

**MALACOFUNA FROM CAPPALOMBO SITE:
ENVIRONMENTAL RECONSTRUCTION AND SUBSISTENCE STRATEGIES OF
THE BONTOCANI HIGHLAND KARST REGION, SOUTH SULAWESI**

***Malacofauna dari Situs Cappa Lombo:
Rekonstruksi Lingkungan dan Strategi Subsistensi
di Dataran Tinggi Kawasan Karst Bontocani, Sulawesi Selatan***

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Abstract. *The remains of mollusk shell fragments are ecofacts that can explain the environmental conditions occupied by humans, especially in the context of the Holocene period in Sulawesi. This research answers questions related to the types of mollusks found in the cultural layer and aims to identify malacofauna remains at the Cappa Lombo site, Bontocani, South Sulawesi. The data collection method was carried out through excavation, and the analytical method involved taxonomic identification, external morphological identification, taxonomic classification, and documentation. This study successfully identified 10 families consisting of 15 genera and species. Terrestrial gastropod mollusks consist of the families Alycaeidae, Cyclophoridae, Ariophantidae, Dyakiidae, Clausiliidae, Achatinidae, and Camaenidae. Freshwater gastropods consist of 2 families, namely Pachychilidae and Viviparidae, while the bivalve class is only represented by the Cyrenidae family, which inhabits estuaries. Based on this identification, this research shows that the reconstruction of the environmental conditions around this site indicates a wet rainforest environment, which tends to be covered with vegetation and primary tropical forest. Additionally, during the occupancy period, there was a change in land use around this site. Data on the presence of mollusks also indicate consumption. Although mollusks were not a primary dietary source, humans during the Holocene at this site were able to utilize the aquatic environmental resources around the site they inhabited.*

Keywords: *Faunal Remains, Mollusk, Cappa Lombo, Bontocani Karst, South Sulawesi*

Abstrak. Temuan sisa fragmen cangkang moluska adalah data ekofak yang dapat menjelaskan kondisi lingkungan yang ditempati oleh manusia, khususnya dalam konteks masa Holosen di Sulawesi. Penelitian ini berupaya menjawab permasalahan terkait apa saja jenis-jenis moluska yang ditemukan dalam lapisan budaya, dan bertujuan mengidentifikasi sisa malacofauna yang ditemukan di situs Cappa Lombo, Bontocani, Sulawesi Selatan. Metode pengumpulan data dilakukan melalui ekskavasi dan metode analisis dilakukan dengan identifikasi taksonomi, identifikasi morfologis eksternal, klasifikasi taksonomis dan pendokumentasian. Penelitian ini berhasil mengidentifikasi 11 famili yang terdiri dari 15 genera dan spesies. Moluska gastropoda terestrial terdiri dari famili Alycaeidae, Cyclophoridae, Ariophantidae, Dyakiidae, Clausiliidae, Achatinidae, dan Camaenidae. Gastropoda air tawar terdiri dari 2 famili, yaitu Pachychilidae dan Viviparidae, sedangkan kelas bivalvia hanya diwakili oleh famili Cyrenidae yang memiliki habitat di estuari. Berdasarkan identifikasi tersebut, penelitian ini menunjukkan rekonstruksi kondisi lingkungan di sekitar situs ini adalah hutan hujan basah yang cenderung tertutup vegetasi dan hutan tropis primer. Selain itu, pada masa huniannya, terjadi perubahan penggunaan lahan di sekitar situs ini. Data kehadiran moluska juga menunjukkan indikasi pengkonsumsian. Meskipun bukan sebagai sumber diet primer, namun manusia pada masa Holosen di situs ini mampu memanfaatkan sumberdaya lingkungan perairan di sekitar situs yang mereka huni.

Kata kunci: Sisa Fauna, Moluska, Cappa Lombo, Karst Bontocani, Sulawesi Selatan

1. Introduction

Ecofacts consisting of mollusk shells are commonly found at prehistoric sites, often in the form of shell middens or shell accumulations. These accumulations can vary significantly, from small collections typically found in caves or rockshelters to extensive mounds capable of causing substantial alterations to the landscape (Hardy 2017). Among the mollusks, two significant classes, gastropoda and bivalvia, are frequently found within these accumulations (Allen and Payne 2017). These mollusk shells offer valuable insights for archaeological investigation. They can provide evidence for various aspects, including dating, subsistence-related practices, behaviors not directly related to sustenance, and glimpses into ancient environments (Fernandes and Dreves 2017; Hunt and Hill 2017).

Mollusks can provide valuable insights into prehistoric landscapes and environments. While they may not always reveal specific vegetation species, they can shed light on vegetation characteristics, structure, and microenvironmental conditions in the area. Mollusk ecofacts can unveil a wide range of microenvironmental characteristics, including aspects such as vegetation structure, ground coverage, soil surface, rocky terrain, and more. Through the analysis of malacofauna, distinctions between various microenvironments, such as closed-canopy forests, open areas, areas covered with leaf litter, or grasslands with low vegetation, can be determined (Allen 2017).

Karstic areas formed by limestone are well-known for harboring a diverse malacofauna composition (Clements *et al.* 2008). The nature of these limestones in karst regions provides robust support for mollusk growth and survival. In fact, the presence of mollusk shells on the surfaces of caves within karst landscapes can serve as a promising indicator of archaeological potential (Wibowo *et al.* 2022).

