives through concise graphic depictions, such as the Jataka and Avadana. The third category of relief panel is characterised by the depiction of a narrative story that is not presented continuously. Still, its interpretation adheres to the conventional method of reading narrative stories, as demonstrated by the Karmawibhangga. The Karmawibhangga relief is recognized as an extensive depiction of the artistic, cultural, religious, and social fabric of ancient Javanese civilization, rendered with meticulous fidelity to the authenticity of its spiritual traditions (Krom 1920, Fontein 1989, Santiko & Nugrahani 2012, Rusdianto *et al.* 2024). These scholars have demonstrated that the term "karma" signifies "action" or "deeds", and "vibhanga" means "wave" or "flow". Thus, the Karmawibhangga symbolises the concept of the karmic law, also known as the law of cause and effect. However, it is noteworthy that these scholars' analyses do not elucidate the role of biodiversity in each panel. Consequently, the full scope of the role of biodiversity remains unidentified. The Karmawibhangga reliefs, widely recognized for their aesthetic importance, are situated within the primary architectural framework of the Borobudur Temple. There is a total of 160 panels, of which four relief panels are accessible and visible to tourists on the southeastern front. Among a series of panels, specific panels display biological adornments in the form of archaeofauna and archaeoflora. However, the precise identity and intended use of these adornments remain unknown. The comprehensive range of animal adornments portrayed in every panel of Karmawibhangga's story is not consistently revealed. Therefore, this present article aims to categorize the 160 Karmawibhangga panels, identify and describe the archaeofauna species engraved on each panel in terms of morphology, ecology, and behavioural characters to elucidate the meaning of the archaeofauna's presence in the social context of the entire story on each panel.

Materials and Methods

The Karmawibhangga relief (Fig. 1), particularly following the work of J.W. Ijzerman in 1885, is of particular interest. Between 1890 and 1891, Ijzerman conducted an archaeological excavation at the lower section of Borobudur Temple, where he unearthed a series of relief sculptures. Ijzerman subsequently dismantled these reliefs to facilitate the capture of images. The Karmawibhangga reliefs, comprising 160 panels, were thoroughly documented by Kassian Chepas, a prominent Indonesian photographer, thereby enhancing their recognition within the field. Presently, all photographic documentation is housed in the Borobudur World Heritage Unit, and a systematic numbering system has been devised to align with the sequence of Karmawibhangga's narrative. Our analysis is based on this numerical code.

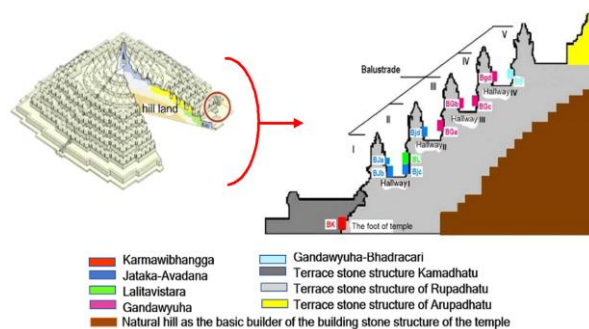


Figure 1. Position of Karmawibhangga relief in Borobudur Temple (Ashari *et al.* 2021)

Harto (2014) posits that the panels are sequentially read in a *pradaksina* (walking around the temple in a clockwise direction, carried out from the ground level to the top). The panels located within the temple are systematically numbered, starting at the eastern gate and progressing in a sequential order. A collection of 20 panels is present, each labelled O-01 to O-160. The panels are numbered in a clockwise manner, with a total of 40 panels on each of the southern, western, and northern sides, respectively. The sequence culminates with a series of 20 panels on the eastern side, from O-140 to O-160. Panels containing fauna carvings were sorted from the 160. Comparative morphological identification was then carried out on each exposed species, and the ecological habitat of the identified species was evaluated. The "V" and "Λ" outcrops are examples of each environmental habitat in the form of water or hilly land. All results were grouped based on fauna taxa similarities and compared with existing literature in the disciplines of

mammalogy (Gunawan *et al.* 2008, Phillipps & Phillipps 2016), ornithology (del Hoyo & Collar 2014), ichthyology (Kottelat *et al.* 1993), and herpetology (Frost *et al.* 2006). The Karmawibhanga panels were analysed by implementing an iconographic methodology used to analyse the representations of uncovered fauna and analysis of matrix education modifications as carried out in the Lalitavistara story panel (Achmadi *et al.* 2020, Rusdianto *et al.* 2020, Ashari *et al.* 2021). Furthermore, this study uses a philological analysis of the correspondence between local languages and outcrops identified in each panel. The approach to local language words that emerge from the identification of outcrops is then analyzed for their onomatopoeic correspondence to test whether there is a correspondence between outcrops and stories in each panel. Using the flashback repeated methodology, the results of identifying the emergence of fauna or flora outcrops can provide certainty in interpreting the revealed meaning of *wimba* (an image or scene engraved on a hard surface). The analysis of the social and environmental dimensions of archaeofauna—depicted animals used to infer past human-animal relationships and ecological contexts—in the narrative reliefs of Borobudur is grounded in a triangulated semiotic framework that integrates intratextuality, intertextuality, and extratextuality. This multimodal approach, as proposed by Mundayat (2021) and Rusdianto *et al.* (2024), enables a layered and context-sensitive interpretation of visual narratives, allowing scholars to move beyond surface-level iconography toward a deeper understanding of symbolic, narrative, and historical meanings embedded in the temple's sculptural program.

Intratextuality: Decoding internal panel dynamics. The interpretive process begins with intratextuality, which focuses on the internal structure and relational dynamics within a single relief panel (Sharrock & Morales 2000). This level of analysis examines how human figures, animals, architectural elements, gestures, and spatial arrangements interact within the same frame to construct meaning. In the context of archaeofauna, intratextual analysis reveals how animals are symbolically positioned in relation to humans or deities, whether as companions, offerings, obstacles, or spiritual emblems. For instance, a panel depicting a deer quietly standing beside a meditating ascetic in a forested landscape suggests an intratextual narrative of harmony between humans and nature, possibly

reflecting Buddhist ideals of non-violence (*ahimsa*) and mindfulness. The proximity, posture, and natural setting of the animal are all internal cues that contribute to this interpretation. Thus, intratextuality serves as the foundational layer of analysis, establishing the semantic coherence of individual scenes.

Intertextuality: Tracing narrative and thematic continuity across panels. Building upon intratextual insights, intertextuality expands the scope of analysis to examine the relationships between panels across the sequential narrative pathways of Borobudur's galleries (Juvan 2005). As a visual text composed of hundreds of interconnected reliefs, the temple's iconographic program follows structured storylines—such as the Jataka tales (stories of the Buddha's past lives) and the Lalitavistara (the Buddha's earthly biography). Intertextual analysis investigates how the representation of animals evolves across these sequences, reflecting shifts in theme, setting, or social hierarchy. For example, a transition from panels showing domesticated water buffalo in rice fields to later scenes of elephants in royal processions may signal a narrative progression from rural, agrarian life to urban, courtly power. This shift not only marks a change in environment but also encodes socio-political values—where certain animals become symbols of labour, fertility, or sovereignty. By mapping these transformations, intertextuality reveals how archaeofauna function as narrative markers, contributing to the didactic and moral dimensions of the Buddhist teachings conveyed through the reliefs.

Extratextuality: Situating the reliefs in a historical and cultural context. Finally, extratextuality grounds the interpretation in the broader world beyond the temple walls, connecting the visual narrative to external sources of knowledge (Langlands 2018). This includes historical records, religious scriptures (e.g., Pali Canon, Jataka commentaries), ethnographic data on ancient Javanese agrarian practices, and scientific reconstructions of the 8th–9th century Central Javanese environment (e.g., paleobotanical and zooarchaeological findings). For example, the frequent depiction of water buffalo in agricultural scenes can be corroborated by archaeological evidence of wet-rice cultivation in the Kedu Plain, while the presence of mythical creatures like makaras or nagas can be traced to cosmological texts and ritual symbolism in Mahayana Buddhist and Hindu-Buddhist syncretic traditions. Pollen and

sediment analyses further support the accuracy of flora and fauna representations, suggesting that the reliefs are not only symbolic but also reflect real ecological conditions. Through extratextuality, the reliefs are interpreted not as isolated artworks but as cultural products shaped by, and reflective of, their historical, religious, and environmental contexts.

