Title:

Cataloguing cowries: a standardised strategy to record six key species of cowrie shell from the West African archaeological record.

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Abstract

Two species of cowrie shell, *Monetaria moneta* (Linnaeus 1758) and *Monetaria annulus* (Linnaeus 1758), occur repeatedly in archaeological contexts across West Africa. Despite their archaeological and ethnographic importance, these shells remain poorly and inconsistently reported in the archaeological literature. The absence of standardised data on species composition, size and condition of cowrie assemblages, and whether and how the shells were modified, make it difficult to examine their significance in a regional and/or chronological framework. To address this, we propose a standardisation of the criteria and coding used to systematically record cowrie assemblages – in particular species, size, condition and state of modification. We aim to enable non-shell specialists within the wider archaeological community to securely identify intact or intact but modified specimens of *M. annulus* and *M. moneta,* showing how these can be distinguished from four cowries native to West Africa (specifically *Luria lurida* (Linnaeus 1758)*, Zonaria zonaria* (Gmelin 1791)*, Zonaria sanguinolenta* (Gmelin 1791) and *Trona stercoraria* (Linnaeus 1758)) that occur in assemblages from West African sites. We demonstrate how accurate species identification

[1] The work for this paper was completed while Dr Christie was a Senior Research Associate at University of East Anglia on the Leverhulme funded Cowrie Shells: An Early Global Commodity Project (Prof. Anne Haour PI, Prof. Alastair Grant co-I).

and the assessment of proportions of different sizes of shells within suitably large assemblages can provide insight into their provenance, and through this enhance our appreciation of the exchange networks within which these shells moved. We also identify five different strategies documented in the archaeological record that were used to modify cowries, detailing how these can be differentiated and classified. The aim here is to suggest a recording strategy that will enable comparisons of the use and value of cowries in West Africa and more widely.

Acknowledgements

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Introduction

Two species of cowries, *Monetaria moneta* (Linnaeus 1758) and *Monetaria annulus* (Linnaeus 1758), often reported in the literature using their older names of *Cypraea moneta* and *Cypraea annulus,* are ubiquitous in the archaeological record. Originating in the coastal environments of the Indo-Pacific, they were in widespread use in China during the Shang dynasty (starting about 3500 years ago), with thousands of shells recovered from burial sites more than 1000 km from the sea (Yang 2011). They occur in small numbers, but widely, across the Mediterranean and Europe (for example in early medieval England) (Reese 1991, Mikkelsen 2000, Kovács 2008, Deyell 2010). In West Africa, they are found in various contexts – from isolated occurrences in pits or from abandonment levels (MacDonald et al. 2011, Huysecom et al. 2015) to burials (Magnavita 2015, Togola 2008).

As far as West Africa is concerned, the importance of cowries is well known. Data improve in quantity and in nature as we get closer to the present, and historical sources become available for coastal regions after contact with European travellers, so a great deal of excellent research has focused on relatively recent periods (especially Hogendorn and Johnson 1986, Ogundiran 2002). However, the earliest occurrence of cowries in West Africa substantially pre-date European contact. The earliest reported to date are from the site of Kissi in Burkino Faso, where a small number of cowries were recovered within funerary contexts dated to the fifth-seventh centuries, associated with items such as brass jewellery, weapons, and glass beads (Magnavita 2015). This, and a number of other occurrences (see Haour and Christie 2019 for a recent overview), substantially predate the opening of Atlantic trade routes and thus these shells must have been transported over land for great distances. Evidence for large-scale overland transport is provided by a well-known assemblage, a sample of 3433 shells recovered from what appears to be a much larger abandoned caravan load in the Mauritanian Sahara, of likely eleventh/twelfth century date (Monod 1969; recently restudied, see Christie and Haour 2018). This site, the Ma'den Ijafen, however remains an exception.

Numerous studies (e.g. Jackson 1917, Quiggin 1949, Hiskett 1966, Johnson 1970, Hogendorn and Johnson 1982, 1986) have examined the role of cowries in West Africa, as 'primitive money', ritually-charged objects and ornaments. Cowries, notes Quiggin (1949, p. 25), are a good rival to precious metals, fitting all the requirements of money: handy, lasting, easy to count and difficult to counterfeit. In addition to their economic value, cowries have been used in various practical and ritual contexts; indeed, in a thesis focused on their cultural uses, Iroko (1987, p. 80-88) highlights that cowries have, perhaps more than gold, been the subject of numerous West African myths and popular beliefs.

Despite their archaeological and ethnographic importance, cowries remain poorly and inconsistently reported in the archaeological literature of the region and historically motivated assumptions surrounding provenance, exchange mechanisms, use and value have often been uncritically repeated. Few publications specify which cowrie species are present in the assemblages; even fewer describe their condition (e.g. intact, fragmented), whether they were unmodified or modified, or the nature of these modifications (Heath's examination (2017, p. 62-4) of cowries from Saclo, Benin is a recent exception to this). Almost none elaborate on their size.

Consistent examination and reporting of cowries through the adoption and application of a standardised recording strategy is advantageous from two perspectives. First, insights provided through accurate species identification and relative shell size can be used to elucidate the provenance of assemblages, enhancing our understanding of the exchange networks within which these shells moved. Second, greater consistency in recording and reporting will enable us to make comparisons about the use and value of cowries in West Africa and throughout the continent more widely.

To this end, this paper details the research strategy developed as part of a three-and-a-half-year research project which examined the occurrence of cowries in West African archaeological sites. As part of this, 4559 cowries from 78 sites across West Africa, covering a date range from the tenth/eleventh to the nineteenth centuries as well as a number of undated sites, were systematically examined to record condition, species, size and evidence and nature of any modifications. Zoological specimens from natural history museum holdings and our own collections, as well as archaeological collections from around the Western Indian Ocean (particularly the Maldives and Tanzania), were also examined for comparison. Specifically, this paper seeks to standardise the criteria and coding used to record cowrie species, size, shell condition and modification, including a summary of diagnostic features to identify different modification practices. It draws together data from disparate taxonomic guides and our own hands-on analysis to assist the archaeological community in identifying and recording two commonly encountered species, *M. annulus* and *M. moneta.*

We also consider shells native to West Africa. In a paper on the use of cowries as type fossils in Ghana, York (1972, pp. 94-95) suggested that cowries collected from the West African coast could have substituted for Indo-Pacific shells. Specifically, he proposed that specimens of *Luria lurida* (Linnaeus 1758) and *Zonaria zonaria* (Gmelin 1791) washed onto the beach may have been used as a viable alternative to *M. annulus* and *M. moneta*, arguing that these would have been indistinguishable from the Indo-Pacific species and could therefore have been used as ‘free money’.

To evaluate this proposition, we also provide guidance on distinguishing *M. annulus and M. moneta* from four cowries native to West Africa. In addition to the two species directly mentioned by York (1972) (*L. lurida* and *Z. zonaria*) we also include *Trona stercoraria*

(Linnaeus 1758), and *Zonaria sanguinolenta* (Gmelin, 1791) as these species have also been recovered archaeologically (Haour and Christie 2019)[2]. Lepetit (1989, p. 7), describing the key species present along the West African coast, reports that *Z. sanguinolenta* were collected by local fishermen around the Dakar harbour and Gorée Island, observing that "*Cypraea* [i.e. *Zonaria*] *sanguinolenta* lives in shallow water (2 to 8 metres) and in calm and easily accessible places. Its overcollecting by the local fishermen threatens this beautiful species which is becoming rarer and rarer". Details of the distribution, habitat and abundance of the species discussed in this paper are presented in **Table 1.**

Species	**Distribution**	**Habitat**	**Abundance**
M. annulus	Indo-Pacific	Inter-tidal on coral and seagrass	Very common
M. moneta	Indo-Pacific	Inter-tidal on coral and seagrass	Very common
T. stercoraria	Senegal to Angola	Inter-tidal under large rocks	Common
L. lurida	Morocco to Angola	Inter-tidal to 150m depth	Common
Z. zonaria	Mauritania to Angola	Inter-tidal, under stones. Occasionally trawled up to 40m depth	Common
Z. sanguinolenta	Senegambia	Shallow water under rocks Occasionally trawled up to 25m depth	Uncommon

Table 1: Distribution, habitat preferences and abundance of species discussed (After Lorenz and 2000, pp. 51-52, 80-81,107, 112-115)

Of the four species discussed, *Z. sanguinolenta* has the most restricted geographical range – limited to the waters around Senegambia – a factor that appears to have influenced its archaeological distribution (Haour and Christie 2019).

Although three other species – *Schilderia achatidea* (Gray in GB Sowerby I, 1837), *Zonaria pyrum* (Gmelin 1791) and *Zonaria picta* (Gray 1824) – also occur along the West African

[2] It should be noted that the nomenclature of *L. lurida, Z. zonaria* and *Z. sanguinolenta* has recently changed. These species were previously placed in the genus *Cypraea* – hence in York (1972) and other papers are referred to as *Cypraea lurida, Cypraea zonaria* and *Cypraea sanguinolenta.* These names not used in this paper as they are no longer accepted by taxonomists.

coast, they are either restricted geographically (*Zonaria picta*) or prefer habitats in deeper waters that would not have been accessible to human collectors (*Schilderia achatidea, Zonaria pyrum*).

We have chosen to focus on six significant cowrie species. As such, the present article should not be considered a universal or definitive guide for cowrie identification, as this would be a major undertaking beyond the scope of a single paper – over 750 species of cowrie exist worldwide (Lorenz 2018). It must be acknowledged that in addition to *M. moneta* and *M. annulus* other Indo-Pacific cowrie species occur in much smaller numbers in the West African archaeological record. At least five of these were recovered in small numbers in the Ma'den Ijafen assemblage (Christie and Haour 2018, p. 136)[3], and our ethnographic interviews with cowrie collectors in the Maldives and Tanzania indicate do not suggest preferential collection of certain species. Thus, care should be taken, uncertainties in identification acknowledged and an archaeomalacologist consulted in troublesome cases.

This is particularly important for shell fragments and more friable juvenile shells (Irie and Iwasa 2003, p. 1133) which often lack key diagnostic features. However, we believe that the taxonomic criteria we outline here will enable most intact or intact but modified specimens of these six cowrie species to be identified by non-specialists.

Key Terms

A number of terms (illustrated in **Figure 1**) require definition at the outset:

Ventral side: the side where the teeth and aperture (the gap between the teeth) are located.

[3] The following Indo-Pacific species were observed in the Ma'den Ijafen assemblage: *Palmadusta asellus* (Linnaeus 1758) (n=1), *Naria helvola* (Linnaeus 1758) (n=4), *Naria erosa* (Linnaeus 1758) (n=2), *Staphylaea staphylaea* (Linnaeus 1758) (n=2) and *Naria gangranosa* (Dillwyn 1817) (n= 3). These compare with 3224 specimens of *M. moneta* and 10 specimens of *M. annulus* from the same assemblage (Christie and Haour 2018: Table 1).

Dorsal side: the side with the domed part of the shell, referred to as the **dorsum**. The dorsum is often pierced or removed by human users.

Posterior: In the species considered here, this is located at the widest end of the shell, associated with the narrowest gap in the aperture. Note that malacological convention dictates that shells be illustrated with the posterior at the top of the image.

Anterior: In the species considered here, this is located at the narrowest end of the cowrie, often associated with the widest gap in the aperture.

When looking at the *ventral side* of the cowrie with the *posterior to the top*, the **Columellar side** is on the left – identified by the body whorl (columellar); whereas the **Labial side** or **labium** is on the right (**Figure 1**).