The Bontocani karst area is characterized by a distinctive highland environment that offers ample resources capable of sustaining human existence. Remnants of prehistorical human settlement are preserved through a range of artifacts and ecofacts found in archaeological sites, which encompass caves and rockshelters scattered throughout this region. Notably, this area shares cultural attributes with the Holocene period of the Maros and Pangkep karst regions in Sulawesi (Fakhri 2017). The individuals responsible for cultivating the prehistoric culture of this region exhibited innovation in the advancement of stone artifact technology, marked by unique features. Elaborate artificial stone artifacts were crafted in a more intricate manner and underwent evolution within the Southeast Asian context. This evolution encompassed the development of items like Maros points and backed artifacts, featuring geometric microliths and backed blades, alongside certain incised stone artifacts (Suryatman I. 2021; Ferdianto *et al.* 2022). Bone points, encompassing both monopoints and bipoints, experienced a similar progression. Discoveries of this nature are consistently encountered in nearly every prehistoric study conducted within the cultural expanse of the Tonasa karst formation in Sulawesi, a limestone formation which has a wide distribution, stretching from the Barru region in the north to the Jenepono region in the south. (Sompotan 2012; Farida *et al.* 2013). These findings collectively offer pivotal evidence, highlighting the Wallacea region's significance as both a migration route and an optimal region for human habitation. This is supported by the availability of resources essential for sustaining human life.

One of the notable prehistoric habitation sites situated in this region is the Cappa Lombo. Its discovery took place in 2014, followed by extensive excavation efforts conducted from 2017 to 2022 (Fakhri *et al.* 2022). The Cappa Lombo stands as one of the sites nestled

within the karst hills of the Bontocani region. This site is administratively situated in the Pattuku village, Bontocani District, Bone Regency, South Sulawesi Province (Figure 1). Astronomically, the site's coordinates are 5° 04' 29.26" S and 119° 57' 46.5" E, boasting an elevation of 628 meters above sea level. The Cappa Lombo site occupies a rockshelter that faces northwest, measuring approximately 10 meters in width and spanning a length of around 40 meters. Within this site, a diverse array of archaeological remnants has been unearthed, encompassing stone artifacts, bone artifacts, animal bone remains indicative of food consumption, ochre deposits, and a limited quantity of mollusk shells (Fakhri *et al.* 2022). All these archaeological remains are intricately linked to the discovery of a flexed burial, housing the remains of seven human individuals. This burial pattern aligns with the characteristics associated with Holocene burials, providing insights into the practices and rituals of that era (Fakhri *et al.* 2021, 2022).

The data collection and research in this karst area have been conducted intensively for almost the past decade. However, the

identification of malacofauna from the Cappa Lombo site is still considered very limited. The discovery of mollusk shells as one of the comparative data for environmental identification has never been comprehensively studied, whereas more comprehensive studies have been conducted on stone artifacts, rock arts, remains of vertebrate fauna, and human skeletal remains (Mulyadi 2016; Fakhri 2018; Saiful 2018; Fakhri *et al.* 2021; Suryatman *et al.* 2021, 2022; Ferdianto *et al.* 2022). However, mollusks can also serve as proxy evidence for vegetation structure, indicating factors such as shading, ground cover, humidity, the presence of forests or open land, leaf litter, and more (Allen 2017). Studies on malacofauna can complement the reconstruction of local environmental changes related to land use and human activities in the Bontocani karst region, especially at the Cappa Lombo site.

A fairly comprehensive study of malacofauna was previously conducted, which successfully explained the subsistence strategy of the Gua Babi community in South Kalimantan (Aziz 2001). In this research, all mollusk ecofact data were analyzed based

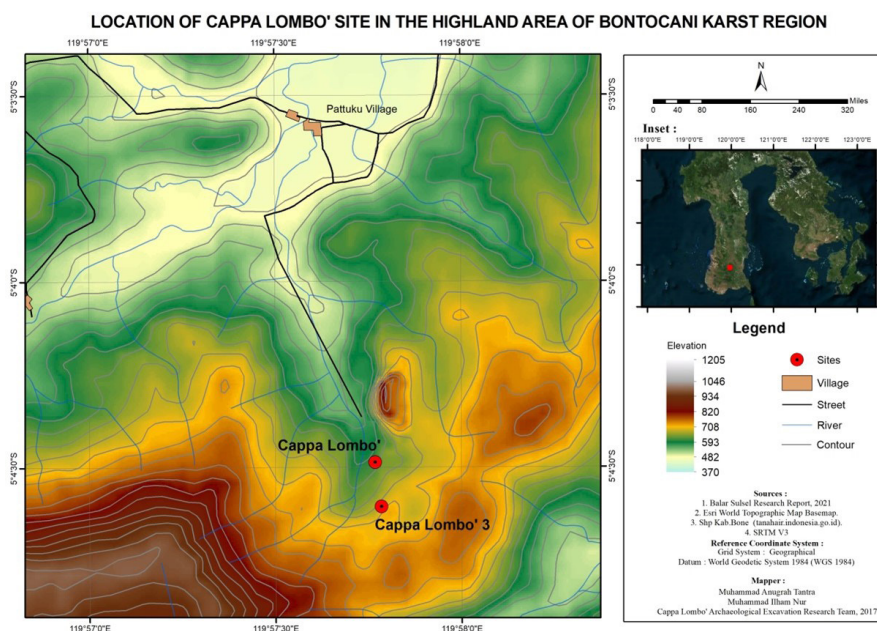


Figure 1. The location of the Cappa Lombo site is in the highland area of the Bontocani karst region (Source: Fakhri *et al.*, 2022)

on the principle that by examining the entire collection of mollusk shells, which is considered a representation of past fauna, the environment of the past can be reconstructed (Allen 2017). Therefore, ideally, an archaeomalacologist should be part of the excavation team and oversee the data collection and recording process in the field, ensuring that there is no bias in collecting only the large or obvious mollusk specimens (Ridout-Sharpe 2017).