Results

The Karmawibhangga relief exhibits a diversity of archaeofauna, commonly shown in relief panels that have not yet been analysed. This study presents scientific findings indicating that the reliefs unearthed at Karmawibhangga encompass a broader spectrum of thematic content, surpassing the mere depiction of causal relationships. Furthermore, these literary works encompass elements of documentation, scientific knowledge on archaeofauna, symbol meanings, and sociological concerns, along with the integration of critical perspectives on matters of social significance. The archaeofauna identified in these panels consists of five taxonomic groupings: mammals, birds, reptiles, fish, and molluscs. From a total of 160 panels in the Karmawibhangga relief, we found 60 panels depicting archaeofauna consisting of 52 species with a total of 221 individuals (Table 1). The Karmawibhangga panel depicts a wide range of natural creatures, predominantly found within the geographical confines of Java Island, with the noteworthy exception of lions. However, many animals illustrated in the relief panels, such as the Javan elephant (*Elephas maximus borneensis*) and Javan tiger (*Panthera tigris sondaica*), are presently extinct in the Java region. The findings on the comprehensive identification of the complete spectrum of archaeofauna indicate that not all can be accurately classified to the species level. The limitation arises from the typical physical characteristics identified throughout the artworks. The process of identifying faunal reliefs to the species level involves a mix of morphological identification and the analysis of contextual narratives and surroundings associated with the archaeofauna. The Karmawibhangga narrative commences its depiction of the natural world by presenting visual depictions of many species, such as the Mahseer fish (*Tor* sp.), Whistling duck (*Dendrocygna* sp.), Rail bird (Ralliidae), Javan elephant, and the Domestic horse (*Equus caballus*).

Mammals. Mammal archaeofauna sculptures were found in 25 panels, consisting of 20 species with a total of 45 individuals. The most common mammal relief found in the panels is the Kintamani dog (*Canis lupus*) (Fig. 2A). The Kintamani dog in the relief phenotypically resembles the Asian dog (*Cuon alpinus*) with its distribution in Java. The subject is not identified as an Asian dhole; rather, it is referred to as Kintamani, a dog breed that has been domesticated in Java for a considerable time and which is still found in Bali under the same name. This variety of Kintamani dog is rarely encountered in Java. The Kintamani dog is indigenous and endemic to the island of Bali, Indonesia, and is genetically closely related to the Australian dingo. It is believed to have predominantly originated in the Kintamani, Bali region (Puja *et al.* 2005) with a potential presence in Java as well.

The Kintamani was displayed in a configuration consisting of six distinct panels, each showcasing a collection of six animals. The panels are O-4, O-49, O-65, O-87, O-88, and O-92. Moreover, a solitary pedigreed Kintamani is shown on the southern facade of panel O-53. The Kintamani dog is a canine breed with a remarkable nature of courage and resilience, which underwent selective breeding over the years by the locals. The Kintamani dog exhibits distinctive physical characteristics, particularly with the morphology of its ears. In contrast to Domestic dogs (Fig. 2C), which frequently display ears in a flattened position, the ears of Kintamani dogs are upright and show a notable resemblance to those of a coyote. The behaviour exhibited by the wild dog, under the specific setting of a rice field habitat, exhibits resemblances to the typical behaviour observed in the Kintamani dog breed.

Four individual Rice field rats (*Rattus argentiventer*) were exhibited (Fig. 2B). Santiko & Nugrahani (2012) interpreted the relationship between rats, dogs, and humans in panel O-65, where four rats entered a garden guarded by a dog and its owner. Anggorojati *et al.* (2023) observed that rice plants were ready for harvest, evidenced by filled grains, and were guarded by several people from rat pests. The taxonomic differentiation of the Rice field rat at the species level can be established through the examination of its physical traits, namely the proportionally shorter tail with the body length and their ecological habitat (Phillipps & Phillipps 2016).

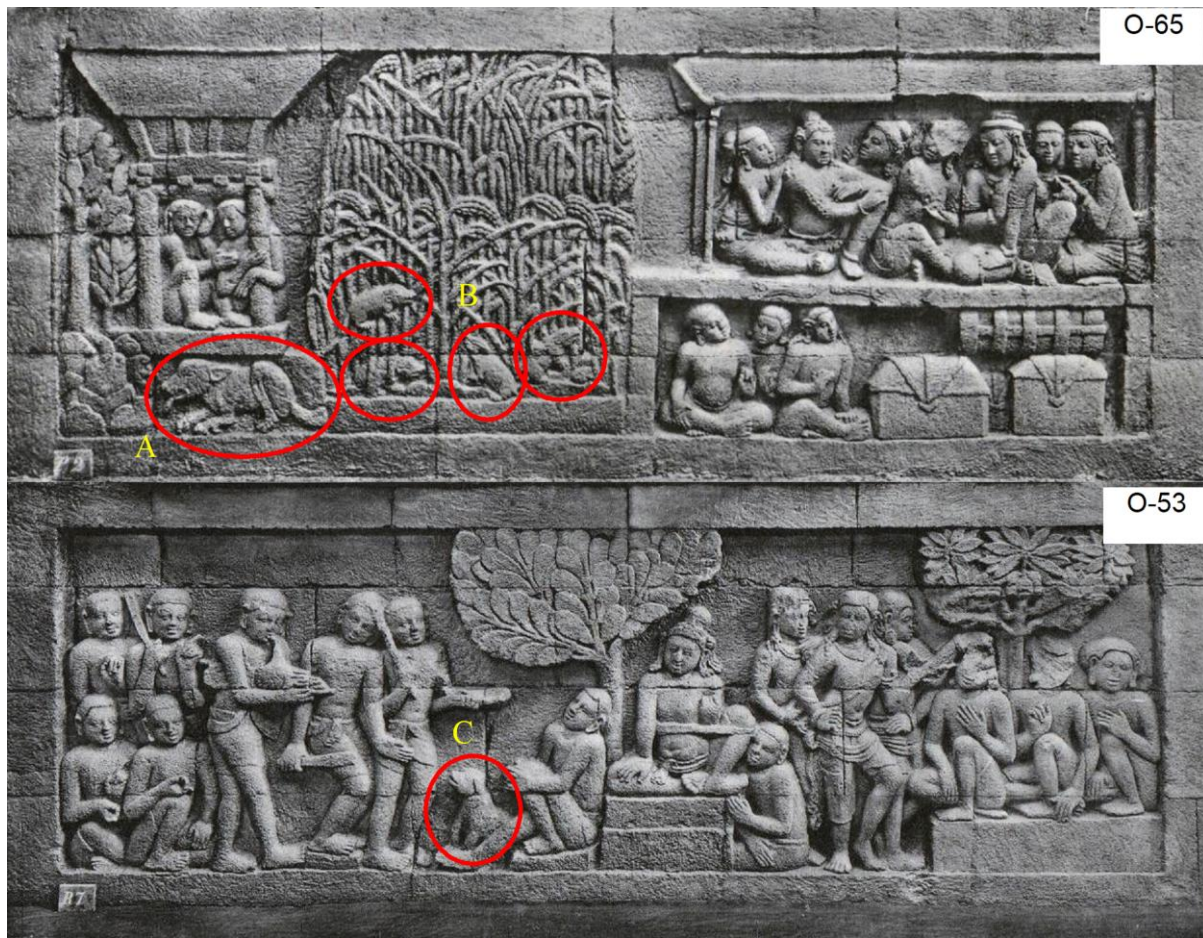


Figure 2. A sculpture of (A) a Kintamani dog, (B) four rice field rats, and (C) a domestic dog in Karma-wibhangga relief; © Photo: Borobudur Conservation Office

Other mammalian species include domestic horses (*Equus caballus*) (Fig. 3A) and Javan elephants (*Elephas maximus borneensis*) (Fig. 3B). The species are arranged in a configuration comprising five panels and five individuals, respectively. The representations of the two species are visible in panels O-87 on the western side, O-129 and O-132 on the northern side, and O-150 and O-159 on the eastern side. The panels depict the mutual relationship formed between Javan elephants, Domestic horses, and humans.