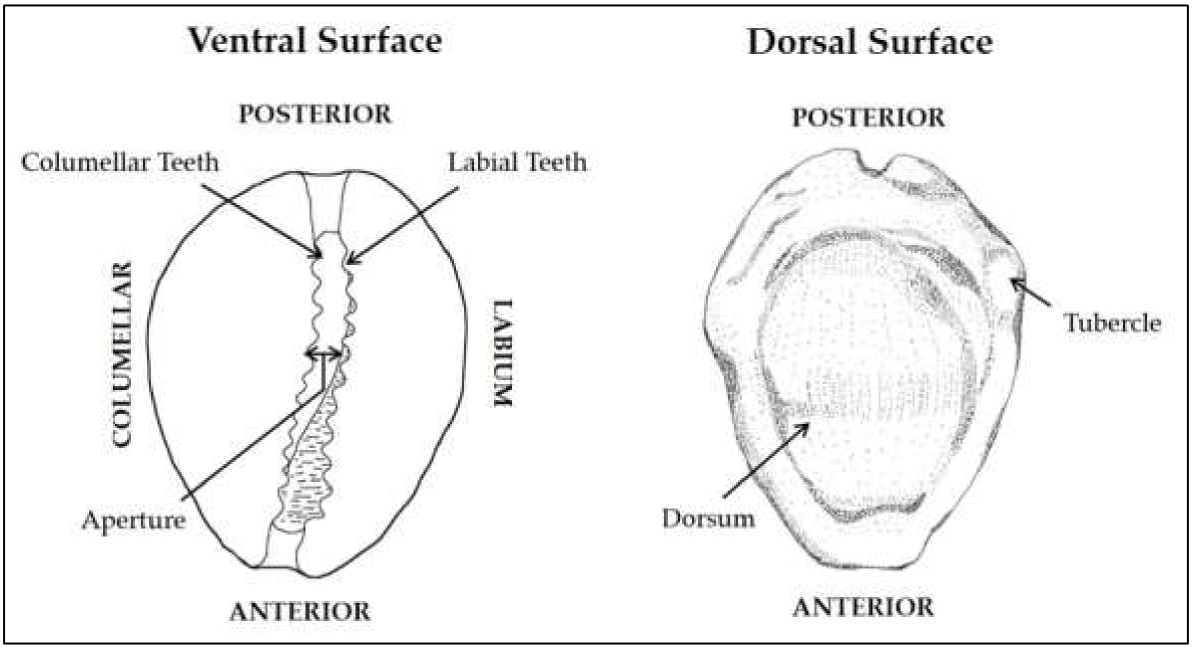

Figure 1: Key features of a cowrie shell. Illustration: Christie

Population: a group of organisms of the same species that inhabits the same geographical area at the same time.

Community: the group of associated populations of multiple species that inhabit the same geographical area at the same time.

Cowrie Morphology

Cowries re gastropods (snails), belonging to the large Mollusca phylum. Unlike other molluscs, their growth is determinate; that is, growth ceases once a genetically pre-determined stage has been reached. The spiral shell with a pointed apex and wide aperture characteristic of most snails is, in cowries, only visible during an initial juvenile period (Irie and Morimoto 2008, figure 1; Bridges and Lorenz 2013, figure 1; Katoh 1989, figure 1). As the shell grows, the "lip involutes toward the body whorl, producing a long but restricted aperture" at maturity (Foin 1989, p. 506); this slit-like aperture is characteristic of cowrie shells. Juvenile growth may be rapid (increases of shell length up to 3 mm a week when well fed in laboratory conditions, Katoh, 1989).. But after maturity, the shell's internal volume does not increase and the shell's apex can no longer be clearly distinguished, although the shell's whorls can be seen if the dorsum is removed (e.g. Figs. 19 and 21 below). External shell growth does continue, particularly in the period immediately after maturity, but the increase in size is small (Katoh, 1989). After maturity, animals completely cover their shell with a retractable fold of living tissue (known as the mantle), and deposit new material over the whole of the outside of their shell (Foin 1989, p. 506). These mechanisms of shell deposition have important consequences for cowries' visual attractiveness - a key motivator for their use as cultural artefacts (Hogendorn and Johnson 1986, p. 80). Whereas the external surface of most shells becomes worn with age, the continual addition of new material over the entire surface of cowrie shells ensure they remain shiny and retain surface patterning, which is vivid in some species. Material may be added in larger amounts to the sides of the shell to create a "callus" (Irie 2006, Figure 3; Bridges and Lorenz 2013, Figs 9, 14 and 19). The thickness and prominence of this callus, which is thought to strengthen the shell against predation, varies both within and between species (Irie 2006). In many species, a cross-section of the dorsal shell shows a convex outer surface, with no external sign of the callus. In others, the dorsal surface is slightly to moderately concave, with an inflexion near the point of transition between the juvenile shell and the more or less well-defined callus. This determinate growth pattern means that it is not possible to infer exploitation rates from population size structures or determine seasonality of harvesting from geochemical measurements on shell growth increments (see below).

Size differences between the sexes are either not significant or small (Schilder and Schilder, 1961; Katoh, 1989; Villamor and Yamamoto, 2015). In a very large collection of both species from multiple locations, there was very little difference in size between *M. annulus* and *M. moneta*, with median lengths of 19 and 20 mm respectively (Schilder and Schilder, 1966). However, larger differences have been reported between populations of individual species. For example, the mean size of *M. annulus* from Heron Island was 24.7 mm (Frank, 1969) and was 18.7 mm at Olango island in the Philippines with other populations in Japan and the Philippines falling between these values (Villamor and Yamamoto, 2015). *M. annulus* (and *M. moneta*) from the Maldives are some of the smallest reported, with approximately 50% of individuals smaller than 15 mm in our ecological collections (see below). Animals move only a few metres over periods of several months and adult mortality rates have been estimated as between 10 and 16% per year (Frank, 1969), which implies that animals live for several years after maturity. The breeding season varies between populations, but is prolonged or continous. Reproduction was observed in March, June and July on Heron Island in the Great Barrier Reef (Frank, 1989) but occurred all year round in Okinawa, Japan (Katoh, 1989).

Recording Strategy

During excavations, both intact and fragments of cowrie shells should be separated from other shell remains and bagged by context. This is particularly important as it may enable differentiation between different deposition events. Each shell should be examined individually, and each record contain the following contextual information: site, site location, context and date of recovery (if known). Additional site records should be consulted to identify any associated material culture and to determine whether the shells are from a special context such as a burial. Attributes to be recorded for each shell include species, shell size, condition, the presence or absence of modification and interpreted modification type, and any other observations. In the following sections we outline suggested best practice in recording these attributes.

Species Identification

Differentiating between species relies on three diagnostic characteristics considered in combination. These are:

- **Dorsal morphology and pigmentation**: prominence and shape of the callus, the presence or absence of tubercles, and the nature and location of colouring and patterns;
- **Ventral morphology**: number, length and definition of the teeth;
- **Shape and size**: shape and size.

Details of variations in these features between *M. moneta, M. annulus,* and West African species are outlined below.

Dorsal morphology and pigmentation

M. moneta and *M. annulus* almost always manifest an externally visible callus. In *M. annulus* this is defined by a slight inflection in the sides of the shell, close to the position of the gold/orange ring visible on almost all fresh specimens (**Figure 2a**). The callus is normally more prominent in *M. moneta* and this can give the shell a 'winged' appearance when viewed in section from the posterior (**Figure 2b**). In profile *M. annulus* shells tend to be more domed, whereas *M. moneta* shells tend to be wider and squatter.

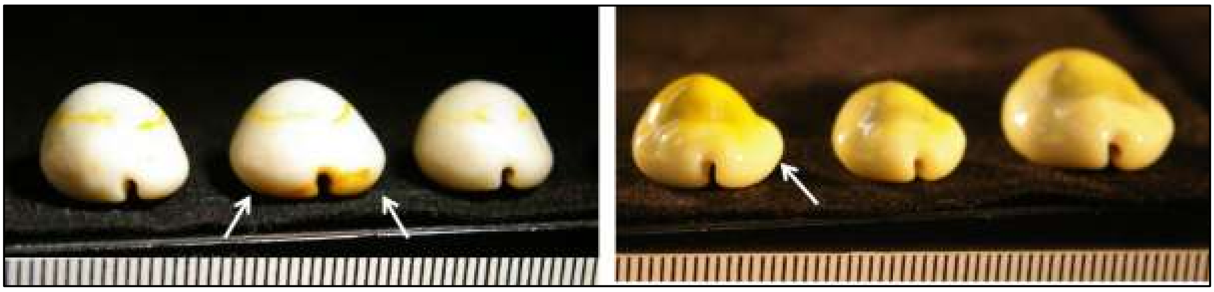

Figure 2: View of the posterior end of M. annulus (left) and M. moneta (right). Arrows indicate the location of the visible callus showing inflected callus for M. annulus (left) and more prominent 'winged' callus for M. moneta (right). Photos: Authors. With thanks to the Natural History Museum in London for access to their collections.

Neither *L. lurida* nor *Z. zonaria* have an obvious callus and both have a wider aperture than do either *M. moneta* or *M. annulus*. Viewed from above, both ends of the aperture in *L. lurida* are usually visible as notches in the outline, and there are small ear-like projections of shell at either side of these notches at the anterior end. In *Z. zonaria* a notch is visible from above at the anterior end (**Figure 3**).

A distinctive feature of *M. moneta* is the presence of raised lumps, called tubercles, around the dorsum. These form as a result of highly localised deposition of shell material by adult cowries and tend to be situated either side of the dorsum at the posterior end of the shell (see **Figure 1, Figure 3**). While De Rochebrune (1884) includes the statement "4 tuberculis ovoideis crassis, coronata" (four thick ovoid tubercles, like a crown) in the species description, these are not invariably present (see e.g., Renaud 1976 and Foin 1989). The presence or absence of these tubercles can be influenced by local ecology. In his surveys at Enewatek, Marshall Islands, Renaud (1976, p. 155) observed that *M. moneta* specimens with tubercles – so called "knobby morphs" – were associated with subtidal areas, while those without tubercles were recovered from intertidal areas. Our own collections in the Maldives and in Tanzania suggest that *M. moneta* with and without tubercles can occur on the same reef, a feature also observed by Lorenz and Hubert (2000, p. 205) who note “two or three distinct forms can be found sympatrically on one reef”. Therefore, while the presence of tubercles conclusively identifies a shell as *M. moneta*, their absence does not automatically identify it as *M. annulus*, as some *M. moneta* lack tubercles. Assessment of other diagnostic features is required.