2. Method

Mollusk shell ecofacts were obtained through excavation research at the Cappa Lombo site in 2022. These ecofacts originated from excavation unit U2T3, which was dug down to spit 9 (Figure 2). The excavated soil was sifted using a fine-mesh sieve (1 mm). Due to the relatively loose and dry soil structure, dry sieving was employed as the method. Mollusk shell ecofacts, including whole shells and fragments, were collected, labelled, placed in plastic bags, and then proceeded to the post-excavation analysis phase (Ridout-Sharpe 2017). In this phase, external morphological identification and documentation were carried out (Sulistiyo *et al.* 2022). Identification of the mollusk shells involved grouping fragments based on shell parts, especially gastropoda fragments. The next step was to categorize these shell parts into specific genera. The entire

macroscopic analysis was performed in the field.

The observations obtained were then compared with literature sources on malacofauna in Indonesia in general (Dharma 1992), freshwater and terrestrial malacofauna (Marwoto *et al.* 2020), and karst malacofauna in Sulawesi (Sarasin and Sarasin 1898, 1899; Marwoto and Isnaningsih 2013; Heryanto 2020). Mollusk shell ecofacts were identified as accurately as possible up to the genus or species level. This was carried out to understand the habitat and environment in which the mollusks lived and to reconstruct the environmental conditions at the prehistoric habitation site of the Cappa Lombo. Shell fragments that could not be identified beyond the family level were categorized as unidentified. The identified shells were taxonomically named according to nomenclature using the MolluscaBase mollusk database with the assistance of literature (Ridout-Sharpe 2017; MolluscaBase eds. 2022).

3. Result and Discussion

Only a few shell ecofacts could be found based on surface observations at the Cappa Lombo site. There were thick fragments of bivalve shells characterized by concentric external ridges, strong hinges with protrusions, and the position of the ligament outside. These

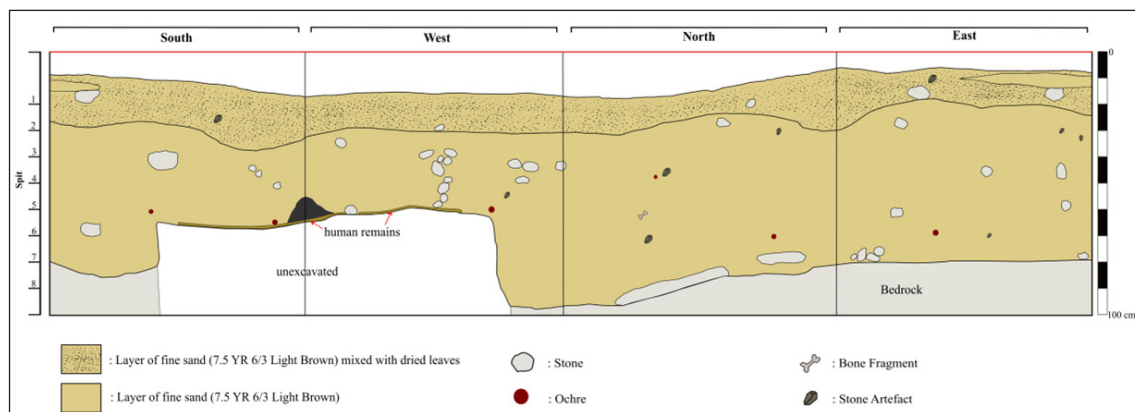


Figure 2. The stratigraphy of excavation unit U2T3, which includes cultural layers containing folded human burial remains discovered at the Cappa Lombo site, extends to a depth of 100 cm (Source: Fakhri *et al.*, 2022)

characteristics are commonly found in shells from the Cyrenidae family, which inhabit muddy substrates in river mouths or estuaries. Another finding was gastropod shells with a condition where the spire up to the apex is missing, leaving a brown-colored body whorl. The aperture is semi-circular, and the outer lip is still intact. Based on these characteristics, the shell belongs to the freshwater gastropod genus *Pila*, commonly known as apple snails, which are often found in rice field areas. Taxonomic identification was performed on the mollusk ecofacts obtained from excavation unit U2T3, which measured 1 x 1 meter.

3.1 Taxonomic Identification

The excavation of the Cappa Lombo site, specifically excavation unit U2T3, successfully uncovered mollusk ecofacts from 10 families, comprising 15 genera and species. Terrestrial gastropod mollusks from the excavation at Cappa Lombo site encompass various families, including Alycaeidae, Cyclophoridae, Ariophantidae, Dyakiidae,

Clausiliidae, Achatinidae, and Camaenidae. Freshwater gastropods are represented by two families, Pachychilidae and Viviparidae, while the bivalve class is only represented by the Cyrenidae family, which is typically found in estuaries (table 1).

Throughout the excavation of the Cappa Lombo site, specifically in excavation unit U2T3, fragments of *Hemiplecta* sp. were consistently discovered in each spit. Within this genus, there are species such as *Hemiplecta weberi* and *Hemiplecta wichmanni*, both of which are types of gastropods reported by Paul and Fritz Sarasin, in addition to other terrestrial gastropods listed in the table (Sarasin and Sarasin 1899). The distinguishing feature between these two species lies in their shells; *Hemiplecta weberi* has brown to dark brown lines on its lateral whorls, while *Hemiplecta wichmanni* has broader and more distinct dark lines. Both species are abundant in Sulawesi (Dharma 1992). At the Cappa Lombo site, there are fragments of *Hemiplecta* sp. with relatively large body whorl fragments and traces of