The visual characteristics of these things may be perceived as enigmatic beings, commonly referred to as “omens”, which individuals are inclined to support in their quest for Nirvana. Furthermore, it is imperative to acknowledge the profound religious and symbolic significance attributed to both Javan elephants and domestic horses. These creatures have been revered throughout history as venerable mounts, utilized by the nobility and the prince Siddharta Gautama. This phenomenon is depicted in many Lalitavistara stories, where ornaments, such as crowns and bells, are attached to the bodies of

elephants and horses, which are often shown standing together on a single panel (Rusdianto *et al.* 2020, Santiko & Nugrahani 2012).

Panel O-105 (Fig. 4) has the most diverse archaeofauna. At least six species have been identified, including Muntjac (*Muntiacus muntjak*) (Fig. C), Long-tailed macaques (*Macaca fascicularis*) (Fig. D), Asian palm civet (*Paradoxurus hermaphroditus*) (Fig. E), a pair of Lesser mouse-deer (*Tragulid javanicus*) (Fig. F) Binturong (*Arctictis binturong*) (Fig. G), and Sunbirds (Nectariniidae) (Fig. H). Additionally, four people are meditating solemnly. Besides living creatures, there are also water symbols (V) and mountains/hills (Λ), so that it can be interpreted that the four people are meditating in a dense primary forest near a spring and surrounded by various species of fauna.

The Indian muntjac has small antlers present in males, which are relatively short with long fur; the females have tufts of hair and small bony knobs that are in the location of the antlers in males, and a short coat of hair. Long-tailed macaques can be recognized by their

characteristic tail that reaches 50-60 cm in length and is longer than head and body length, the eyes are directed forward for binocular vision, the nose is flat, and the nostrils are narrow and close together, with terrestrial habitats in primary, disturbed/secondary forests, and riverine and coastal forests. Asian palm civets are small, weighing only about three kg with an average body length of 50 cm. The tail is 48 cm long, with a length ratio of head and body to tail of about 1:1, elongated bodies with short legs, and a tail that is almost as long as their head and body combined. The nose is pointed and protrudes from the small face. The Binturongs are the largest species in the Viveridae family, recognizable by morphological traits such as long, coarse, black fur covering their bodies, small eyes, and long ear tufts protruding from small, rounded ears. The Lesser mouse-deer does not have antlers or horns. The appearance of the “V” (Fig. 4B) and “Λ” (Fig. 4I) symbols implies a deep meaning. The V symbol may symbolize something open or receptive. In Buddhist iconography, it may be interpreted as a vessel or place that receives blessings or teachings. The V symbol can also be interpreted as a sign of victory or something that points upwards, indicating spiritual attainment or victory over worldly suffering. Meanwhile, the symbol Λ is often construed as a representation of a mountain or peak. In the Buddhist tradition, mountains usually symbolize a sacred place, a cosmic center, or a place of spiritual height. The Λ symbol can also symbolize stillness and stability, leading to the attainment of nirvana or ultimate wisdom.

Birds. Avian archaeofauna sculptures were found in 36 panels, consisting of 20 species with 91 individuals. The dominant species is the renowned avian organism referred to as the mythological bird of “Kinara-Kinari” (Kinara/male and Kinari/female are half-human, half-bird creatures in Hindu and Buddhist mythology). The subsequent presentation showcases the Columbidae species, commonly referred to as pigeons (Fig. 5C), arranged in a sequential manner consisting of ten panels, with each panel comprising 22 individuals. Pigeons can be classified into two main categories based on their habitat or geographical location: those that inhabit woodland surroundings and those found in urban or residential areas. The bird taxa documented inside the forested region consist of pigeons and doves from the Columbidae family. In contrast, the population residing in the

immediate proximity of the residential structure is distinctly recognized as *Columba livia*, often known as rock doves or rock pigeons. Other bird species in the area include the native Domestic chickens (*Gallus gallus domesticus*) (Fig. 5B). Domestic chickens (*Gallus gallus domesticus*) are distinguished by several morphological characteristics that allow for precise identification. These characteristics include a smaller body size, a slender body, short tail feathers, and the absence of dangling tail feathers. Domestic chickens are typically maintained under conditions of indulgence or with access to the surrounding environment, such as gardens, forests, and residential yards, where they are capable of foraging for sustenance (see Fig. 5).

Jungle fowl, on the other hand, generally have longer tail feathers and larger bodies. They also tend to live in forests or other wild habitats. Figure 5 presents a scene depicting the presence of livestock, including pigs, as well as aquatic animals such as fish, which are stocked and fed. Additionally, the scene includes village chickens that are permitted to forage actively in the yard. This scene exemplifies the symbiotic relationship between humans, flora, and fauna within their natural environment. The panels depict the appearance of avian creatures, notably the mythological beings referred to as Kinara Kinari (Fig. 3C), in a series of ten instances. Kinara Kinari commonly has a central body structure that bears a resemblance to that of a pigeon, incorporating anatomical features from several bird species. The bird species that exhibits a physical structure reminiscent of that of a pigeon can be observed inside panels O-101 and O-147, and other physical traits similar to those of the Green Peafowl (*Pavo muticus*) are documented in panel O-86 (Fig. 6B).

The bird species that have a single occurrence in the sculptures are the Whistling duck (*Dendrocygna* sp.), the Rail bird (Rallidae), the Long-tailed parakeet (*Psittacula longicauda*), the Flowerpecker bird (*Dicaeum* sp.), an Eagle (Accipitridae) (Fig. 6A), and the Oriental magpie-robin (*Copsychus saularis*). Further, the western side (panel O-94) is a representation of human bird Humanoid Falconiformes sculptures. Notably, the facial characteristics of these sculptures are distinguished by their sharp, downward-curving beak, their prominent eyes, and their acute vision, exhibiting similarities to those seen in bird species classified under the order Falconiformes.