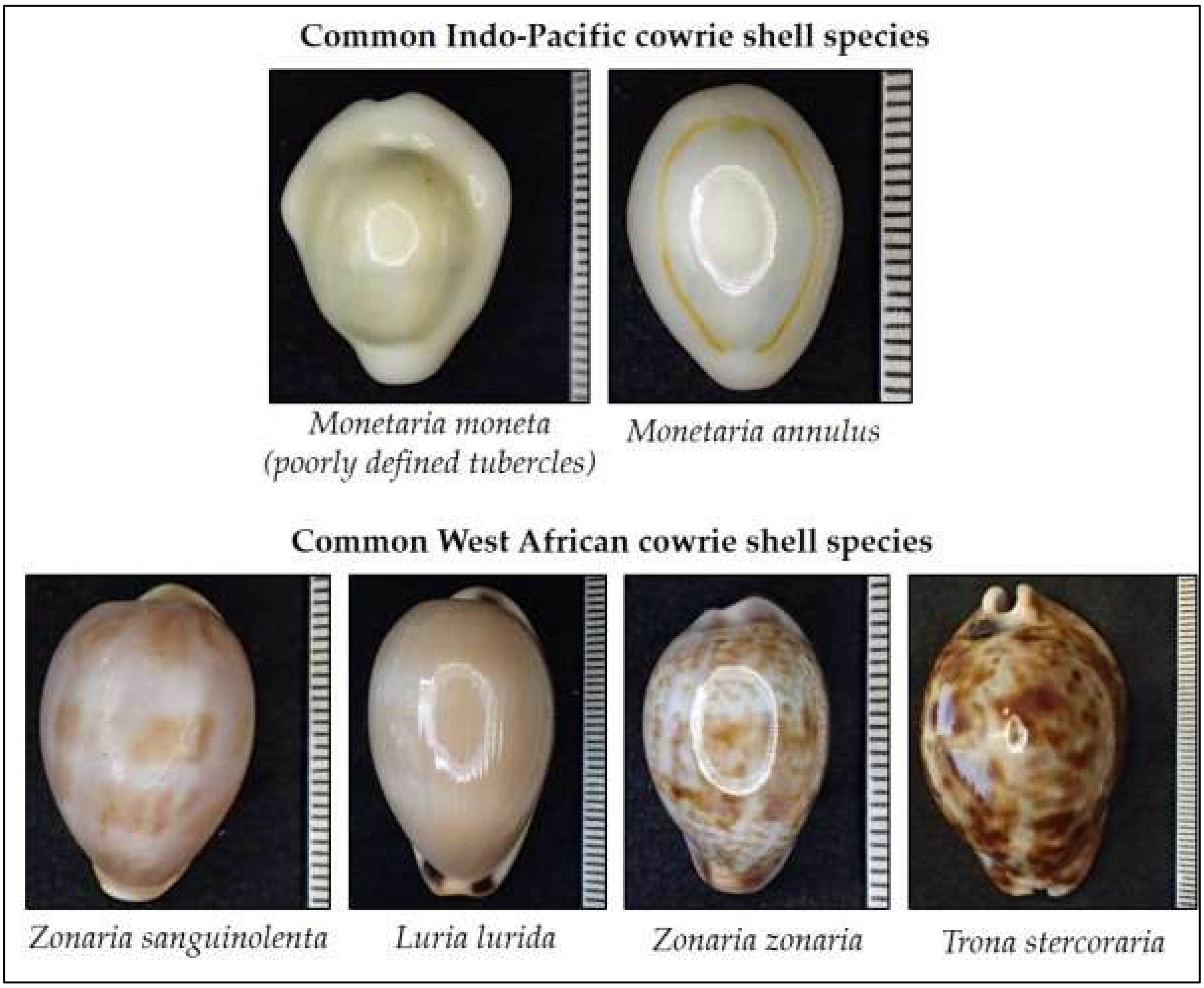

Figure 3: Dorsal morphology of species discussed. Photos: Authors

In specimens collected fresh or soon after death, pigmentation can help differentiate the shells. *M. moneta* is yellowish green white, occasionally with horizontal bands of darker green over the dorsum. *M. annulus* is purplish blue/white with a distinctive gold/orange ring around the dorsum. While the orange ring is almost always present on fresh *M. annulus* shells, it is also occasionally noted on *M. moneta* shells. The West African cowries are, with the exception of

L. lurida, mottled or spotted red or brown. *L. lurida* is blueish green with two black terminal spots at both ends of the dorsum (**Figure 3**).

This said, pigmentation and patterning are unlikely to survive on archaeological specimens. Shells may be bleached or discoloured if they were collected as beach-washed specimens (see below).

Ventral Morphology

A key feature differentiating West African cowries from *M. moneta* and *M. annulus* is the number of teeth (de Rochebrune 1884). While *M. moneta* and *M. annulus* have fourteen or fifteen teeth, the West African species discussed here all have more than twenty. Unfortunately, tooth number cannot differentiate *M. annulus* from *M. moneta* since there is a positive correlation between tooth number and size in both species. Here, the length, shape and definition of the teeth and the width of the aperture are more diagnostic. In *M. annulus* the teeth tend to be longer and more defined (**Figure 4, indicated as a)**, and the aperture is wider **(Figure 4, indicated as b)**. By contrast, the teeth in *M. moneta* specimens are much shorter and stubbier **(Figure 4, indicated as c)**, and the aperture is narrower **(Figure 4, indicated as d).**

In both cases these features are markedly different in the West African species. A key diagnostic feature amongst these is the distinctive scalloped shape to the teeth at the anterior end of *T. stercoraria* (**Figure 4, indicated e)).** Other features characterise the remaining West African species. While *Z. zonaria* specimens have defined columellar and labial teeth (**Figure 4, indicated f))**, the teeth of *L. lurida* are shorter and the aperture is wider (**Figure 4, indicated g)).** While *Z. sanguinonta* shells also have a wide aperture (**Figure 4, indicated h)),** only the columellar teeth are defined. The labial teeth are shorter and stubbier.

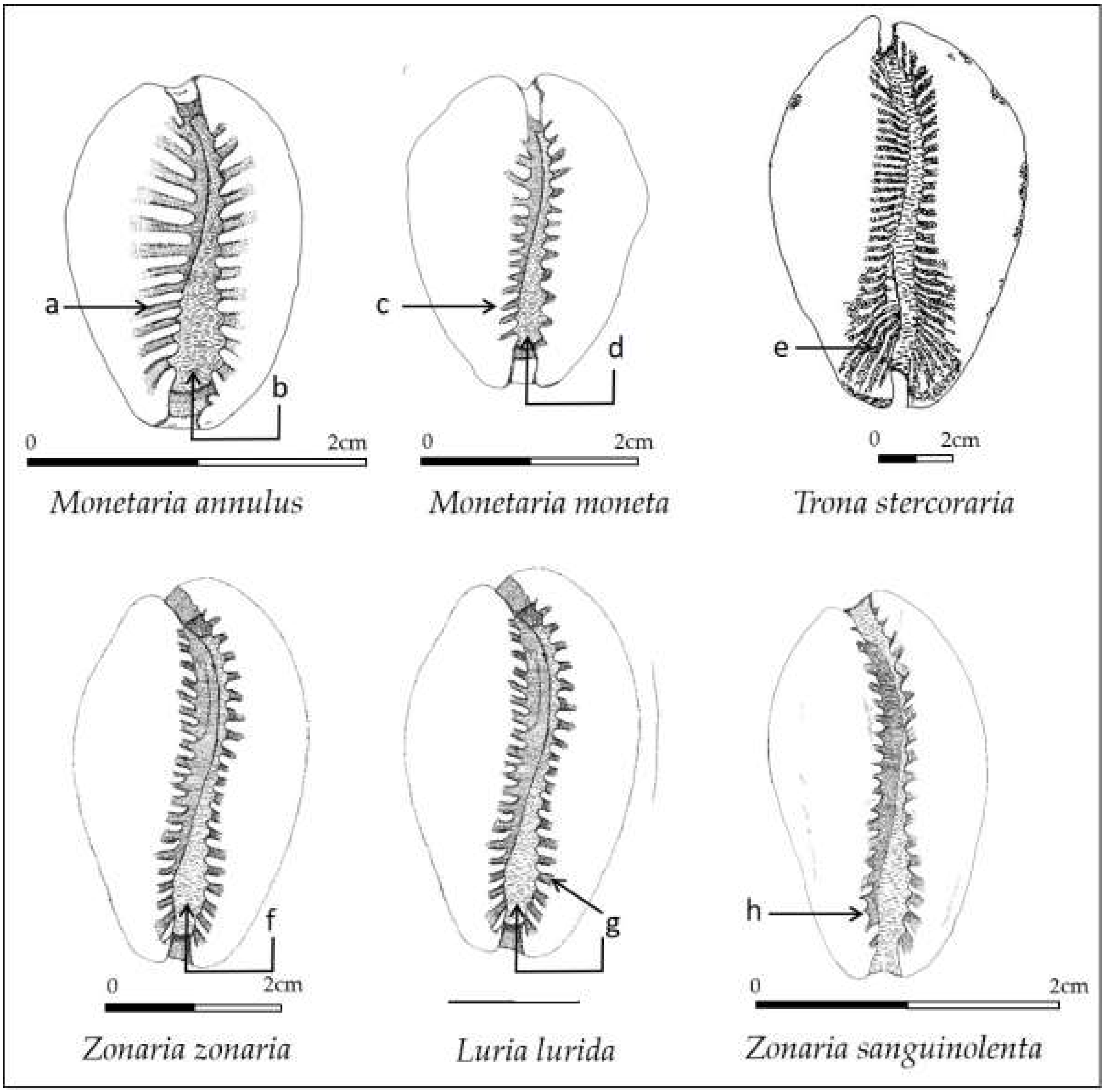

Figure 4: Ventral morphology of shells discussed. Illustration: Christie

Shape

As *M. moneta* and *M. annulus* can have similar shapes, we conducted Fourier shape analysis using a sample of shells from each species in order to identify variations or similarities in the shape of species. Although *M. moneta* shells have a rhomboidal shape, *M. annulus* never do (upper half of **Figure 5**)[4]. On the other hand, some *M. moneta* have a more ovoid shape similar

[4] Photographs of *M. moneta* and *M. annulus* against a black background were downloaded from http://www.cypraea.eu and Fourier shape analysis was carried out using a custom script in Matlab. Images were converted to monochrome using a cut-off of 10% saturation, and the shell perimeter identified as the boundary between black and white in the resulting binary image. A Fourier transform of this shape, expressed as

to that seen in all *M. annulus* (bottom half of **Figure 5**). This highlights the need to use a combination of characteristics to identify shells species. In general, however, *M. annulus* has an ovate outline, while *M. moneta* has a rhomboid outline. *M. moneta* also has a more prominent callus and one end of the aperture is usually visible as an anterior notch.

Considering whether shape can be used to differentiate *M. moneta* and *M. annulus* from the West African species discussed, it can be said that *L. lurida* and *Z. sanguinolenta* shells are markedly different. In addition to being much larger than either *M. moneta* or *M. annulus* (**Table 1**), *L. lurida* has a cylindrical shape while *Z. sanguinolenta* is pyriform. *Z. zonaria* and *T. stercoraria*, on the other hand, are, like *M. moneta* and *M. annulus*, ovular, so other characteristics must be used to differentiate them.