Table 1. The outcomes of malacofauna identification at the Cappa Lombo site

Family/Genus/Species	Habitat	Spread	Reference
Cyrenidae <i>Batissa violacea</i> (Lamarck, 1818)	Brackish/Estuary	Anthropic	(MolluscaBase eds., 2023a)
Alycaeidae <i>Stomacosmethis jagori</i> (E. von Martens, 1860)	Terrestrial	Native	(MolluscaBase eds., 2023k)
Cyclophoridae <i>Lagocheilus buginensis</i> P. Sarasin & F. Sarasin, 1899 <i>Cyclophorus</i> Montfort, 1810 <i>Leptopoma</i> L. Pfeiffer, 1847	Terrestrial Terrestrial Terrestrial	Native Native Native	(MolluscaBase eds., 2023g) (MolluscaBase eds., 2023c) (MolluscaBase eds. 2023h)
Pachychilidae <i>Tylomelania</i> P. Sarasin & F. Sarasin, 1897 <i>Tylomelania perfecta</i> (Mousson, 1849)	Freshwater Freshwater	Native Native	(MolluscaBase eds., 2023m) (MolluscaBase eds., 2023n)
Ariophantidae <i>Hemiplecta</i> Albers, 1850 <i>Xesta</i> Albers, 1850	Terrestrial Terrestrial	Native Native	(MolluscaBase eds., 2023f) (MolluscaBase eds., 2023o)
Dyakiidae <i>Dyakia</i> Godwin-Austen, 1891	Terrestrial	Native	(MolluscaBase eds., 2023d)
Clausiliidae <i>Paraphaedusa bonthainensis</i> (P. Sarasin & F. Sarasin, 1899)	Terrestrial	Native	(MolluscaBase eds., 2023i)
Achatinidae <i>Paropeas</i> Pilsbry, 1906	Terrestrial	Native	(MolluscaBase eds., 2023j)
Camaenidae <i>Tricheulota zodiacus</i> (A. Férussac, 1821) <i>Bradybaena</i> H. Beck, 1837	Terrestrial Terrestrial	Native Introduced	(MolluscaBase eds., 2023l) (MolluscaBase eds., 2023b)
Viviparidae <i>Filopaludina javanica</i> (von dem Busch, 1844)	Freshwater	Introduced	(MolluscaBase eds., 2023e)

Source: Sulistiyo & Fakhri, 2023

orange lines that are still observable (Figure 3-A). Another terrestrial snail whose shell fragments dominated the findings is *Tricheulota zodiacus*. This species is characterized by its aperture with a broad outwardly extending peristome. The shells of this species also have a pattern of two parallel lines in shades of orange to brown on the last whorl (Figure 3-B). This species was documented by Paul and Fritz Sarasin under the name *Planispira zodiacus* (Var.) *bonthainensis* (Sarasin and Sarasin 1899). *Tricheulota zodiacus* belongs to the Camaenidae family of terrestrial snails, a large family with many genera and species. Species in this family typically exhibit interesting shapes, colors, and patterns (Dharma 1992). Shells with orange lines as a characteristic are also possessed by the *Dyakia* sp. (Figure 3-C) although their frequency of discovery is not as high as the two genera mentioned earlier.

Small to micro-sized gastropod ecofacts are also present at the Cappa Lombo site, although not in large quantities. These micro-snails typically have shell widths of less than 1 cm. For the *Paraphaedusa bonthainensis* (Figure 3-E) and *Paropeas* sp. (Figure 3-I), the length of the shell can exceed 1 cm. The smallest snail found belongs to the *Stomacosmethis jagori* (Figure 3-H), and the shells of these snails were also abundant on the surface of the Cappa Lombo 3 site, a cave with archaeological potential, during our observation. This site is located approximately 200 meters northwest of Cappa Lombo within the same karst hill cluster. Micro-snails like these are typically found living beneath damp leaf litter, on moss-covered surfaces, or in crevices of dead wood.

Some freshwater mollusk shells also found in Cappa Lombo site, which provides evidence



Figure 3. *Hemiplecta* sp. (A), *T. zodiacus* (B), *Dyakia* sp. (C), *Leptopoma* sp. (D), *P. bonthainensis* (E), *Xesta* sp. (F), *Lagocheilus* sp. (G), *S. jagori* (H), *Paropeas* sp. (I), *Tylomelania* sp. (J), *T. perfecta* (K), *F. javanica* (L), & *B. violacea* (M)
(Source: Doc. Sulistiyo, 2022)

of human-mediated transport from its original habitat. This freshwater gastropods include *Tylomelania* sp. (Figure 3-J) and *Tylomelania perfecta* (Figure 3-K) from the Pachychilidae family, as reported by Paul and Fritz Sarasin (Sarasin and Sarasin, 1898). These two species were found from the surface to a depth of spit 5. The species *Filopaludina javanica* or rice paddy snail from the Viviparidae family (Figure 3-L) was only found in the first two spits, spit 1 and spit 2. The only bivalve mollusk present at the Cappa Lombo site belongs to the Cyrenidae family, which is *Batissa violacea*, although intact valves were not found. This species was found in fragment form in limited quantities. Fragment of the right valve, somewhat intact, were found in spit 5, associated with human skeleton CPL-R7 (Figure 3-M).

In general, the quantity and weight of mollusk shell ecofact findings, including fragments and intact shells, show an increasing trend in spit 2 and spit 5. After spit 5, both the quantity and weight of shells began to decrease until they were no longer found in spit 9 when reaching the bedrock. Detailed data on the mollusk shell ecofact findings can be found in Figure 4 and Figure 5.