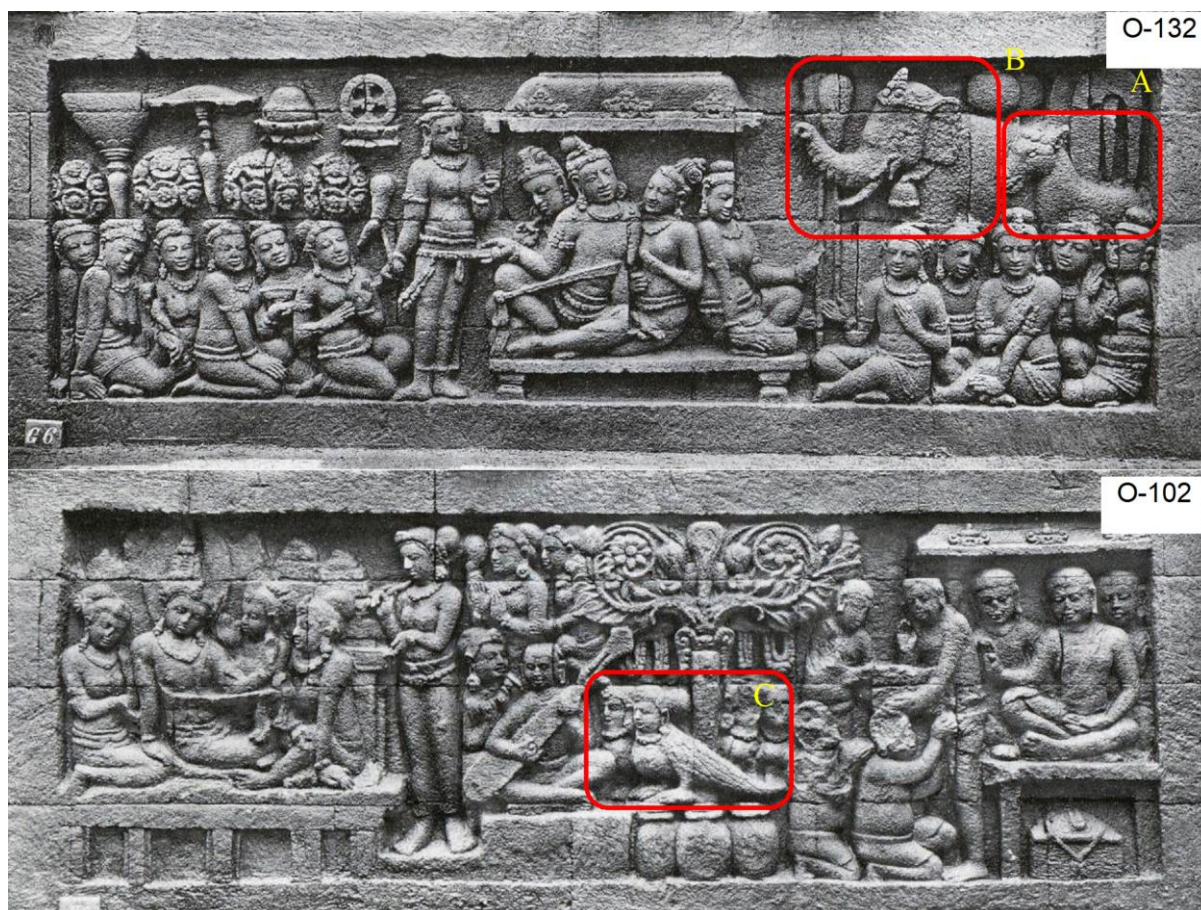


Figure 3. A sculpture of (A) a domestic horse, (A) a Javanese elephant, and (C) a kinara-kinari in Karma-wibhanga relief; © Photo: Borobudur Conservation Office

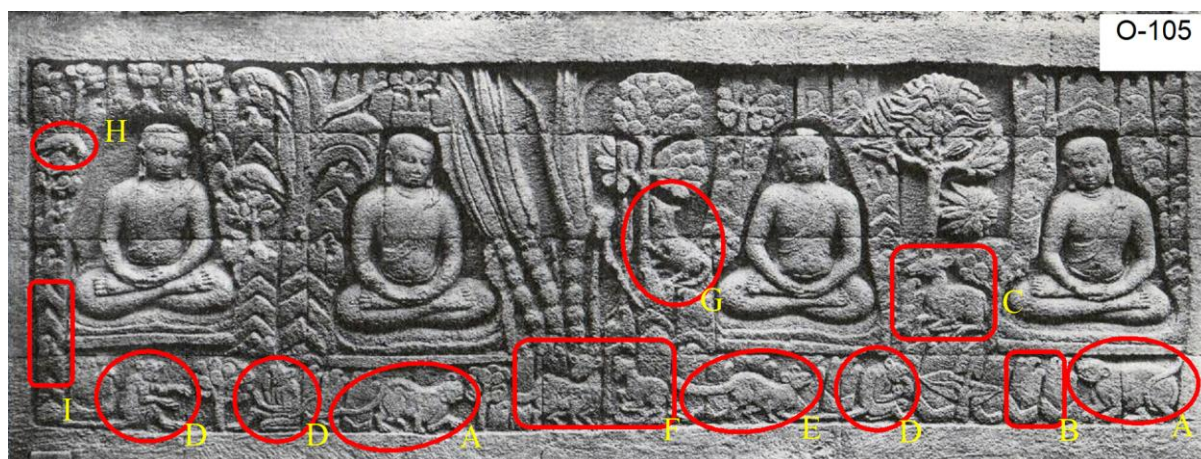


Figure 4. A sculpture of (A) a pair of Javan tigers, (B) V symbol, (C) Muntjac, (D) Long-tailed macaques, (E) common palm civet, (F) a pair of Lesser mouse-deer, (G) Binturong, (H) Sunbirds, and (I) a symbol; © Photo: Borobudur Conservation Office

Reptiles. Reptile archaeofauna sculptures were found in seven panels, consisting of four species with a total of 16 individuals. The softshell turtle (*Amiysa* sp.) is the species with the most occurrences, with a total of five individuals spread across two panels, namely three individuals in panel O-89 (Fig. 7) and two

individuals in panel O-129. The presence of snakes was seen in panel O-90, with a single occurrence, as well as in the Cobra sculpture (*Elapididae*). The existence of snakes was additionally verified in panels O-91 and O-94, when a collective count of six individuals was recorded.

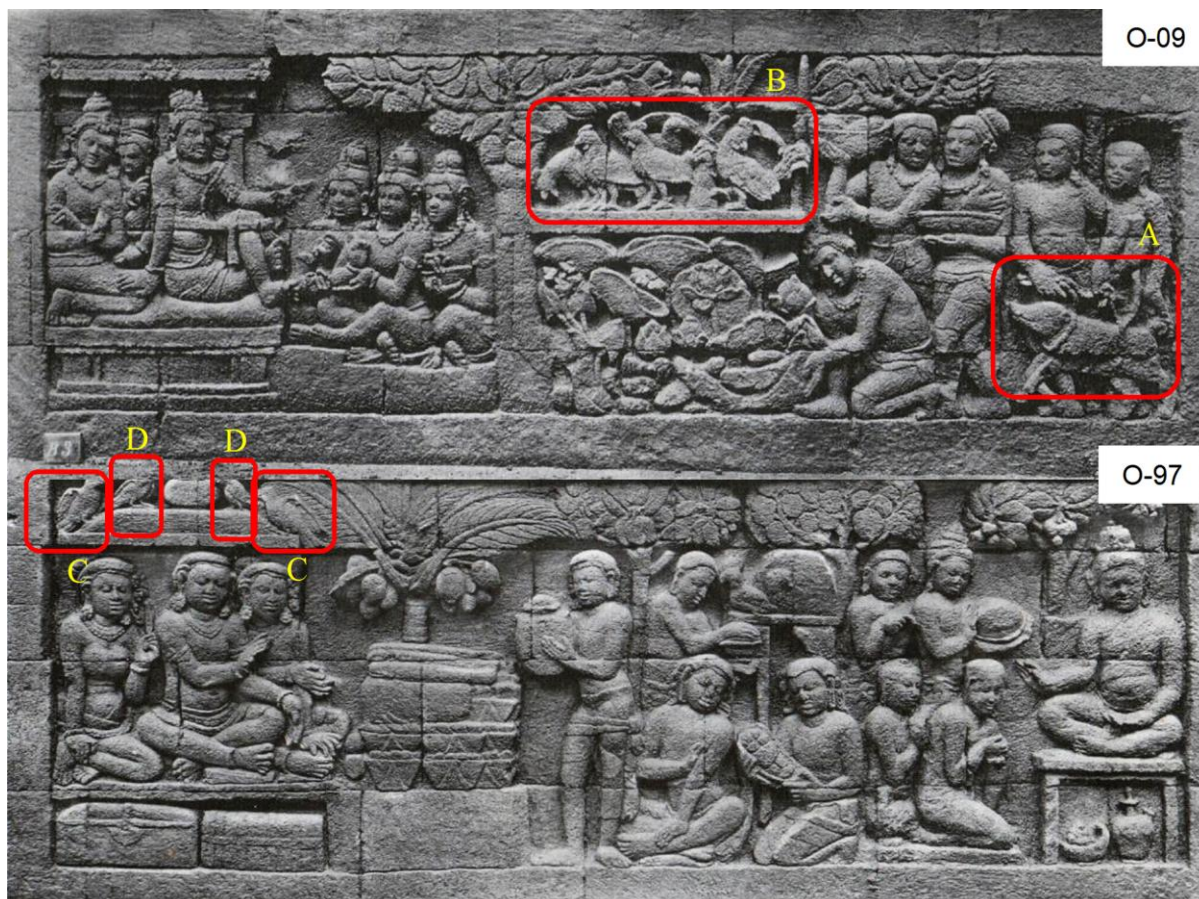


Figure 5. A sculpture of (A) a wild boar, (B) domestic chickens, (C) a pigeon, and (D) estrildid finches; © Photo: Borobudur Conservation

Fishes. Fish archaeofauna sculptures were found in eight panels, consisting of six species with a total of 45 individuals. The most sculpted fish is the Mahseer (Fig. 8) with a total of 36 individuals. Some fish species are quite difficult to identify to the species level due to limited visible morphological characteristics. The fish archaeofauna were carved in several conditions or scenes, such as swimming in a pond, being caught using traditional fishing gear called “bubu”, being carried for sale, being cut for cooking, and being put in a cauldron along with several softshell turtles for cooking. The various scenes depict how the ancient Javanese people utilized and processed fishery resources at that time. In Figure 8, the opening (panel O-01) of the Karmawibhangga story shows the living conditions of the people at that time, and the mahseer fish was one of the commodities traded. The Mahseer fish typically inhabits freshwater habitats located in the upstream sections of rivers, and in Indonesia is found mainly in Sumatra, Java, and Kalimantan. These habitats are renowned for their excellent water quality and swift-flowing currents.