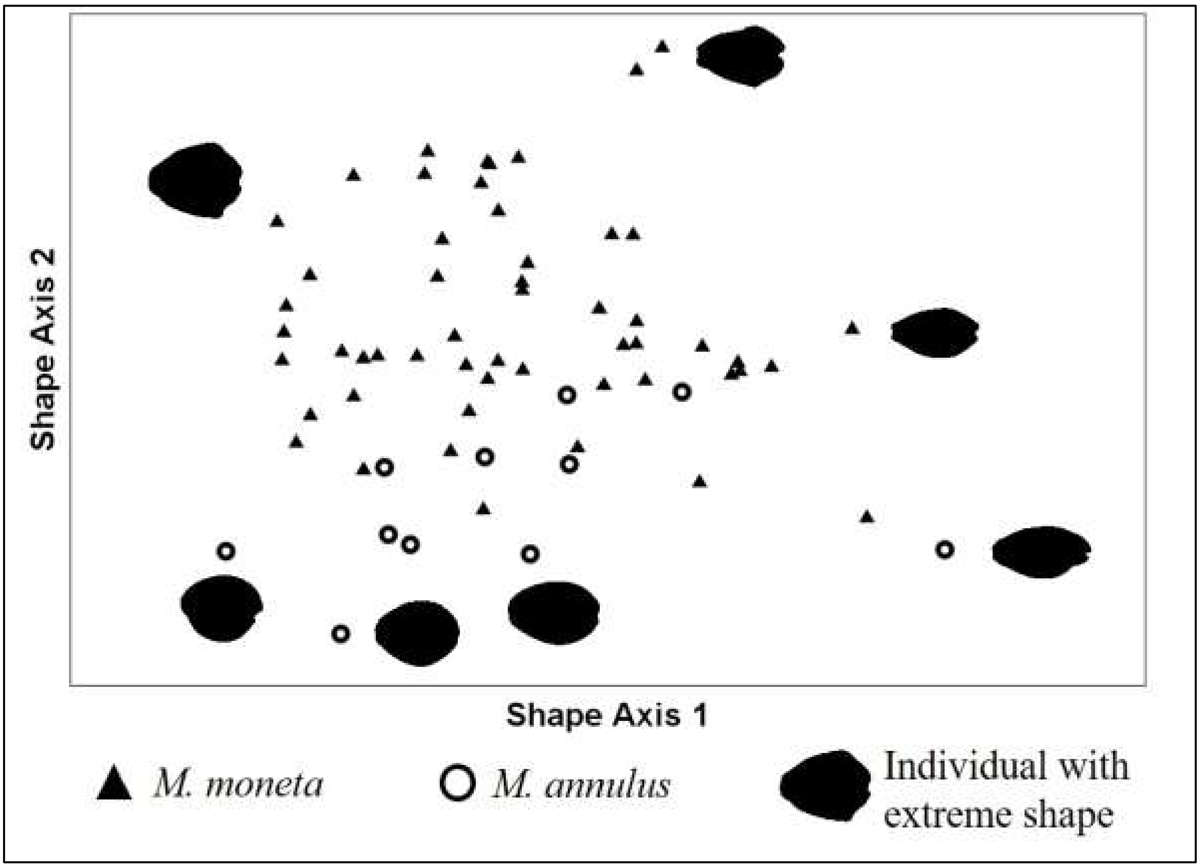

Figure 5: Outcomes of Fourier shape analysis. Illustration: Authors

imaginary numbers x+y√-1, was calculated. The absolute value of the first 20 terms of the Fourier transform were selected, and normalised for shell size by dividing by the first term. Principal component analysis was used to reduce the dimensionality, and the shape of each shell plot in its position in a plot of the first two principal components. For clarity, shell outlines are drawn only for the extreme shapes.

In summary, dorsal morphology and pigmentation, ventral morphology, shape and size offer valuable avenues for distinguishing species. **Figure 6** provides a flow chart which uses diagnostic features to guide users through an assessment process that enables them to identify the key species discussed. The diagnostic features for each species and the impact of taphonomic processes on the usefulness of each criterion is summarised in **Table 2**.

Criterion	*M. annulus*	*M. moneta*	*T. stercoraria*	*L. lurida*	*Z. zonaria*	*Z. sanginolenta*	Impact of natural or anthropogenic modification
Dorsal Morphology	Inflected callus Domed profile Does not have tubercles	Prominent callus each side of dorsum Squat profile Often (though not always) has tubercles	Anterior edges of the aperture very pronounced High domed profile Does not have tubercles	Anterior edges of the aperture visible as notches. 'Ear like' projections either side Domed profile Does not have tubercles	Anterior and posterior edges of the aperture visible as notches Domed bulbous profile Does not have tubercles	Callus not obvious, anterior and posterior edges are rounded Domed profile Does not have tubercles	*M. moneta's* tubercles are generally visible on fragmented shells, and are rarely (if ever) damaged by anthropogenic modification. When differentiating *M. annulus* and *M. moneta,* tubercles are very distinctive. Their presence conclusively identifies *M. moneta*, but their absence does not rule out identification as *M. moneta*
Dorsal Morphology: Colour/Pattern	Blue/ purplish colouration. Distinctive gold/orange ring around the dorsum	Yellow-green colouration. Occasional faint dorsal ring not frequently apparent. Lateral darker banding often present	Mottled or spotted red or brown	Blueish green with two black terminal spots on the dorsum at both ends of the shell	Mottled or spotted red or brown	Reddish-brown with red traverse banding	Shells from older deposits and beach-washed specimens are often bleached. Thus, colour is not a reliable characteristic for shell identification
Ventral Morphology: Teeth	Strong, long teeth with defined grooves between them	Short, stubby, finer teeth particularly on the labial side. Columellar teeth longer, but grooves not clearly defined	Scalloped shape to the teeth at the anterior end	Short, poorly defined teeth	Defined columellar and labial teeth	Defined columellar teeth. Labial teeth are short and poorly defined	While chemical and physical weathering and some anthropogenic modification can reduce the definition of the dentition, length and morphology of the teeth remain apparent in most cases Dentition can be used to identify species in shell fragments where other features are less apparent
Ventral Morphology: Aperture	Wider anterior aperture than *M. moneta*	Narrower anterior aperture, restricted with less gapping than *M. annulus*	Teeth at anterior end scoop into a narrow aperture	Wide aperture	Narrow aperture	Wide aperture	Aperture width cannot be used to identify fragmented shells.
Shape	Rounded oval outline	Rhomboidal in majority of individuals, but some have oval outline (see **Figure 5** and associated text)	Ovular	Cylindrical	Ovular	Pyriform	Regardless of species, if fragmented, shell shape can be difficult to determine In plan, shell shape remains apparent despite modification; however, the profile cannot not be determined if the dorsum has been removed

Table 2: Summary of diagnostic features for six key cowrie species

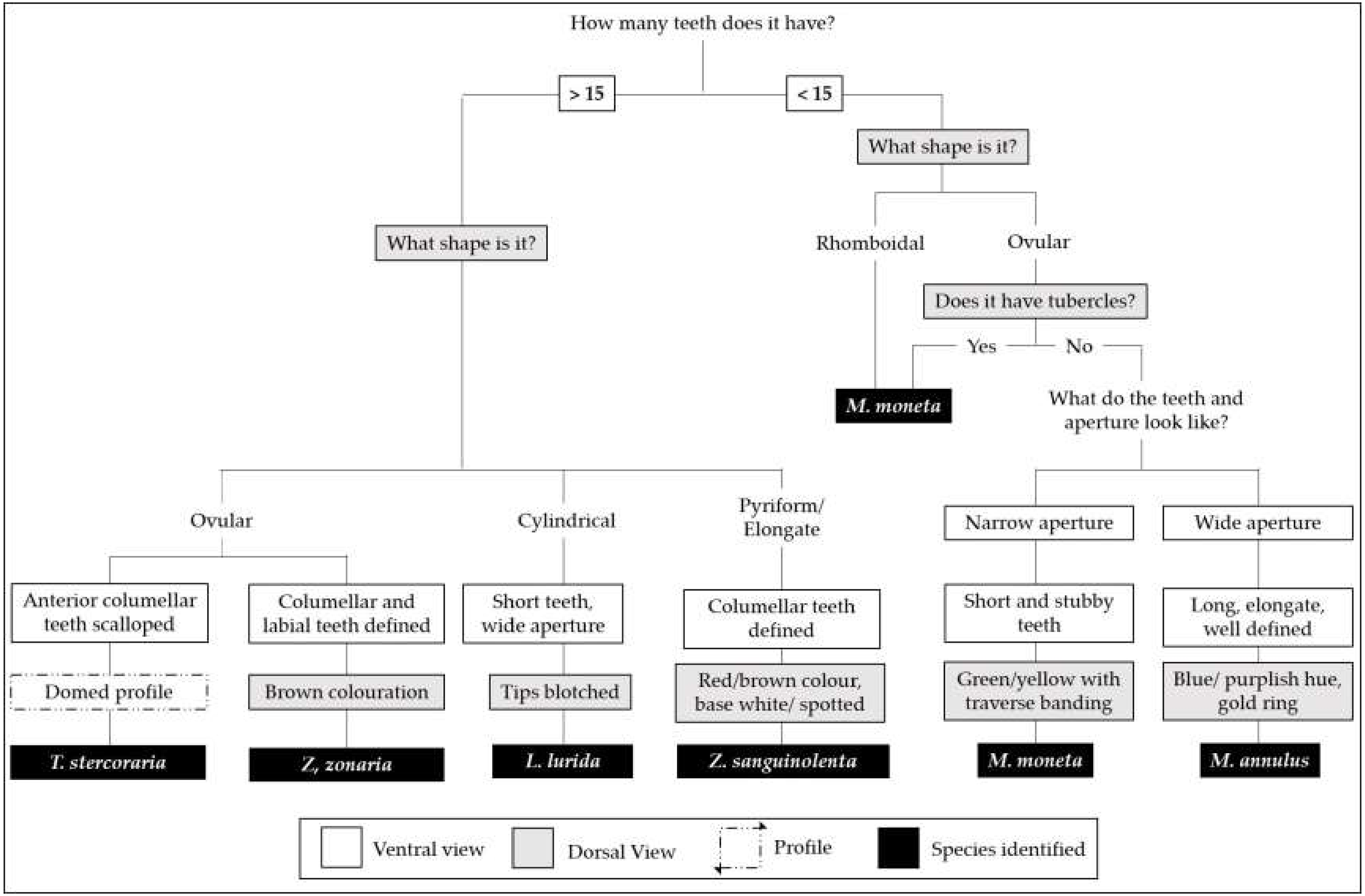

Figure 6: Guide to species identification of West African cowries, M. moneta and M. annulus

Shell Size

The next attribute to be recorded is shell size. In the case of intact, non-fragmented shells three measurements are made using digital callipers: length, width and height (**Figure 7)**. For consistency and comparability of the data, measurements should be made in millimetres.

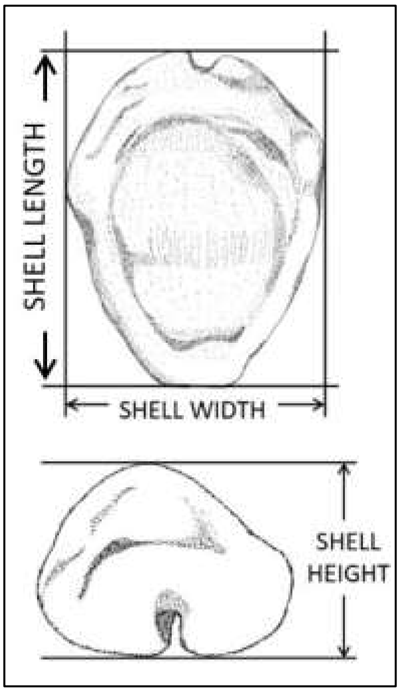

Figure 7: Details of shell measurements to be taken using digital callipers. Illustration: Christie

While shells may subsequently be grouped for further analysis, detailed measurements should be taken in the first instance to facilitate further examination of the raw data.

In instances where the shell is intact, but the dorsum has been removed, it will not be possible to measure the height – only the length and width will therefore be noted. Measuring other fragments should be avoided as these will not provide an accurate appreciation.