3.2 The Past Environment of the Cappa Lombo site

The terrestrial environment around Cappa Lombo is characterized by a relatively high diversity of mollusks. This is indicated by the discovery of terrestrial gastropod shells, whether they are found on the ground surface, dead wood, leaf litter, mossy surfaces,

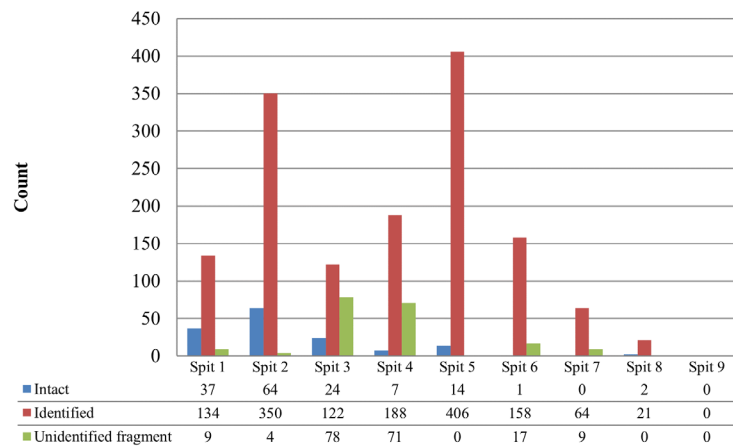


Figure 4. The trend graph based on the number of shell findings (Source: Sulistiyo & Fakhri, 2023)

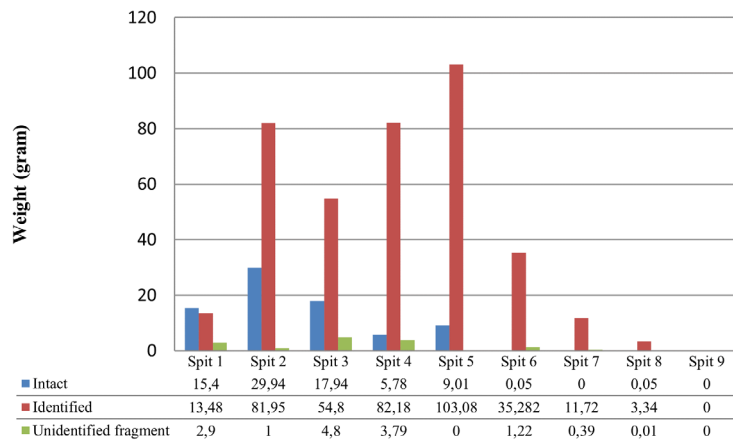


Figure 5. The trend graph based on the weight of shell findings (Source: Sulistiyo & Fakhri, 2023)

shrubs, or trees (Figure 6). Species with attractive patterns, such as *Hemiplecta* sp. and *T. zodiacus*, were found in abundance at the Cappa Lombo site, although in fragmentary conditions. This is because terrestrial gastropod shells are generally thinner than those of freshwater or marine gastropods. These shells are relatively well-preserved, and a small portion still retains shapes and colors that aid in the identification process. Observations have been made around the Cappa Lombo site, but live specimens of these two genera could not be found. Weathered intact shells from both genera can still be found on the forest floor around the site.

There are few live specimens of terrestrial gastropods that can still be found around the Cappa Lombo site compared to the types of terrestrial gastropod ecofacts from the excavation. Seven (7) individuals were found, representing four (4) genera. These mollusks include *Elaproconcha* sp. from the Dyakiidae family, *Leptopoma* sp. from the Cyclophoridae family, *Ganesella* sp. from the Camaenidae family, and *Paraphaedusa bonthainensis* from the Clausiliidae family (Figure 7). These terrestrial snails are typically found on relatively low vegetation, climbing

trees when it rains or when conditions are wet, and retreating into damp rocky crevices when the weather is clear. Larger gastropod species from the excavation findings, such as *T. zodiacus* and *Hemiplecta* sp., did not have live specimens found, and this scarcity is likely due to environmental changes.

One of the influencing factors is the change in vegetation, including deforestation for various purposes, such as agriculture (Dharma 1992). This anthropic factor leads to very drastic specific changes in a short period compared to natural vegetation changes due to long-term climate change (Allen 2017). The vegetation around the Cappa Lombo site is currently relatively homogeneous and dominated by candlenut trees (*Alaurites mollucana*). The candlenut plantation area in the Bontocani sub-district covers approximately 4,629 hectares, accounting for about 57.36% of the total 8,070 hectares of candlenut plantations in the Bone regency (BPS Kabupaten Bone 2023). The candlenut plantation area in the Bontocani sub-district accounts for 9.99% of the total land area of the Bontocani sub-district, indicating significant land use for candlenut plantations. Candlenut trees typically have tall trunks, high

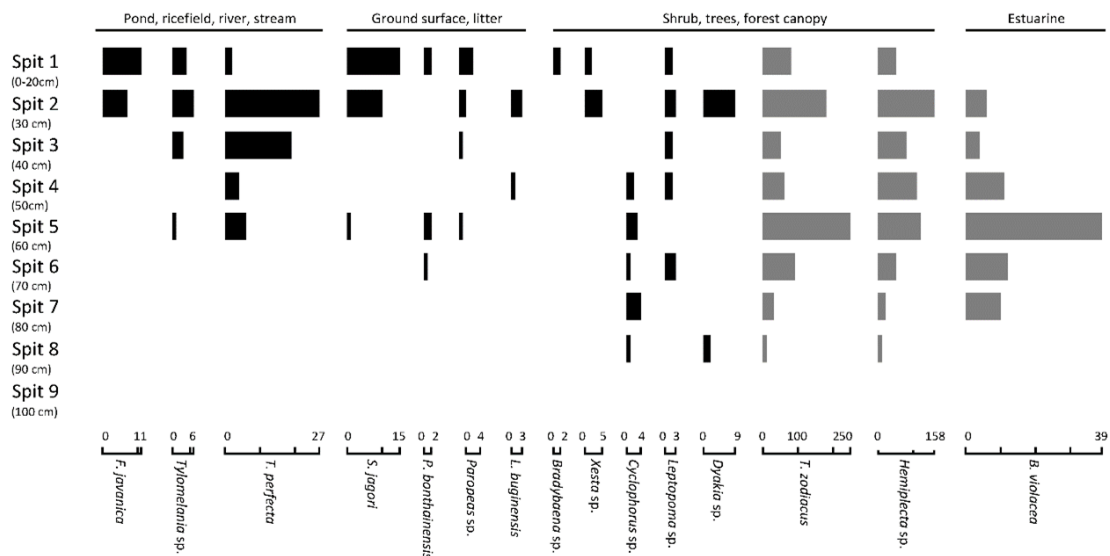


Figure 6. Analysis of the habitat of the malacofauna at the Cappa Lombo site (Source: Sulistiyo & Fakhri, 2023)