The term “Mahseer fish” is widely used by several local community organisations. Furthermore, a segment of the indigenous community believes the mahseer fish symbolizes a divine being, thereby endowing it with sacred status and prohibiting its direct extraction from its natural habitats. The mahseer fish is predominantly restricted to religious ceremonies or specific celebratory events, whereas *Cyprinus carpio*, a widely encountered fish species, is extensively farmed and utilised for sustenance. The inclusion of fish species in the Karmawibhangga's narrative lends credence to the idea that pisciculture was a long-standing tradition among the Javanese people before the 8th century.

Molluscs. Mollusc archaeofauna sculptures were found in three panels, consisting of two species with four individuals. The panels O-31, O-105, and O-150 exhibit depictions of molluscan reliefs. The panels O-31 and O-150 portray *Turbinella* sp. (Fig. 9), a marine gastropod. Panel O-31 depicts an outcrop thought to be *Turbinella* sp. bearing holy water that was intended to be offered to monks.

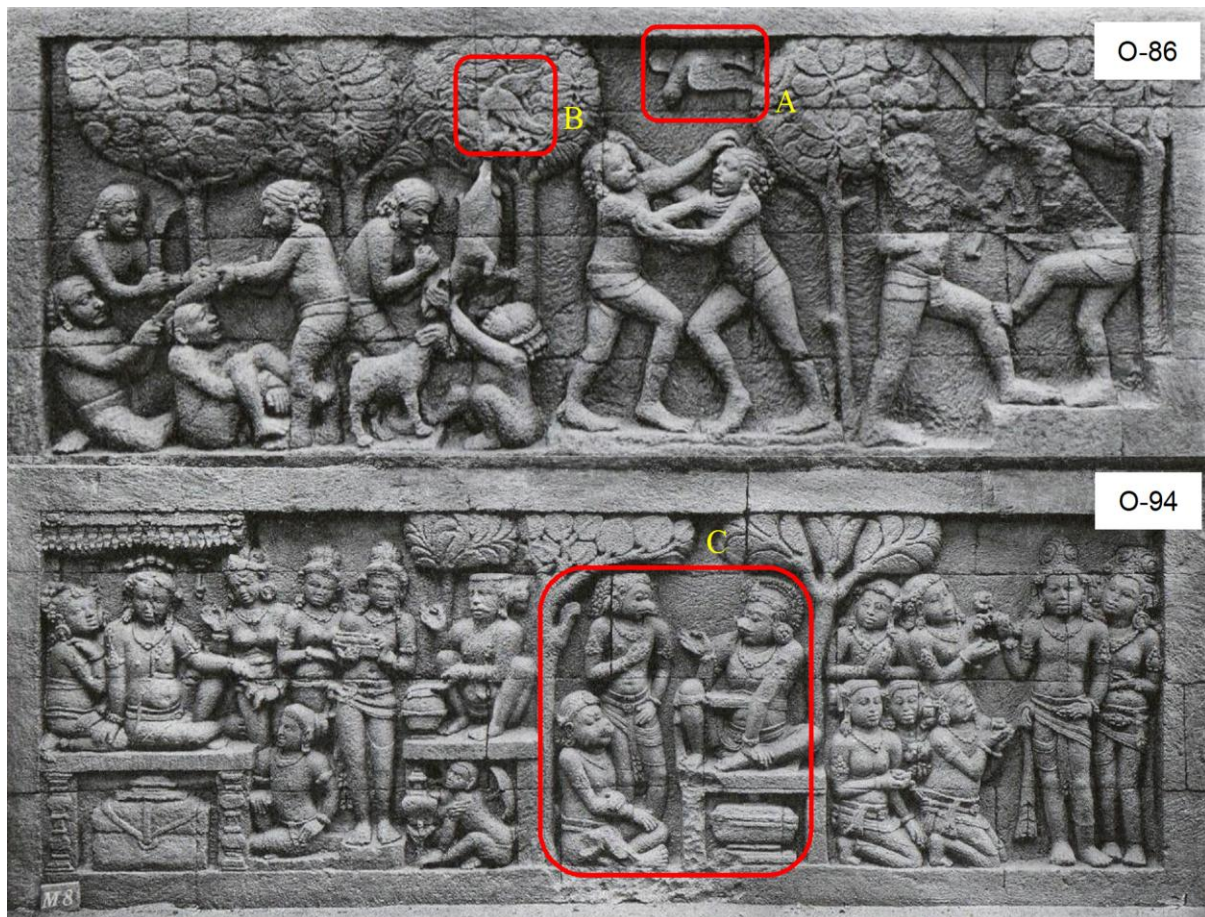


Figure 6. A sculpture of (A) an eagle, (B) a green peafowl, and (C) a humanoid Falconiformes in Karma-wibhangga relief; © Photo: Borobudur Conservation

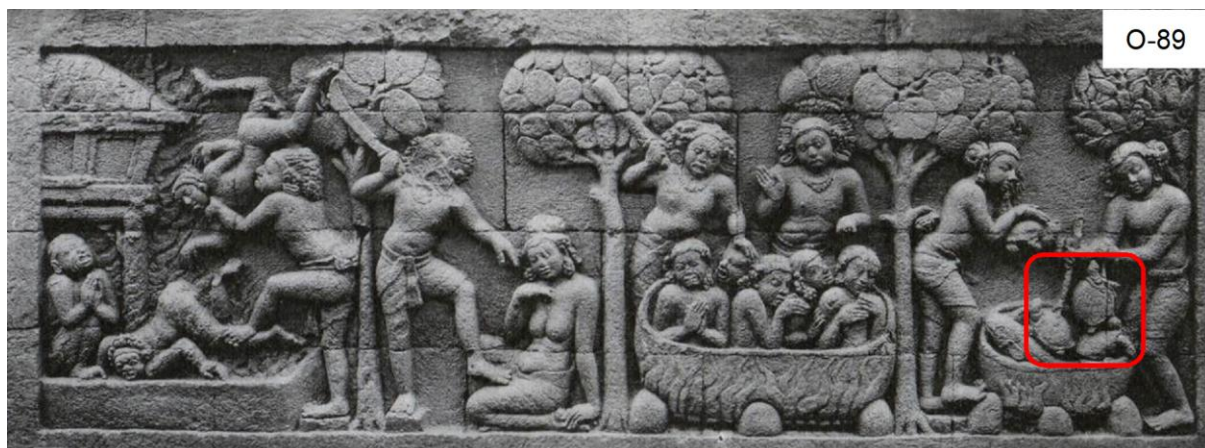


Figure 7. A sculpture of three softshell turtles (red square) in the Karmawibhangga relief; © Photo: Borobudur Conservation

In contrast, panel O-150 depicts a pair of *Turbinella* sp. shells employed for ornamental purposes within pavilions and palaces. The architectural designs of pavilions and palaces frequently incorporated these decorative shells. The gastropods, commonly referred to as “shankha” in the context of Hindu-Buddhist mythology, are the focal point of the ongoing

discourse. The phenomenon may also be observed in Gastropoda, notably in the panel denoted as O-105, where it is depicted as a defensive encasement for the cephalic region of a hermit-like entity. The exact number of individual occurrences in this panel remains ambiguous or undetermined due to the inadequate resolution of the image.