In most snails, shell material is deposited only around the edge of the aperture and the shell forms a spiral (or sometimes a cone) as it grows. The aperture increases in size as the animal grows, all the shells whorls are visible, and the oldest shell material is at the apex with the most recent at the aperture. Growth is indeterminate, although growth rate can be slow in larger individuals. Because growth is indeterminate, measurements of shell size can be used to examine past exploitation practices. At low human exploitation rates, harvesting will normally remove the largest (and thus oldest) individuals, while at high exploitation rates, collectors are required to select smaller and smaller specimens. Claassen (1998, p. 112) for example suggests that changes in average shell height through the deposits can be used "to argue for intensive human-predation", although other factors influencing shell size such as environmental conditions and habitats should be considered (Claassen 1998, p. 134). The incremental pattern of growth in most shells also has the potential to provide insight into seasonal exploitation practices and past climatic conditions through isotopic analysis (e.g. Leng and Lewis 2016 amongst others).

However, as noted above, cowries have a determinate growth pattern. This means that after maturity, shell size increases only very slightly with age. All adult shells are a similar size, so there will be no change in the size of shells being harvested as exploitation rate increases. In addition, the incremental growth lines present in other molluscs cannot be identified. It is, therefore, not possible to gain insight into seasonal collection practices or palaeoclimatic conditions by sampling growth increments for isotopic or elemental analysis. Size may, however, give some information on the provenance of cowries (see below).

Condition

The third variable recorded is shell condition. Is the shell intact (I) or fragmentary (Fr); and if fragmentary, which part of the shell is present (**Table 3, Figure 8**)? Is there evidence to suggest the shell has been beach-washed (W) (i.e. collected sometime after it had died) and is there any evidence of burning (B)? Descriptive elements can be combined; for instance, an intact shell that has been burnt would be categorised as I, B.

Description	Code	Notes
Unknown Fragment	Fr-0	Unknown cowrie fragment. Used when it is clear the fragment is from a cowrie shell but nothing further can be said.
Labium (Intact)	Fr-1a	The shell has broken in half medially and the labial side is intact.
Labium (Anterior)	Fr-1b	The shell has broken in half medially, but only the top end of the labium is present.
Labium (Posterior)	Fr-1c	The shell has broken in half medially, but only the bottom end of the labium is present.
Labium (Unknown)	Fr-1d	
Columellar (Intact)	Fr-2a	The shell has broken in half medially and the columellar side is intact.

Columellar (Anterior)	Fr-2b	The shell has broken in half medially, but only the top end of the columellar is present.
Columellar (Posterior)	Fr-2c	The shell has broken in half medially, but only the bottom end of the columellar is present.
Columellar (Unknown)	Fr-2d	
Base (Unknown)	Fr-3a	Unknown fragment from the ventral side. Use when it is unclear whether the fragment is from the labial or columellar side.
Base (Intact)	Fr-3b	Both columellar and labium are intact, but the dorsum has been removed.
Base (anterior)	Fr-3c	The shell has broken laterally and though both the labium and columellar are present, only the anterior end survives.
Base (posterior)	Fr-3d	The shell has broken laterally and though both the labium and columellar are present, only the posterior end survives.
Dorsum	Fr-4	The domed part of the shell. It is rare that this is found in isolation. Its presence in an assemblage could provide evidence for modification practices (see below).

Table 3: Coding for fragmented cowrie shells

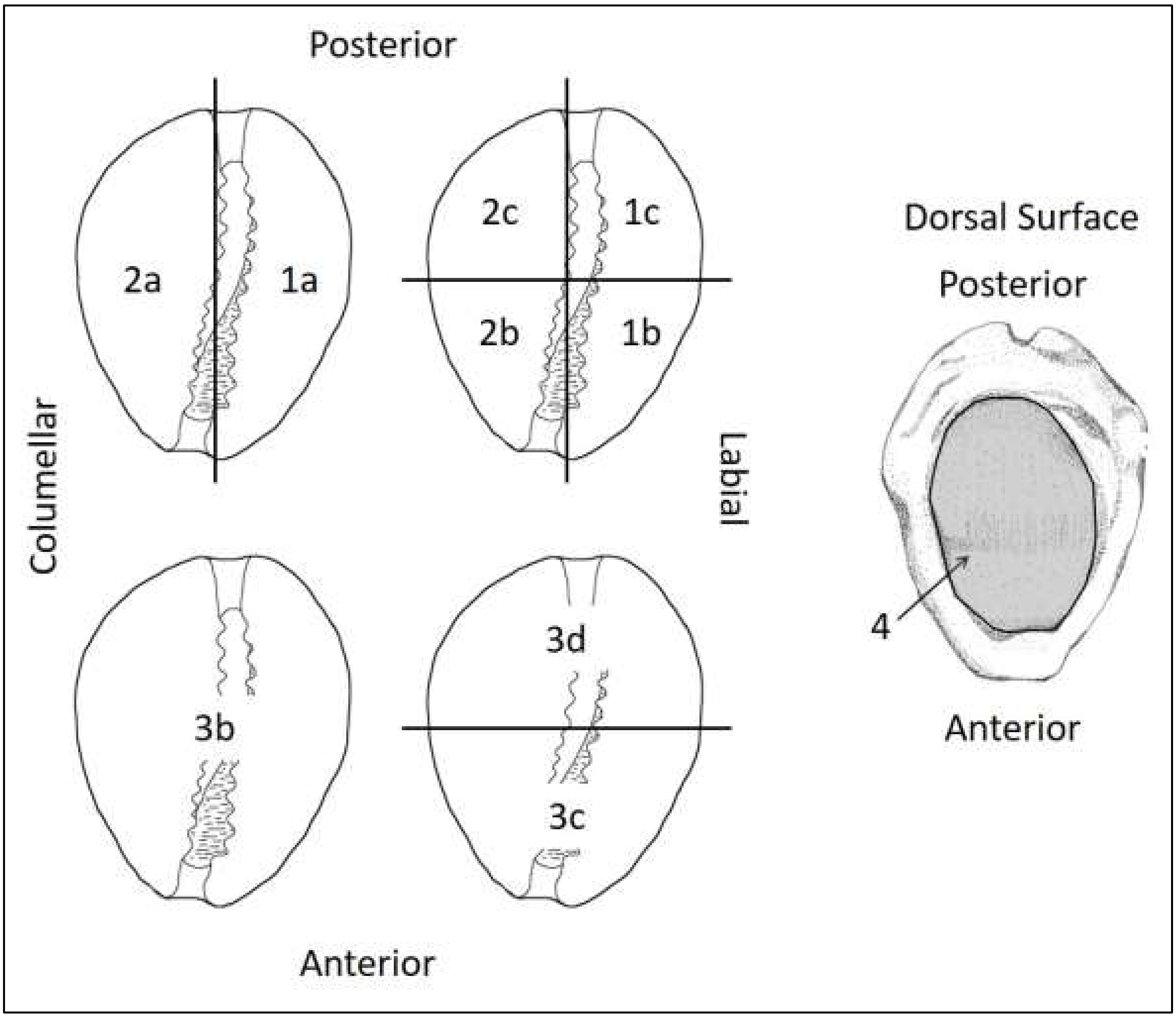

Figure 8: Location of different fragments as per coding in Table 1. Illustration: Authors

Note that with the exception of shells coded as 'Fr-3b' – which indicates a shell with the dorsum removed (**Table 3)**, coding the different fragments relies on the assessor being able to determine which side of the shell is present. The body whorl (columella) is a key diagnostic feature; its presence indicates a columellar fragment, its absence either a columellar or a labial fragment. That said, the body whorl may be damaged through taphonomic or anthropogenic processes and may not always be clear. If uncertain, the code 'Fr-0' – unknown fragment – or 'Fr-3a' – unknown base fragment – should be used. This will allow for a calculation of metrics regarding the presence and number of fragments at sites in the region that in the longer term can be considered in a regional or chronological framework.

Identifying beach-washed shells

Beach-washed shells (W) are those shells that have died prior to human collection. These include reports of *M. moneta* or *M. annulus* shells recovered off the West African coast, identified as the result of shipwrecks or cargo dropped while disembarking (Jackson 1917, Iroko 1987). Such shells are typically very worn and pitted and, depending on how long they remained submerged, may show evidence of boring and/or fouling by other marine organisms and/or damage from abrasion resulting from wave action (**Figure 9**).

Figure 9: Example of a beach-washed Z. zonaria (Recovered from Abonsey, Ghana, with thanks to James Boachie Ansah, University of Ghana-Legon). Left: dorsal side, showing the tube of a serpulid polychaete inside the shell; right: ventral side, showing damage from boring organisms, probably spionid polychates. In this case the dorsum has been removed. This shell would be coded as: W, Fr-3b. Photos: Authors

Depending on deposition and recovery context, shells from archaeological sites can become bleached and chalky due to the destruction of the outer layer of shell. Such shells can be differentiated from beach-washed specimens since rather than appearing pitted, the outer surface of the shell looks like it has flaked off (**Figure 10)**.

Figure 10: Live collected intact M. annulus from Karfi, Nigeria (with thanks to Abubakar Sule Sani, Ahmadu Bello University Zaria) showing some deterioration to the outer shell surface. Note the surface appears to be flaked rather than pitted, and the shell is still smooth. This shell was recovered from the surface, which likely accounts for its bleaching. Left: dorsal side; right: ventral side. This shell would be coded as: I. Photos: Authors

In other cases, however, shells will retain their shiny lustre and will look much as they did when they were originally collected (**Figure 11**). In these cases, identification is much more straightforward.

Figure 11: Intact M. annulus in good condition from Molla, Benin (Amoussou et al. 2018). Note that the shell retains it smooth, shiny surface and pigmentation, indicating that it was collected live. Left: dorsal side; right: ventral side. This shell would be coded as: I. Photos: Authors

Identification of beach-washed shells has major implications for our understanding of cowrie use and value in West Africa. Evidence for beach-washing is common on the West African species which we have studied, suggesting that these were not collected live (Haour and Christie 2019). While it is true that *L. lurida* and *Z. zonaria* bear resemblance to *M. annulus*, hey are unlikely to have been confused by users. Furthermore, it is unlikely that beach-washed shells were considered suitable for use as currency or ornamentation. Hogendorn and Johnson (1986) for example remarked that in recent historical times only *M. moneta* cowries collected live in the Maldives commanded a high value in long-distance trade networks. Beach-washed specimens on the other hand "were of course useless for ornamental purposes and in some places, were not acceptable as currency or commanded a lower price" (Johnson 1980, p. 19).

Identifying burnt shells

Burnt shells are typically characterised by golden-brown, grey or black discolouration to their original pigmentation **(Figure 12)** depending on the duration and intensity of the exposure to the heat source. Although the colouration of the shells changes, their patterning may remain. While this is likely the product of depositional or post depositional processes rather than intentional human action, activities such as ritual destruction or burning the shell as part of another process cannot be excluded.

Figure 12: Burnt cowries: Left two are dorsal and ventral images of an M. anulus from Savè, Benin (with thanks to Andrew Gurstelle, Wake Forest University), Right two are dorsal and ventral images of a M. moneta from Toutoukayeri (Nikis et al. 2018). Note the black discolouration. In both cases the shells would be coded B, Fr-3b as the dorsum has been removed. Photos: Authors

Modifications

The final attribute considered is whether the shell has been modified and, if so, what type of modification has occurred. Examining this attribute has a number of benefits, particularly if regional or chronological differences in the nature of modifications or the technology used can be identified. Furthermore, when combined with species data, assemblages from multiple sites can be compared to examine whether shells from different species are treated differently. We had initially hypothesised that shells were being brought into West Africa already modified, but our study of West African and Maldivian archaeological assemblages has indicated that they were likely being modified after they reached West Africa (Christie and Haour 2018, p.141; Haour and Christie 2019). One well-known example is that of the kingdom of Dahomey, Benin; an eighteenth century source reports that "Strung cowries were one cowrie short of the nominal 40, the reward to the stringer for the work of piercing and stringing the shells. Cowries were strung at the king's palace by the women there…" (Johnson 1970, Hogendorn & Johnson 1986). But whether shell modification was carried out at regional centres, or by individuals on an ad-hoc basis, likely varied in time and region.