Figure 7. *Elaproconcha* sp. (Helicarionidae), *Leptopoma* sp. (Cyclophoridae), *Ganesella* sp. (Camaenidae), and *P. bonthainensis* (Clausiliidae) at Cappa Lombo
(Source: Doc. Sulistiyo, 2022)

branchings, and very tall leaves, and they are not densely packed. Tall-trunked trees with high branching are not suitable for terrestrial snails. Moreover, such plants allow sunlight to penetrate the surrounding environment, resulting in dry conditions, high temperatures, reduced humidity, and slower humus formation. These conditions are not conducive to snail habitats. Snails thrive in forests with heterogeneous vegetation and can only feed on specific plants. Snails of the genera *Elaproconcha*, *Hemiplecta*, and *Asperitas* typically consume fruits like coffee, papaya, water apple, and other soft fruits, as well as leaves (Dharma 1992). This phenomenon is observed at the Cappa Lombo site, where the previously mentioned species emerge, climb, and feed on the same plant leaves when it rains (Figure 7). The absence of these species is likely related to vegetation conditions, even though species from the Ariophantidae and Cyclophoridae families generally dominate karst environments, as seen in the Maros and Pangkep Karsts (Heryanto 2020) and the Sewu Mountains Karst (Irsyad et al. 2015).

The diversity of terrestrial gastropod ecofacts at the Cappa Lombo site reflects environmental conditions that were conducive to mollusk life in the past. Snails from that era

lived in environments with dense vegetation, high humidity, and tended to be dark due to the vegetation cover. High soil humidity also aided in the formation of humus. Humus provides a high-nutrient content and serves as a habitat for the growth of fungi and mosses, which are food sources for snails. Karsts with limestone content also provide the primary material for the growth of mollusk shells. Mollusks in areas rich in limestone content tend to have stronger and thicker shells (Dharma 1992).

Species of freshwater gastropods that can still be found in the surrounding environment of Cappa Lombo include *Tylomelania* sp., *Tylomelania perfecta*, and *Filopaludina javanica*. *Tylomelania* sp. can be abundantly found in small rivers that originate from springs in the karst region (Figure 8). This species can thrive in slightly disturbed water conditions, as these small rivers are also utilized for human activities. In such small rivers, another species from the same genus, *Tylomelania perfecta*, can also be found, although not as abundantly as *Tylomelania* sp. *Tylomelania perfecta* is more commonly discovered in the Soppo River, a tributary of the Wallenae River. Their habitat is characterized by shallow rivers with rocky bottoms, a strong and clear current, or areas among the roots of plants (Marwoto

and Isnaningsih 2013). Based on observations, *Tylomelania perfecta* moves on the surfaces of mud, rocks, tree branches, and submerged roots at the river's edge. The zone where the water meets the roots of riparian plants (interrhizone) serves as a suitable habitat for *Tylomelania perfecta* (Figure 8). The shape of the *Tylomelania perfecta* shell, with its coarse granular carvings, is an adaptation to withstand strong water currents and provide a better grip on the substrate. The presence of riparian vegetation at the river's edge offers a habitat for terrestrial snails as well. Riparian areas are typically shaded, moist, cool, and provide access to water sources for mollusks to produce their mucus. Rivers originating from karst springs supply essential calcium for the growth of mollusk shells.



Figure 8. *Tylomelania* spp. dan *T. perfecta* live in different habitats
(Source: Doc. Sulistiyo, 2022)

In general, the freshwater environment around Cappa Lombo remains relatively healthy. This is evident due to the presence of living specimens of freshwater gastropods discovered at the Cappa Lombo site. The preservation of these freshwater gastropods is influenced by the karst hydrology, which is closely linked to well-preserved karst conditions and low levels of pollution.

The only bivalve class found at this site is *B. violacea*. While this species is a common estuarine bivalve often encountered at prehistoric sites (Jutting 1939; Fauzi et al. 2023), its numbers were relatively small at the Cappa Lombo. Despite being frequently utilized as material for shell tools, this

phenomenon was not observed at the Cappa Lombo site. The majority of *B. violacea* fragments were discovered in the same layer as the CPL-R7 human skeleton.

3.3 The Taphonomy of Shells and Subsistence Efforts

The malacofauna ecofacts at the Cappa Lombo site in unit U2T3 are relatively limited, as shown in Figure 4. The findings mainly consist of fragments from two genera of terrestrial gastropods and one species of estuarine bivalvia: *T. zodiacus*, *Hemiplecta* sp., and *B. violacea*, as shown in Figure 6. *Hemiplecta* sp. and *T. zodiacus* are the largest terrestrial snails discovered at the Cappa Lombo site. These two species are the most frequently encountered ecofacts, albeit often in fragmented states. Notably, complete shells of *Hemiplecta* sp. were not recovered. Despite being considered large snails, shells of terrestrial gastropods are generally thin and fragile. Among these, the shells of *T. zodiacus*, obtained through the sieving process, are particularly delicate and are frequently found in fragments as small as 2 mm, and in substantial quantities. These species have also been documented to have been found in prehistoric caves in Sulawesi during archaeological excavations led by Dr. P. V. van Stein Callenfels in caves north of Tjani, South Bone (Bontocani) in 1934, and Gua Panganreang Tudea, Bantaeng in 1937 (Jutting 1939).