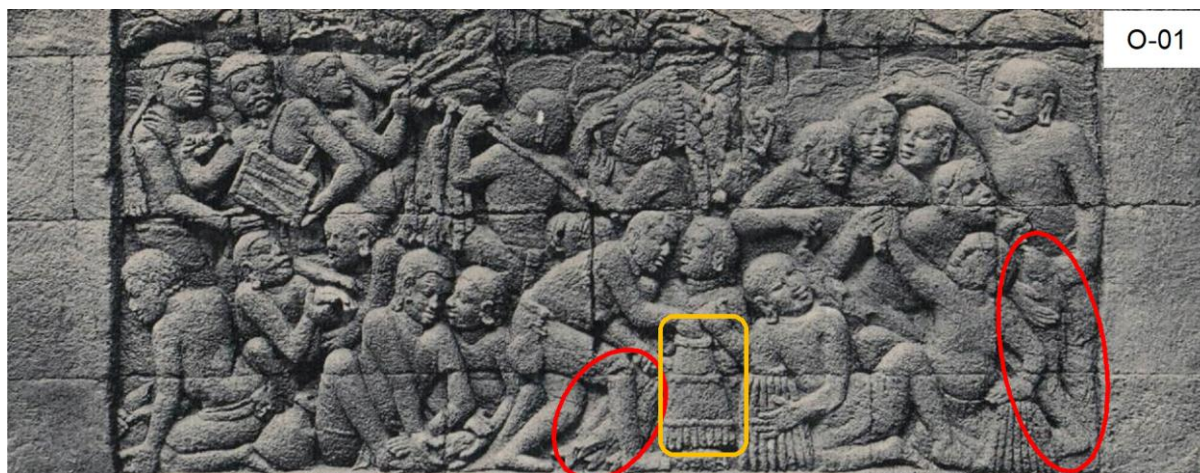


Figure 8. A sculpture of a Mahseer fish (red oval) being caught using traditional fishing gear (yellow square); © Photo: Borobudur Conservation

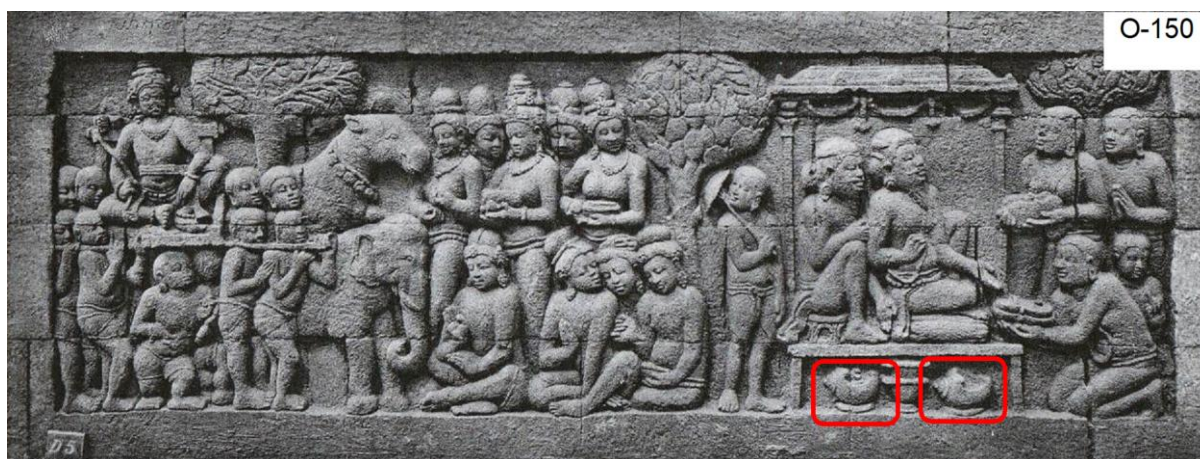


Figure 9. A sculpture of a pair of *Turbinella* shells as ornaments in Karmawibhangga relief; © Photo: Borobudur Conservation

Discussion

Diversity of archaeofauna engraved on the Karmawibhangga relief. The Karmawibhangga relief showcases a diverse array of fauna that reflects the biodiversity and the relationship between humans and animals within the context of life and moral teachings (Fig. 10). Fauna in Karmawibhangga reliefs is often used to illustrate various human traits and the consequences of their actions. The depiction of fauna in reliefs shows the close relationship between humans and nature. It demonstrates how humans depend on animals for various needs such as transportation, agriculture, and protection. Fauna in the reliefs are also used to teach the law of karma, with certain animals representing the results of good or bad deeds.

The Karmawibhangga features a Lion sculpture relief (*Panthera leo*), which serves as a guardian for a highly respected structure. This portrayal diverges significantly from the

portrayal of lions as plentiful in the Lalitavistara tale (Achmadi *et al.* 2020). The lion reliefs that intermittently appear in the Karmawibhangga story are portrayed as of comparable importance to the main portrayal of human existence.

On the other hand, it might be argued that the Lalitavistara text offers a more extensive and detailed portrayal of the being and experiences of Sidhartha Gautama (Anandajoti 2017). Moreover, all fauna species in sculpture reliefs occur in Java are except for the Lion.

Lion paw adornments, attributed to the lion, have been unearthed within several religious edifices, including Buddhist and Hindu temples such as Borobudur and Prambanan Temple, respectively, which are located in Central Java, Indonesia. The ornaments are similar to the Kinara Kinari, which may be found in two structures that incorporate architectural elements from both Buddhism and Hinduism (Raffles 2008).

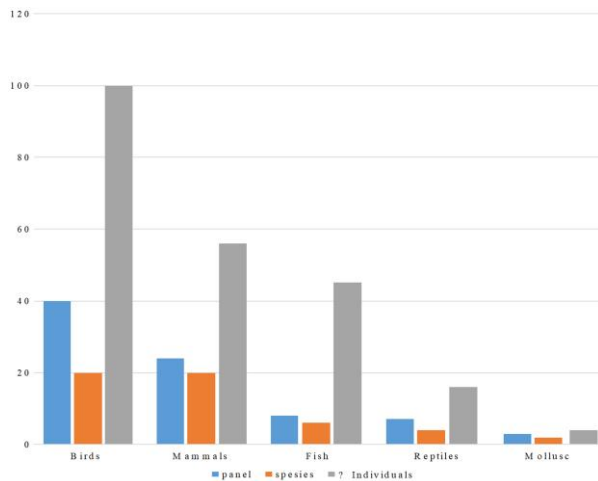


Figure 10. The total numbers of panels, total numbers of species and total occurrence of five archaeofauna groups engraved in Karmawibhanga relief

The lion motif, frequently found in Buddhist teachings, is commonly associated with the metaphorical portrayal of the Buddha. The appellation "The Lion of the Sakya Family" and the teachings disseminated by the Buddha have likewise been analogized to a resounding voice, commonly referred to as "Simhanada", which resonates in all cardinal directions (Halim & Herwindo 2017). It is also a top predator in the natural food chain (Rusdianto *et al.* 2020).

Generally, the fauna portrayed in each panel is representative of a distinct taxonomic class. Our analysis reveals that a total of 11 panels display a particular category of mammals, whereas birds are observed in 26 panels. Furthermore, our study showed a limited number of simultaneous instances of various combinations of fauna within a singular panel. The Karmawibhanga tale demonstrates that each panel encompasses a maximum of three distinct classes of fauna, e.g., sculpture of Birds, Mammals, and Mollusca in Panel 105 (Fig. 4, Table 1).