Why were cowries modified?

One of the most common modifications noted on cowrie shells involves the removal of the dorsum. Nineteenth-century records make numerous references to cowries being strung (Johnson 1970). Heinrich Barth, passing through what is today Niger, called the counting of shells most tedious, remarking that "in all these inland countries of Central Africa [cowries] are not, as is customary in some regions near the coast, fastened together in strings of 100 each, but are separate, and must be counted one by one" (cited in Hogendorn and Johnson 1986: 118). In eighteenth-century Dahomey, strung cowries were one cowrie short of the nominal 40, the reward to the stringer for the work of piercing and stringing the shells (Johnson 1970). Therefore, convenience can be assumed to have been a major factor in the piercing and stringing of cowries. However, so much attention has been paid to the monetary use of cowries that it is easy to lose sight of one key point, which is that most uses of these shells – be they monetary or ornamental – require modification. In order for cowries to be suspended or sewn, and for them to sit neatly together, they must be pierced or backed.

Previous work on modifications

Several authors have touched on cowrie modification processes. York (1972, p. 100) proposed three methods of modification – grinding, chipping and piercing. Ground cowries were observed to have had a flat, smooth surface, whereas chipped cowries evidenced a more rugged hole. Piercing was not used to remove the dorsum but rather to create a small hole at one or both ends of it.

Francis (1987, p. 29) conducted experimental archaeology studies on shell bead manufacture, focusing in particular on the efficiencies of hammering, grinding and combination of these methods as a means by which to remove the shells' dorsum, noting that the combination of the two strategies was most efficient. From our perspective, his observation that grinding removed all traces of hammering (Francis 1987, p. 30) is noteworthy, as while shells may appear to have been ground (discussed below), this may not have been the primary method of modification. In these cases, microscopic analysis may reveal more details.

Most recently, Heath (2017, p. 62-64) assessed an assemblage from Saclo, Benin. She categorised perforated shells into three groups, seemingly indicative of different modification strategies (Heath 2017, Figure 4.1). Cowries from her Group 1 have a large and rugged dorsal hole, which she posits was created by chipping (**Figure 13**)[5].

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[5] We were able to re-examine the assemblage from Saclo on which Heath's (2017) classification is based, and Figures 13, 14, and 15 below show shells that match Heath's (2017, pp. 62-64 and Figure 4.1) classification.

Figure 13: M. annulus Group 1 specimen – note the wide dorsal hole with rugged edge – from Saclo. Benin (with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville). Photos: Authors

By contrast, Group 2 specimens had a smoother edge around a noticeably smaller dorsal hole – a feature Heath attributes to the shells having been ground **(Figure 14**).

Figure 14: Group 2 specimen of M. annulus – note the smaller dorsal hole with straight edge – from Saclo, Benin (with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville). Photos: Authors

Finally, Group 3 shells were characterised by the keyhole shape of the dorsal hole (**Figure 15**). While Heath was unable to determine the modification practice that achieved this characteristic perforation, we propose this reflects a technique here referred to as 'popping the cap' – discussed below.

Figure 15: Group 3 specimen of M. annulus – note the 'keyhole' shape to the dorsal hole and the straight edge – from Saclo, Benin (with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville). Photos: Authors

Characterising cowrie modifications

A fundamental concern is to differentiate between naturally and anthropogenically perforated shells, and to elucidate potential modification processes.

Three types of modification have been observed: partial dorsal perforation, total removal of the dorsum and deliberate linear incisions on one or both sides of the aperture on the ventral surface (**Figure 16a to c**). Linear incisions, approximately parallel to the teeth, were observed both on intact shells and on shells where the dorsum had been removed. The purpose of these incisions is unclear.

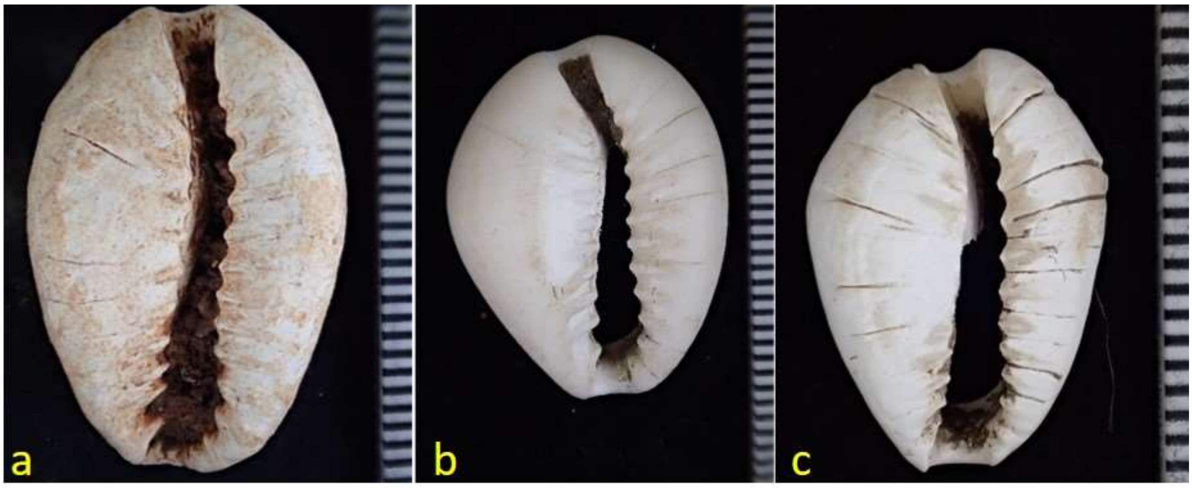

Figure 16: a) Linear incisions on the columellar side of the aperture: M. annulus coded IN-1A. Shell from Ijebu Ode, Nigeria (with thanks to Gérard Chouin, College of William & Mary, and Adisa Ogunfolakan, Obafemi Awolowo University Ile-Ife); b) Linear inicisions on the labial side of the aperture, M. annulus coded IN-1B. Shell from Karfi, Nigeria (with thanks to Abubakar Sule Sani, Ahmadu Bello University Zaria); c) Shell with incision on both the labial and columellar sides of the aperture, M. moneta coded IN-1C. Shell from Karfi, Nigeria (with thanks to Abubakar Sule Sani). Photos: Authors

These different modifications and processes can be coded according to the description below (**Table 4 and Table 5**). Unmodified shells are coded as 'N'.

Dorsal Removal		
Partial dorsal perforation	D1/DP	Here only a part of the dorsum has been removed (normally from the anterior end or side). Note this perforation can be natural or anthropogenic. Where it is considered natural, the code DP should be used
Total dorsal perforation	D2	The dorsum has been fully removed
Total (smoothed) dorsal perforation	D3	The dorsum has been fully removed and the edge of the perforation is rounded smooth
Incision		
Incision localised to columellar	IN-1a	Multiple linear incisions restricted to the columellar side of the ventral surface
Incision localised to labium	IN-1b	Multiple linear incisions restricted to the labial side of the ventral surface
Incision on both sides of aperture	IN-1c	Multiple linear incisions on both the columellar and labial sides of the ventral surface

Table 4: Coding and description of different modifications

Modification processes	Coding	Description
Dorsum removal by progressive perforation	P. Perf	- Wide perforation with scalloped edges
Dorsum removal by 'popping the cap' with anterior perforation	PTC-A	- Dorsal perforation has straight, inclined edge - Characteristic notch at anterior end of the perforation
Dorsum removal by 'popping the cap' with posterior perforation	PTC-P	- Dorsal perforation has straight, inclined edge - Characteristic notch at posterior end of the perforation
Dorsum removal by 'popping the cap', location of initial perforation unknown	PTC-U	- Dorsal perforation has a straight, inclined edge characteristic of PTC-A or PTC-P - No notch on either edge of the perforation
Method of dorsum removal obscured by further modification to the perforation edge	Smoothed	- Generally wide perforation with a smooth bevelled edge
Dorsum is removed or shell is shaped by grinding	Ground	- Macro or microscopic striations on the shell around the perforation - Dorsal side of the shell is flat - Depending on location, the shell may be misshapen.

Table 5: Coding used to describe the process used for dorsum removal

Intentional partial dorsal perforation is difficult to differentiate from naturally damaged shells, as the nature of the modification is such that it could represent an early stage of progressive perforation or could be the result of natural taphonomy. This perforation tends to be concentrated at the anterior end of the shell, which is its weakest point. In naturally perforated shells the edge of the perforation will be rugged and angular (**Figure 17a**). Diagnostically, a partially perforated shell that has been deliberately modified will possess one of two features: either the edge of the perforation will be scalloped (**Figure 17b**), or the perforation will extend beyond the anterior end around the edge of the dorsum (**Figure 17c**).

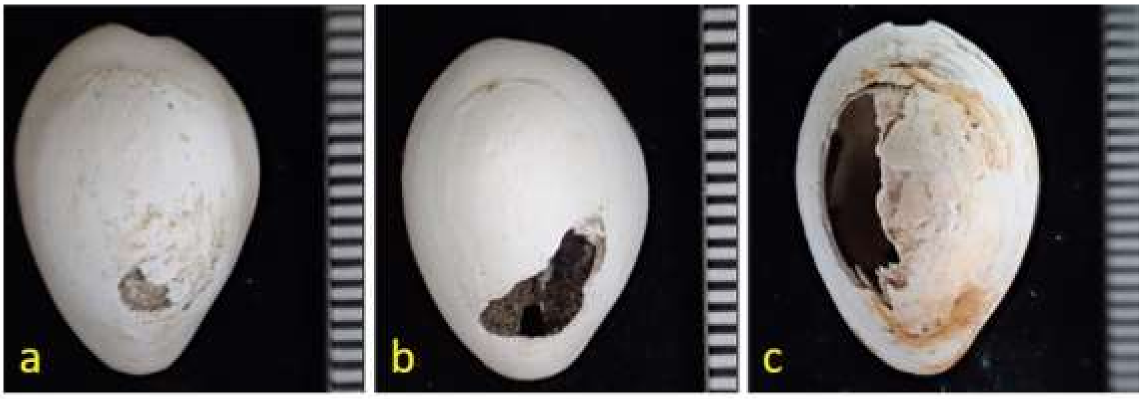

Figure 17: a) Partially perforated M. annulus shell - likely the result of natural taphonomy c.f. b) Partially perforated M. annulus shell, likely anthropogenic - note the scalloped edges; and c) Partially perforated M. annulus shell, likely anthropogenic, note that the perforation extends around the edge of the dorsum. Left and centre from Karfi, Nigeria, with thanks to Abubakar Sule Sani, Ahmadu Bello University Zaria; right from Saclo with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville. Photos: Authors

In cases where the dorsum has been completely removed, five modification processes were observed in the assemblages we assessed, each of which with diagnostic features – some clearer than others. These are progressive perforation, three forms of 'popping the cap' and grinding (**Table 5**). If the process can be determined it is recorded alongside the coded modification attribute. Where there is uncertainty this should be acknowledged and caution used.