When analyzing the composition of malacofauna ecofacts in unit U2T3 (as shown in Figure 6), several interesting phenomena can be inferred from the existing evidence. The uppermost layer in spits 1 and 2 represents a disturbed soil layer and is the youngest cultural layer (depicted in Figure 2). This layer's soil is mixed with rice husks, candlenut seeds, undecomposed leaf litter, and other artificial materials. This is supported by the presence of several species found exclusively in spits 1 and 2, notably *F. javanica*, commonly known as the

rice paddy snail. This snail typically inhabits stagnant or slow-flowing waters, and its population expanded with the advent of human rice cultivation. Additionally, *Bradybaena* sp., often referred to as the garden snail, was also discovered. This snail is an introduced species, and its population tends to proliferate with the opening of new areas, such as fields and plantations (Marwoto et al. 2020). Notably, *Bradybaena* sp. was absent in spit 2 and the layers below it, indicating that these snails are relatively recent arrivals at Cappa Lombo and are not associated with prehistoric habitation or burials.

Another noteworthy phenomenon is the distinct abundance of ecofacts, quantitatively, in terms of weight, and in the diversity of mollusks within layers spit 2 and spit 5 (as depicted in Figure 4, Figure 5, and Figure 6). This observation leads us to infer that these two layers, spits 2 and 5, were characterized by significant activities, encompassing both natural processes and human interventions. As evident in the graphical representations, the shells of *T. zodiacus* and *Hemiplecta* sp. exhibit the highest degree of fragmentation, observed both in spit 2 and spit 5. It is noteworthy that the shells of these two genera, despite being delicate and thin, would not naturally fragment into such small pieces due to environmental factors like weather and water action. This is supported by the discovery of weathered shells near the site that remain relatively intact, belonging to these two genera (as illustrated in Figure 9). The specific pattern of shell fragmentation suggests the presence of external force exerted on the shells. Differentiating between natural factors causing shell breakage, such as consumption by animals, and human-induced patterns is essential. For instance, rodents tend to bite the final whorl on the side of the shell opposite to the aperture, allowing them to access the gastropod's soft parts without dealing with its foot. Meanwhile, birds often shatter shells on stone surfaces, commonly observed at cave

entrances, resulting in scattered fragments of broken shells (Hunt and Hill 2017).



Figure 9. Weathered shells of *T. zodiacus* in the riparian zone and *Hemiplecta* sp. in the forest floor around the Cappa Lombo

(Source: Doc. Sulistiyo, 2022)

Land snails are acknowledged to have been consumed by humans, a practice that endures to the present day. These snails are characterized by their low-fat content yet high protein levels, rendering them more suitable as supplementary rather than primary sustenance. They are typically resorted to when preferred food sources are unavailable (Hunt and Hill 2017). This pattern can be discerned at the Cappa Lombo site, where vertebrate fauna ecofacts outnumber mollusk ecofacts significantly. However, both categories of ecofacts exhibit a comparable trend of escalating quantities in layers spit 2 and spit 5 as depicted in figure 10 (Fakhri et al. 2022). From these findings, it can be concluded that the consumption of mollusks complements the consumption of vertebrate fauna in Cappa Lombo. The fragmentation of mollusk shells is also a result of human activity, primarily aimed at accessing the soft parts for consumption. Unlike the turbinated-shaped shell, the lenticular-shaped shell cannot be cut at its apex, so the entire shell must be broken to access its soft tissue. This is likely to occur in the shells of *Tricheulota zodiacus* and *Hemiplecta* sp. at the Cappa Lombo site. Employing stone tools or spines to puncture the shells leads to perforations that can be challenging to differentiate from those inflicted by dog bites. This practice has been documented ethnographically in Tunisia (Hunt and Hill 2017). Removing the apex to separate the soft tissues from gastropod shells stands

as the prevalent practice observed among the ecofacts of gastropods at prehistoric sites (Aziz 2001). This procedure has emerged as a distinctive marker of shell middens formed through human activities and can be readily identified.

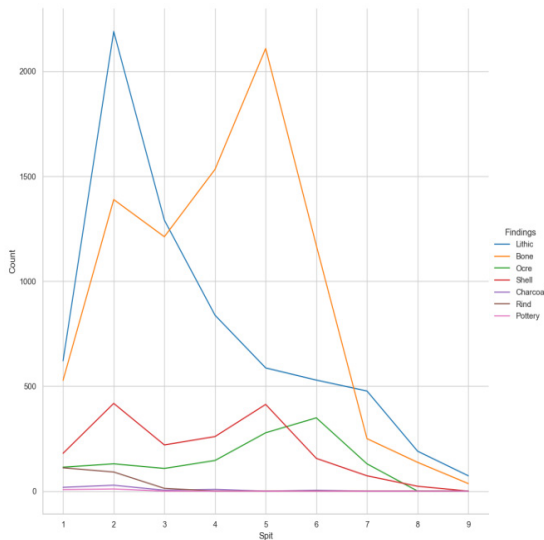


Figure 10. Shells, bones, and other findings association in unit U2T3
(Source: Fakhri *et al.*, 2022)

This phenomenon is evident in the ecofacts of freshwater gastropod shells belonging to the genus *Tylomelania*, where their apices have been intentionally removed. The Pachychilidae family, encompassing species such as *Tylomelania* sp. and *Tylomelania perfecta*, constitutes a group abundant in the waters surrounding the site in contemporary times. However, in terms of quantity, these species do not display pronounced indications of consumption comparable to those observed at certain other prehistoric sites. The families Pachychilidae, Bithyniidae, Thiaridae, and Assimineidae are also recognized as intermediaries or vectors for specific species of Trematoda worms (Ponder, Lindberg and Ponder 2020). Snail infections are typically followed by infections in fish, which act as the second intermediate host (SIH). The *Tylomelania* genus encompasses endemic snails found in the karst regions of Sulawesi, including the Maros region (Marwoto and Isnaningsih 2013).