Including a significant quantity of panels representing a specific category of fauna in each panel enables the comparative examination of psychology among persons. The present analysis incorporates a range of factors, including the unique characteristics, behaviours, and ecological functions of the subject under investigation. The inclusion of fauna inside the panels of the story, as exemplified in the panels, is anticipated to enhance readers' comprehension of the narrative's underlying message. This specific panel presents a dichotomous classification of fauna. The visual representation primarily features the portrayal of an individual's

death, which is further emphasized by the addition of two avian species, specifically the Slender-billed Crow (*Corvus enca*) and the Javan Owlet (*Glaucidium castanopterum*).

The intra-, inter-, and extra-textual iconography analysis. Through careful examination, the iconography provides useful insights into the recognition, depiction, and analysis of different elements in visual representations. Simultaneously, semiotics serves as an analytical framework that critically examines the signs associated with an object to discern the latent meaning inherent within the entity. Damisch (1975) conducted a study that established a correlation between semiotics and iconography, wherein iconography assumes a secondary role to semiotics, facilitating the ongoing association of linguistic meanings.

Furthermore, the analysis of the social and environmental dimensions of depicted animals used to infer post-human-animal relationships and ecological contexts in the narrative reliefs of Borobudur is grounded in a triangulated semiotic framework that integrates intratextuality, intertextuality, and extratextuality. This multimodal approach, as proposed by Mundayat (2021) and Rusdianto *et al.* (2024), enables a layered and context-sensitive interpretation of visual narratives, allowing scholars to move beyond surface-level iconography toward a deeper understanding of symbolic, narrative, and historical meanings embedded in the temple's sculptural program.

The interpretive process commences with intratextuality, which concentrates on the internal structure and relational dynamics within a solitary relief panel (Sharrock & Morales 2000). This analytical level examines the manner in which human figures, animals, architectural elements, gestures, and spatial arrangements interact within the same frame to construct meaning. In the context of archaeofauna, intratextual analysis discloses the symbolic positioning of animals in relation to humans or deities. This positioning may be as companions, offerings, obstacles, or spiritual emblems.

For instance, a panel depicting a deer standing quietly beside a meditating ascetic in a forested landscape suggests an intratextual narrative of harmony between humans and nature, possibly reflecting Buddhist ideals of non-violence (ahimsa) and mindfulness. The proximity, posture, and natural setting of the animal are all internal cues that contribute to this interpretation. Intratextuality, therefore, can be regarded as the

foundational layer of analysis, establishing the semantic coherence of individual scenes.

Building upon intratextual insights, intertextuality or tracing narrative and thematic continuity across panels expands the scope of analysis to examine the relationships between panels across the sequential narrative pathways of Borobudur's galleries (Juvan 2005). As a visual text composed of hundreds of interconnected reliefs, the temple's iconographic program follows structured storylines such as the Jataka tales (stories of the Buddha's past lives) and the Lalitavistara (the Buddha's earthly biography) (Achmadi *et al.* 2020, Ashari *et al.* 2021). Intertextual analysis investigates how the representation of animals evolves across these sequences, reflecting shifts in theme, setting, or social hierarchy.

Finally, extratextuality or situating the reliefs in a historical and cultural context grounds the interpretation in the broader world beyond the temple walls, connecting the visual narrative to external sources of knowledge (Langlands 2018). This includes historical records, religious scriptures (e.g., Pali Canon, Jataka commentaries), ethnographic data on ancient Javanese agrarian practices, and scientific reconstructions of the 8th–9th century Central Javanese environment for example, the extratextuality shown in relationship between the iconography of relief animals and their linguistic meaning can be illustrated by the depiction of Javan wild boars (Fig. 5A), referred to as “Celeng” in the ancient Javanese language. Pigs, notably wild boars, distinguish between nutritionally superior and inferior choices. The behaviour that has been observed displays discernible traits associated with the concept of greed. Furthermore, the term “Celeng” has its origins in the lexicon of Old Javanese. This language is still associated with impulsive behaviours and the practice of saving money for future financial stability.

The phrase “Celengan,” which can be translated as “piggy bank,” refers to a container adorned with images of “Celeng” animals, designed for accumulating funds. The emblem of the message maker held significant cultural value among the Javanese population during the Borobudur era, which is closely linked to the interpretation of the portrayed fauna in the Karmawibhangga relief. On the other hand, its interpretation may not be congruent with a postmodern perspective or align with current understandings of subjective interpretation.

Utilizing Mundayat's (2021) theoretical framework, one could argue that wild boars, colloquially known as “Celeng”, hold symbolic importance in the context of festive environments. The constant portrayal of pre-feast relief (panels O-9, O-74) may be seen as a symbolic representation consistently linked to the concept of wealth. In panel O-74, the relief portrays the animal referred to as the “Celeng” in a progressive motion. This pig species exhibits a total of 16 mammary glands, allowing it to produce a total of 16 piglets per pregnancy. Piglets are also known as “Genjik” (Old Javanese language). This term signifies piglets and is closely linked to fertility and abundance.

The wild boar demonstrates a proclivity for walking, moving, and running in a straight line. It frequently hits obstacles when endeavouring to execute abrupt changes in direction. Therefore, by utilising intra, inter, and extra textuality tests (Sharrock & Morales 2000, Juvan 2005, Langlands 2018), the portrayal of the “Celeng” or boar on the separate panels demonstrates a consistent and symbolic pattern of connection. The behaviour of the “Celeng” is commonly recognised for its straightforward nature. This behaviour is closely linked to the symbolism of courage as well as the desires for fertility and achievement.

As previously discussed, the concept of intratextuality interpretation shares similarities with the philological method used when encountering ancient manuscripts that do not have variations or different interpretations within a single body of text. In instances of this nature, the intratextuality intuition method is utilised to discern the manuscript that exhibits the highest degree of originality. According to Badruzaman & Kosasih (2019), the intratextual method focuses on analysing textual variations inside a specific version. In contrast, the extratextual method examines textual variations across many manuscripts within a single corpus.

The appearance of reptiles is exemplified by the portrayal of a serpent on panel O-94 (Fig. 6). The depicted scene reveals a composition positioned to the left of a seated nobleman, equipped with a majestic headdress embellished with a snake motif. Based on the research conducted by Santiko and Nugrahani (2012), the tale focuses on individuals who engaged in transgressive acts and afterwards underwent a metamorphosis, assuming the appearance of humanoid entities characterised by eagle heads and five cobra heads.

The precise whereabouts of the individual adorned with a snake crown and the concealed box containing valuable treasures are not thoroughly elucidated. The portrayal of a dragon in Javanese temples represents a *Python* sp. However, in the early 9th century in Java, various features had a notable similarity to the Indian dragon, which was influenced by the visual representation of the cobra (Kinney *et al.* 2003).

From a biological standpoint, the ethological traits exhibited by the cobra encompass a constant state of vigilance, aggression, peril, venomousness, evasiveness, and apprehension in response to visual stimuli that indicate the presence of a potential predator. Therefore, within the context of psychology, individuals who exhibit such a personality require regulation due to their connection with emotions of rage and greed. In contrast, individuals may choose to identify with the depiction of an esteemed character who, while embracing their worldly responsibilities, experiences apprehension at the potential loss of their wealth due to the actions of the Asura aggressors. Regardless of the scenario, it is crucial to maintain this way of life consistently.

The Gastropods demonstrate a correlation with Hindu-Buddhist mythology, particularly in their association with the concept of “shankha”. Hariyadi (2020) posits that this concept is intricately linked to notions of security and overall welfare. Furthermore, Mujiono (2021) highlights the significance of the Shankha's aquatic characteristics in establishing a symbolic association with the elemental concepts of water and fertility. The “Shanka” technique is proposed to facilitate the collection of holy water. Furthermore, Buddhists have also adopted the Shankha as a symbol of the supremacy of Buddhist teachings. The use of this metaphorical item serves to create a concrete manifestation, drawing upon its biological attributes, to construct a unified storyline within a panel.

Based on intertextual analysis, elephants in O-159 are shown using magnificent decorations, typical depictions of revered creatures. The extratextuality of elephants occupies an essential role as herbivorous organisms within the framework of the food chain in the realm of biology.