Progressive Perforation

Progressive perforation may be akin to the 'chipping' process proposed by York (1972, p. 100). Here the shell's dorsum is systematically punctured, with each perforation enlarging the hole being created. Different stages of the process will have different diagnostic features. As noted above, in early stages, a shell modified by progressive perforation may manifest as partial dorsum removal. As the process progresses, the hole is enlarged around the edge of the shell (**Figure 18c**) until the dorsum is completely perforated. This hole will be wide and, like its incomplete counterpart, will have a scalloped edge (**Figure 18**).

Figure 18: Progressive perforation of M. annulus evidenced by scalloped edge to the perforation (Zoomed in Left). Shell from Saclo (with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville.). Photos: Authors

At this stage, the shell is characteristic of those classified as Group 3 in Heath's (2017, p. 64) typology. In some cases, this edge is then smoothed, producing a shell with a wide perforation and a bevelled edge (**Figure 19**). However, this smoothing process may have been used for shells backed by other processes, and the smoothing of the edge can remove evidence of the initial modification. Shells with smoothed edges are classed as D3 (**Table 4**).

Figure 19: M. annulus shell from Karfi, Nigeria, with smoothed dorsal perforation showing bevelled edge to the hole (With thanks to Abubakar Sule Sani, Ahmadu Bello Universoty Zaria). Photos: Authors

To ‘back’ a cowrie using ‘popping the cap’ a single small perforation is made, and the dorsum is levered off in a single piece. The shell breaks naturally and the edge of the resulting perforation has a characteristic and highly diagnostic straight edge, which crucially – when compared to other processes like grinding – slopes inwards (**Figure 20a**). The straight edge is similar to the shells which Heath (2017) assigns to Group 2 (**Figure 20a cf. Figure 14**).

The initial perforation can be achieved in one of two ways. In the first, it is made through the aperture at the anterior end of the shell (PTC-A). This can result in the presence of a small diagnostic notch at the top of the dorsal hole **(Figure 20b),** giving it a keyhole shape similar to the features of Heath’s Group 3 category shells (**Figure 20b cf. Figure 15)**. In the second, the initial perforation is made through the dorsum at the posterior end of the shell (PTC-P) and creates a small diagnostic notch at the posterior end of the dorsal hole **(Figure 20c)**.

In instances where the shell has a straight, inward sloping edge and is identifiable as having been modified by PTC but it is not obvious where the initial perforation was made (as is the case in **Figure 20a),** the code PTC-U should be used.

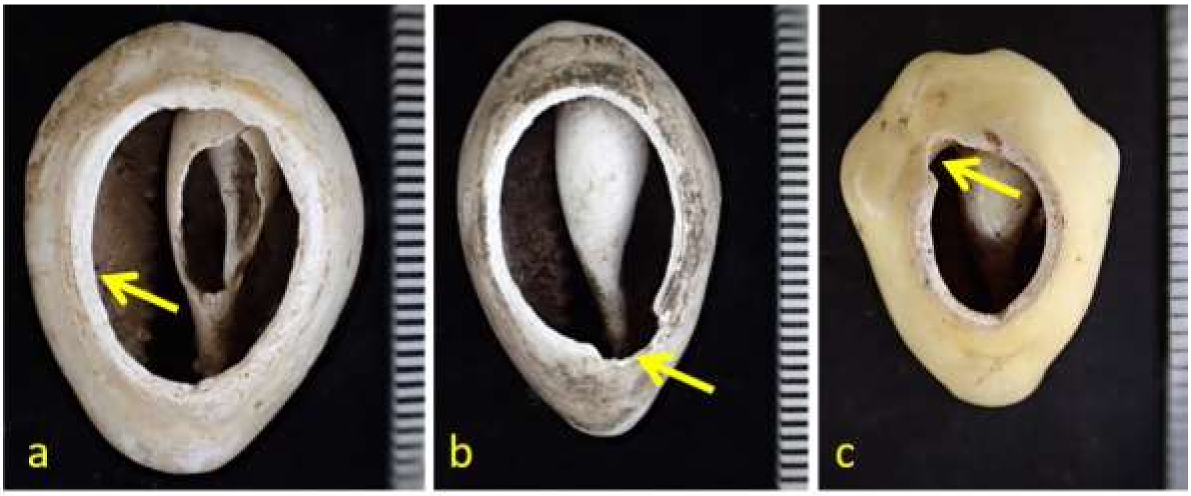

Figure 20: a) Shell perforated by PTC - note the characteristic straight edge to the dorsal hole, sloping inward. b) Shell perforated by PTC with the initial perforation made at the anterior end – note the characteristic notch and keyhole shaped dorsal hole alongside the straight edge, coded PTC-A; and c) Shell perforated by PTC with the initial perforation made from the posterior end. Note the characteristic notch at the poterior end of the dorsal hole alongside the characteristic straight edge of the perforation, coded PTC-P. a) from Toutokayori (Nikis et al. 2018); b) Savè surface collection, with thanks to Andrew Gurstelle, Wake Forest university; c) Ede Ile, with thanks to Akin Ogundiran, University of North Carolina Charlotte. Photos: Authors

Grinding

Unlike in the case of other processes, in which the impact of perforation is limited to the edge of the hole, grinding is visible across the dorsal side. A key diagnostic feature is that the shell will be flattened at the top (**Figure 21a and b**). Depending on the condition of the shell, this can be accompanied by striations that are visible either microscopically or macroscopically **(Figure 21c and d**). Grinding can also be used to modify the shape of the shell to enhance or remove certain features. This can result in the shell being misshapen (**Figure 22**). Again, depending on the shells' condition, this can be associated with striations. It is noteworthy that while grinding is often a primary method for dorsum removal, it can be a subsidiary process to reshape a shell that dorsum has been removed/ by another process. In both instances, the shell will be flat or shaped.

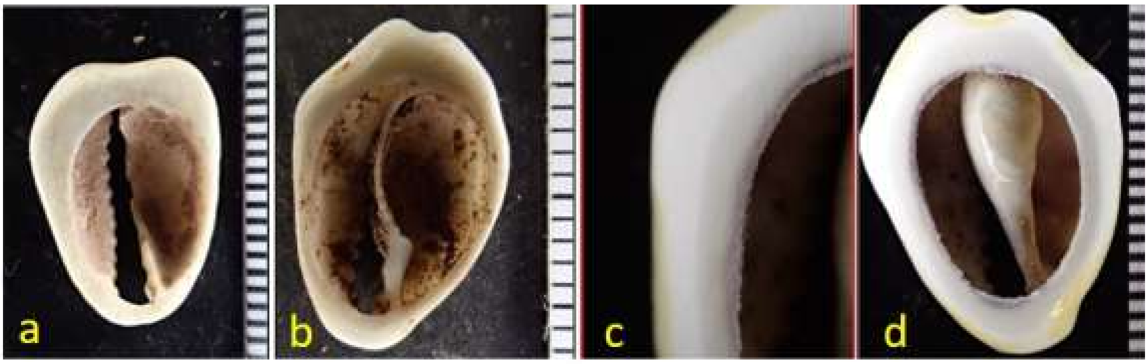

Figure 21:a and b) Examples of shells that have been ground - a - M. moneta from Tichitt, (MAU68-85) with thanks to IFAN; b – M. moneta from Ede-Ile, with thanks to Akin Ogundiran, University of North Carolina Charlotte. c and d) M. moneta ground through experimental archaeology – note the visible striations on the surface. Photos: Authors

Figure 22: M. moneta where grinding has been used to alter the shape - here the grinding has been localised to the columellar side of the posterior, as indicated by arrow. Shell from Doguéme, Benin, with thanks to Inga Merkyte, University of Copenhagen. Photos: Authors

A consistent approach: Benefits and applications

Scales of Interpretation

As is the case with any archaeological assemblage, the nature of the inferences that can be drawn from the dataset is dependent on several factors such as the context of the deposition and the total assemblage size. For instance, the interpretation of an assemblage from a single context, such as a burial, will differ markedly from the interpretation of the same number of shells derived from multiple different contexts across the site. In the same way, the inferences that can be made about a single shell are vastly different to the inferences one can make from 100 or even 1000 shells. In this final section, we explore what questions can be explored by different scales of assemblages and sound some notes of warning.

Is the assemblage from a single place and time: Only in very rare cases will a *M. moneta* or *M. annulus* assemblage from West Africa represent a 'single death assemblage' – i.e. consisting of the same population (e.g. deriving from one specific reef in the Maldives or East Africa). The nature of exchanges is such that an assemblage consists at best of shells from multiple populations across a particular region, and at worst combines specimens of multiple populations from multiple regions. As such it is not possible to use West African archaeological cowrie assemblages to examine season of death (see Claassen 1998, chapter 6). Historical records and our own ethnographic surveys suggest that in the Maldives, for example, shells collected across the country were exchanged in the capital Male for goods and staples (Hogendorn and Johnson 1986, p. 83). Furthermore, these local exchanges would often combine the shells collected over a period of time. Shells from different populations were therefore aggregated before they were incorporated into international exchange networks. Similar aggregations are equally likely to have occurred in East African collections.

Context: Regardless of sample size, the context of the recovery has significant impact on potential interpretations. For instance, further insights may be possible if the shell assemblage was recovered from a burial context – with the positioning of it in relation to the skeleton offering an opportunity to examine potential value or function. West African examples include the handful of cowries from Kissi, Burkina Faso, apparently attached to a headband (Magnavita 2015, p. 114), while 13 cowries at Akumbu, Mali, were recovered from around the skull and are thought to have been threaded into the individual's hair (Togola 2008, pp.

33-34). Similarly, drawing on ethnographic examples, cowrie shells recovered in direct association with an intact or broken vessel might be interpreted as caches (Iroko 1987).

Sample size: As with most archaeological materials, the larger the sample available the stronger the foundation for interpretation. In West African assemblages, the presence of a single *M. moneta* or *M. annulus* in an isolated context at a site can only suggest that site was involved in an exchange network that had links to the Indo-Pacific. In isolation it would not be possible to infer the nature of these exchanges, neither would it be possible to extrapolate the nature of its discard (deliberate or accidental). Similar issues are faced where the total assemblage from the site is less than ten shells and these all derive from different contexts.

In instances where tens of shells are recovered from multiple contexts across the site further questions might be addressed. Where shells issue from multiple contexts within a single trench, it is possible to combine their analysis with chronological information in order to examine whether species composition, size profile and nature of modifications change over time. Alternatively, where these contexts are from different trenches across a site, spatial variations in the deposition of shells can be examined.

Provenance

If the total assemblage of *M. moneta* and *M. annulus* from a site consists of over 10 intact or intact but 'backed' shells for which the **length** can be accurately measured, and the different contexts of recovery are of a similar period, further interpretations can be advanced. Specifically, species composition and size can, when used alongside other material culture, enable us to address questions of provenance. *M. moneta* and *M. annulus* both have a geographical range covering large sections of the Indo-Pacific (Richmond 1997, p. 262; Lorenz and Hubert 2000, pp. 204-025; Burgess 1970, pp. 342-344). Despite this, they are not equally abundant in all areas. Two areas stand out in historical texts from the medieval period to the nineteenth century as the source of cowries shipped to West Africa: East Africa and the

Maldives (see Levtzion and Hopkins 2000; Hogendorn and Johnson 1986; Kovács 2008 for key surveys of relevant sources). As part of our work we conducted ecological surveys at 22 islands in the Maldives[6] and at nine sites in Tanzania[7], aiming to determine how many cowrie shells could be collected per hour by a single person and to compare the shell size and species diversity of each collection.