Other small terrestrial gastropods, such as *P. bonthainensis*, *Paropeas* sp., and *S. jagori*, usually retain their intact apices, without any signs of cutting. These snails are also deemed highly improbable to have been consumed. The unaltered apices within these genera can also impact taphonomic processes. For instance, gas trapped within the elongated apex of shells, commonly observed in families like Pupillidae or Clausiliidae, can result in their buoyancy and subsequent transport over considerable distances without sustaining damage. This scenario may arise in cave deposits originating from fluvial processes (Hunt and Hill 2017). This scenario is more likely to occur in the upper sections of the Cappa Lombo cavity, taking into account the morphology of the cavity itself. At present, microsnails continue to exist and thrive in the vicinity of Cappa Lombo, confirming that the shells of these microsnails indeed originate from the local environment.

Terrestrial snails are known to venture into cave environments when conditions are suitable, characterized by humidity and not being excessively dry, in their quest for nutrients. Mollusks of the scavenging type may also have connections with food remains within caves. Smaller carnivorous mollusks have been discovered in proximity to human habitation, suggesting that the discarding of organic materials by humans can attract these species (Hunt and Hill 2017). This scenario is particularly probable in archaeological sites characterized by substantial food waste, such as Cappa Lombo, where remains of terrestrial fauna bones are abundant.

Mollusk shells can serve various purposes, including being utilized as artifacts, decorations (Ridout-Sharpe 2017), or tools (Szabó 2017). However, from the terrestrial snail shells that have been discovered, there are no indications that they were employed as artifacts. Terrestrial snail shells are generally small and structurally delicate, making them seldom used in contexts

beyond subsistence. To date, instances of artifacts crafted from terrestrial snail shells have only been documented in the early research of Dr. P. V. van Stein Callenfels, as published in 1938 (van Stein Callenfels 1938). Excavations conducted in a cave near Tjita (Citta District, Soppeng Regency) revealed artifacts such as scrapers with handles, arrowheads, and fishhooks made from the shells of larger terrestrial snails. While the specific snail species' name was not specified, a similar species had been previously reported in 1905 by Paul and Fritz Sarasin during their exploration of the Toala caves in Sulawesi (Sarasin and Sarasin 1905). This species was initially described as *Nanina toalorum*, and in 1938, it was reclassified as *Hemiplecta toalorum* (Jutting 1939). Furthermore, it is worth noting that the operculum of snails from the Pomatiidae family has been employed as beads. This practice has been documented in Mesolithic sites situated in Ethiopia (Assefa, Lam and Mienis 2008).

The shells of *B. violacea* belong to estuarine bivalve mollusks and are frequently discovered at prehistoric sites. Approximately during the mid-Holocene period, shell middens emerged in numerous locations globally. These middens indicate a notable upsurge in the utilization of coastal resources during that era (Hardy 2017). The presence of shells of this kind could indeed be linked to human migration patterns. Humans residing along coastlines might have migrated from coastal regions, transporting estuarine bivalve shells that were once a key and readily available food source. As time progressed and humans expanded into inland regions, these shells became less abundant. Nevertheless, at the Cappa Lombo site unit U2T3, there are no signs of artifacts crafted from *B. violacea* shells.

4. Conclusion

The environment surrounding the Cappa Lombo site in the past was primarily a

closed canopy tropical rainforest with dense vegetation, providing a humid and shaded environment with a forest floor covered in leaf litter. Additionally, there were flowing rivers in the vicinity, providing water and aquatic resources, including freshwater mollusks. The presence of mollusk shells from various habitats indicates subsistence strategies related to diet, although mollusks were not the staple diet of the inhabitants of the Cappa Lombo site. The mollusks found at this site suggest more of a supplementary diet, with vertebrate fauna as their primary food source. The abundance of artifacts found also supports this subsistence pattern. Based on the evidence of ecofacts and artifacts, the acquisition of mollusk food sources was a part of food gathering activities by hand, without the involvement of more advanced technologies like nets and spears.

From this assemblages of mollusk shells, it can be inferred that there has been a remarkably drastic change in land use in recent times. Most genera that should have thrived in this environment no longer have living specimens that can be found. Conversely, genera that were never found in older cultural layers can be discovered in younger layers. Only specific species appear to have adapted to the changes in land use in the present day. Large-sized snails likely began to disappear with the emergence of candlenut plantations or even other commodity plants that were once in fashion, such as teak wood and cloves. Small and micro-sized terrestrial gastropods are known to be still able to survive near cave entrances, such as *Elaproconcha* sp., *Leptopoma* sp., and *P. bonthainensis*. These smaller gastropods are more tolerant of less densely vegetated cave entrances, can thrive in shorter shrubs, and tend to spend more time in leaf litter or humid crevices.

Studies on malacofauna are always fascinating to explore and can provide additional insights into the environment and human life in the past. Because the analysis conducted in

this research was only done macroscopically, there is still a wealth of information that has not been fully uncovered. Further research into the ecofacts of mollusk shells can be deepened, for example, by conducting stable isotope analyses using Accelerator Mass Spectrometry (AMS).

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