From an ecological perspective, elephants exhibit megaherbivorous characteristics and the ability to alter the structure and distribution of plants through their foraging and seed dispersal

behaviour. Therefore, elephants can be classified as a keystone species, exerting substantial influence on the regulation of plant life and occupying a crucial position in the ecosystem. The presence of elephants in the Karmawibhangga panel serves as a symbol of a revered animal, and this condition is also supported by the appearance of the “Svargga” inscription. The inclusion of elephants in the text can be interpreted as more than just a depiction of a mode of transportation. Intertextuality analysis on panel 159 of the Karmawibhangga, in which an elephant outcrop is found, serves as a symbol to direct the reader to the relief that tells the story of Siddhartha Gautama's footsteps in his efforts to achieve enlightenment to become a Buddha as told in the story of Lalitavistara Candi Borobudur (the Buddha's earthly biography).

Animal behaviour as a timepiece. The Karmawibhangga reliefs possess a narrative that extends beyond mere ornamental adornment, as they convey a deeper understanding of the natural world. The representation of animal species in each panel can be seen as equivalent to the representation of human individuals in each panel. Within the framework of Austronesian culture, particularly among the Javanese population, animal actions often assume a symbolic role or function as a metaphorical reflection of human behaviour (Lelono 2016). The story of Karmawibhangga predominantly portrays avian sculptures that exhibit diurnal behaviour, except for the Javan owl, which is nocturnal. The group of nocturnal mammals that are active during the night consists of eight distinct species. These species include the Kintamani dog, Javan tiger, the Asian palm civet (*Paradoxurus hermaphroditus*), Binturong (*Arctictis binturong*), Rats, Rice field rat, Wild boar, and Javan elephant.

According to Krom (1920), the tale of Karmawibhangga presents a portrayal of the interdependence of causes and effects within human existence. Diurnally, the state of being active throughout the day is fundamental to human existence. As a result, the narratives shown in the reliefs of Karmawibhangga focus on daylight hours. The presence of fauna sculptures and reliefs, which primarily depict elements of daily life, lends support to this discovery. The circumstance shows slight deviations from the story, wherein human activities are observed during day and night. The temporal differentiation relies on the existence of nocturnal and diurnal fauna, specific mammals

and birds, that play a crucial role in understanding the complete narrative of the event.

The panel, O-01 is a daytime narration. Krom (1920) and Santiko & Nugrahani (2012) suggested that the panel depicts people catching fish and selling them at the market, where a drummer is found shouting to announce something. There is an alternative explanation to describe the story after considering the presence of flora and fauna and analysing them both intra- and extra-textually. A temporal progression can be observed by examining the presence and behaviour of the Whistling duck and the Rail bird. These birds exhibit a pattern of activity that becomes more pronounced between 5:00 and 6:00 AM, the morning hours.

The depicted panel illustrates a social practice prevalent in the community within that period, which is primarily focused on fulfilling the basic bodily needs of individuals without directly addressing their spiritual well-being. The portrayal of human activity in this panel is positioned below the line of the Lotus Blossom plant (*Nelumbo nucifera*) (which can be observed at the top in panel O-1), indicating that these actions are predominantly of a physical nature and are not entirely pure, as they are intertwined with the impurities of muddy roots. Halim & Herwinda (2017) assert that the Lotus blossom carries substantial symbolic significance within the Buddhist tradition, representing the teachings of the Triloka. The “Triloka”, including truth, purity, and beauty, is a conceptual framework that holds great importance. The symbolism discussed here originates from several plant components, encompassing its roots, stems, leaves, and flowers. Each of these elements represents significant concepts linked to the fundamental nature of existence.

The fauna information in panel O-4 shows a link between the government's punitive actions and the number of nocturnal animals. The inclusion of fauna in the panel functions as a narrative indicator symbol, as evidenced by the biological behaviours displayed by the depicted fauna. The artwork exhibits signs of extinction, symbolising the existence of two animal species whose extinction is linked to human activities, namely the Javan Tiger and the Javan Elephant. The Javan Owl (nocturnal), the Slender-billed Crow (diurnal), and the Kintamani dog fulfil the role of guardians.

The Javan owl and the Slender-billed crow are bird species renowned for their omnivorous

dietary preferences. The Javan owl is predominantly characterised by its omnivorous feeding habits, but the slender-billed crow demonstrates a combination of omnivorous, carnivorous, and scavenging behaviours (del Hoyo & Collar 2014). Based on pervasive Javanese legend, the vocalisations of these birds is commonly associated with the foretelling of an imminent fatality, according to the left position of the sculpture at the “Setra” area. The right side of panel O-4 is commonly linked to diurnal phenomena that are deemed punishable throughout the day.

The interpretation resulting from this study demonstrate a slight divergence from the portrayal of a boar as noted in panel O-9. Although wild boar activity is commonly noticed during nighttime hours, this panel presents a comprehensive display of pig trading activity during the day. This is demonstrated by domesticated chickens (*Gallus gallus domesticus*). Panel O-12 exhibits occurrences of narrative events occurring during both daytime and evening.

The right-side panel provides a comprehensive listing of the types and categories of ideology specifically tailored to monks. The donation operations are hypothesized to have occurred in the late afternoon and evening, as evidenced by the Binturong on the right side of the panel. In addition, the Ebony langur (*Trachypithecus auratus*) and the Yellow-crested cockatoo (*Cacatua sulphurea*) can be witnessed due to the provision of instructional classes held throughout the day, which are made possible through generous donations.

The strategic arrangement of the Binturong on the right side of the panel, oriented towards the left, in conjunction with the deliberate placement of the cockatoo at the centre of the panel, effectively communicates a narrative on the left side. The bird's facial orientation and shape, which are oriented towards the left, serve as a sign of contributions in the form of teaching. The fauna observed in this context might be interpreted as a symbolic manifestation of praiseworthy behaviour that mirrors the biological traits exhibited by the Binturong species, which is in the Viverridae family. Viverrids are commonly arboreal and release a fragrant scent from their anal glands. This should be effectively transmitted and widely distributed, mirroring the behaviour displayed by the Yellow-crested cockatoo, which is recognized for its regular vocalizations.

Conclusion

The diversity of fauna species depicted in the Karmawibhangga reliefs at Borobudur Temple has been shown to both enrich the visual narrative of the karma teachings and provide insight into daily life, biodiversity, and human relationships with nature at that time. The carvings of archaeofauna at Borobudur Temple date back as early as 750-850 AD. In the context of the story told by the panels, various archaeofauna indirectly contribute to the portrayal of the environment depicted in the scene or event through the concept of ecology. Additionally, the behaviour of archaeofauna serves as a corroboration of the temporal framework of the scenes based on the principles of ethology. The addition of archaeofauna into the panel sculptures not only represents the creative and aesthetic concepts embedded in the panels but also functions as an additional component to the full narratives shown in the series. The sculptures in question effectively convey a narrative by including several animal species, each characterised by distinct physical attributes, behavioural patterns, and ecological niches. The narratives surrounding these faunas include a critical examination and revaluation of their stories, with a recognition and validation of their complex and diverse identities. It is argued that by recognising and embracing the intricate nature of ecological systems, we can develop a deeper understanding of and appreciation for the indispensable contributions made by every organism in sustaining the fragile equilibrium of the environment.

Author Contributions

All authors are main contributors and made an equal contribution to the manuscript.

Acknowledgments

We thank the Borobudur World Heritage Unit for their assistance in organizing the focus group discussion and for permission to utilize pictures of the *Karmawibhangga* relief panels in this scholarly work; M. Fathi Royyani (Indonesian Institute of Sciences), Velat Bujeng (University of Science Malaysia), Lee-Sim Lim (University of Science Malaysia), Miguel Giardina (Museo de Historia Natural de San Rafael, Argentina), Clara Otaola (University of Buenos Aires, Argentina), Sofwan Noerwidi (BRIN Indonesia), and Anne-Marie Moigne (Muséum National d'Histoire Naturelle France) for reviewing the manuscript.

Supplemental data

<https://doi.org/10.47605/tapro.v14i2.374>

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