Our own and other ecological surveys along the East African coast (Evans et al. 1997, p. 483; Newton et al. 1993, pp. 242-243) highlight a strong dominance of *M. annulus* in the region compared with *M. moneta*. The surveys we conducted in the Maldives on the other hand suggest the opposite in those waters (Christie and Haour 2018, p. 137). Thus, while both species could be collected and exported from both the Maldives and the East African coast, shipments from these locations would contain higher proportions of *M. moneta* and *M. annulus* respectively. This finds support in the (admittedly limited) archaeological record. Assemblages recovered in the Maldives appear dominated by *M. moneta* (Mikkelsen 2000, p. 12, Haour et al. 2016a, Christie and Haour 2018, pp. 134-135), whereas East African assemblages are dominated by *Monetaria annulus* (Horton 1996, Plate 49; van Neer 2001, p. 398, Christie 2013, p. 108 amongst others).

Although recording shell size in cowries does not offer the same insight into past exploitation practices as it might do in the case of other shells, it does enable us to explore issues of provenance. Building a database which included ecological assemblages from our own cowrie collections and from the Natural History Museum in London, as well as archaeological assemblages, we examined the frequency of extra small (<10mm long), small

[6] Collections in the Maldives were made on the following islands (total number of shells collected at each site is indicated in brackets): Haa Alifu: Utheemu (n=118); Haa Dhalu: Baanaafushi (n=0); Raa: Alifushi (n=4), Kotte Faru (n=62), Kinohas (5 sites) (n=71), Boduhuraa (n=39); Alifu Dhalu: Fenfushi (n=12), Maamigili (n=68), Kumburudu (n=4); Laamu: Ishdhoo (n=24), Dhaanbidhoo (n=39), Gan,(n=63) Fonadhoo (n=70), Hithadhoo (n=76); Ghaafu Alifu: Maamendhoo, (2 sites) (n- 15 and 25), Nilandhoo (n=11), Dhaandhoo (n=19)

[7] Collections in Tanzania were made at the following sites: Zanzibar: Kizimkazi Dimbani (n=38), Unguja Ukuu (n=58), Fukuchani (n=4); Mafia Island: Kilindoni (n=15), Kisimani Mafia (n=353); Chole Island (n=21); Kilwa Kisiwani (n=87), Sanje y Kati (n=8), and Songo Mnara (n=23).

(10.01mm – 15mm), medium (15.01mm – 20mm) and large (>20mm) shells (Christie and Haour 2018, p. 134) in Maldivian and East African assemblages **(Figure 23)**. Although the Natural History Museum assemblages from both regions had a slightly higher proportion of larger specimens when compared with archaeological collections (**Figure 23, bars 2, 4, 6 and 8)**, this is likely attributed to the collectors' preferences; data from our ecological collection suggest that the size profile of the combined shell populations in the Maldives show a much closer correlation with the archaeological assemblages (**Figure 23, bar 10)**.

What emerges is that the assemblages show clear regional variations in proportions of different size shells. Maldivian assemblages tend to feature a higher proportion of small and medium shells (**Figure 23 bars 1, 2, 5, and 6**), while East African assemblages consist almost entirely of medium and large shells (**Figure 23, bars 3, 4, 7 and 8**). These regional differences remain apparent even when the shells of both species are combined (**Figure 23, bars 9-12)**. Methodologically this is significant. The use of shell size as a means of exploring provenance relies on understanding the relative proportions of different sizes within an assemblage and as such is more appropriate for large assemblages. Unfortunately, cowries are often recovered in mall numbers at a given site, with few sites yielding sufficient numbers of one species to enable analysis. By considering the size of *M. annulus* and *M. moneta* shells in combination, we can assess the provenance of assemblages from a larger number of sites. The sample sizes needed to make quantitative comparisons between samples will vary depending upon the magnitude of the difference being assessed and the variability within individual samples. However, using a χ^2 test, a sample of only 10 shells from one of the East African assemblages in **Figure 23** would be sufficient to demonstrate a significantly lower proportion of small individuals than are present in the Maldivian material. As noted, although female shells are, on average, slightly larger than males, the difference in mean size (typically < 10% of the mean) is small relative to differences between the two regions (Maldives and East Africa). In short, shell size can, particularly when combined with a consideration of associated material culture, period and site location, can enable us to explore questions of provenance.

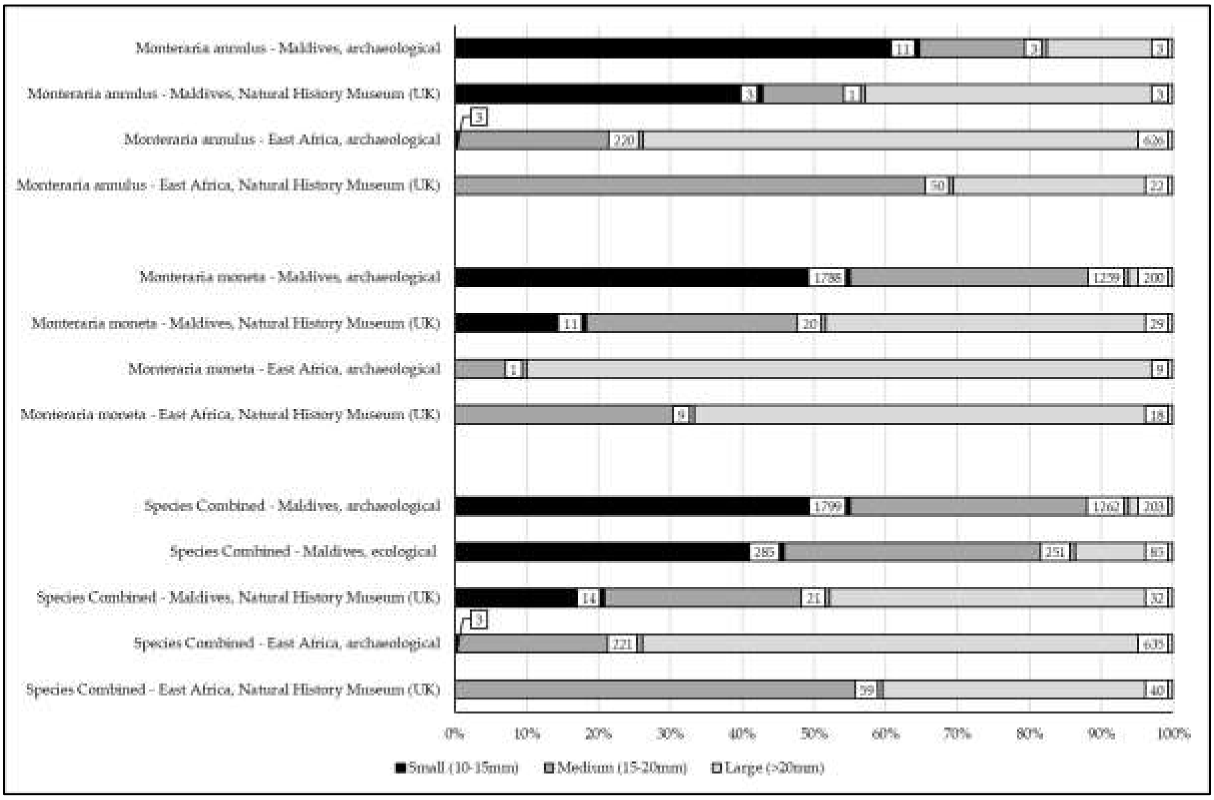

Figure 23:Comparative analysis of different sized shells from the ecological and archaeological assemblages from the Maldives and East Africa - showing shell sizes for M. annulus (top), M. moneta (middle) and combined (bottom). The archaeological assemblage of known East African provenance was sourced from Songo Mnara, a 14th – 16th c.AD site in Tanzania (see Sulas et al. 2016).

Understanding use and value

Implementing a consistent recording and reporting strategy for cowrie shells across West Africa and the continent more widely has major benefits, not least of which is enabling the creation of comparable datasets so that regional and chronological patterns in the selection and use of cowrie shells may come to light. Cowries moved across Africa within networks that also spread ideas, innovations, technologies, belief and political change. One interesting question surrounding the question of cowries is that of the value which they were attributed by different West African communities. Already six centuries ago, writing in Damascus and

Cairo, al Umari described those who risked the journey to West Africa as impelled by profit, setting out with “valueless articles” such as cowries and returning with bullion (cited in Levtzion and Hopkins 2000: 276). Value is, however, in the eye of the user, and it is important to look at the concept of value critically if we are to understand how communities participated in early global trade networks. Research into how cowries were used and the value they had in past societies remains uneven, and has largely centred on traditional economic principles (e.g. Hogendorn and Johnson 1986) or involved localised studies of cowries’ meaning and value (e.g. Ogundiran 2002). Such studies are unquestionably important but a broader, comparative approach is imperative. The systematic framework we have developed in this article will, we hope, make possible a comparative study of ways in which cowries were valued, used and moved within West Africa, and shed light on the different technologies relating to their processing.

Exchange Networks

At this stage, the spread of cowries to, and within, West Africa remains poorly understood. At the present state of knowledge, there is no evidence for an east-west route across the Sahel, directly linking the Indian Ocean with West Africa (and on this see Hiskett 1966: 347-351). Thus, any pre-European import of cowries to regions south of the Sahel would presumably have occurred via the North African seaboard then across the Sahara. Unfortunately, the areas between Sahel and coast remain some of the least well known, archaeologically speaking, and as researchers begin to fill in the blanks on the map between the Niger bend and the forest to the south we are inevitably confronted by new interpretational challenges (Haour et al. 2016b). The assumption that the earliest cowries reached West Africa via the trans-Saharan trade, and that these consisted mainly of *M. moneta*, is supported by the rather limited range of historical evidence and even more limited archaeological evidence; here, the eleventh/twelfth century Ma’den Ijafen load referred to above, recovered in one of the emptiest quarters of the Mauritanian Sahara, remains unique and uniquely evocative, and it consists very largely of *M. moneta* (Monod 1969, Christie and Haour 2018). The majority of shells in the Ma'den Ijafen assemblage are small (Christie and Haour, 2018), which would be consistent with a Maldivian rather than an East African source. Historical narratives envisage a trans-Saharan route followed by a coastal arrival *en masse*, and some scholars (see e.g. Hiskett 1966: 357, Johnson 1970) suggest there was little overlap between the two: as southward Saharan trade declined, it was replaced by expanding coastal trade through which cowries percolated slowly inland. Whether cowries arriving through trans-Saharan networks may in fact have reached the Atlantic coast before European contact is one question of pressing importance. It is certainly clear from shipping logs that cowries were already a commodity valued by coastal West African partners in the very beginnings of European involvement (Mauny 1967).

Other insights from regional and chronological patterns

The condition of cowries recovered can provide insight into the impact of regional vegetation and soil conditions on shell preservation. Carefully reporting the presence and nature of fragmentary cowries helps to examine whether the current paucity of evidence for cowrie usage in certain areas is an artefact of the archaeological record. Similarly, recording whether the shells were collected live, or as beach wash, and whether larger species were processed for food, can provide insight into exploitation practices.

Finally, from the perspective of modifications, consistent recording across datasets offers opportunities to explore broader social questions. For instance, are particular modification processes associated with particular cowrie species? Are shells modified by different processes used in specific ways? Where within the exchange networks were the shells being modified – was it done by individuals at the end of the exchange, or were the shells being imported unmodified and being processed at hubs within the region? If the latter, who was responsible for this?

Conclusion

This paper has summarised a methodology for analysis of cowrie shells in archaeological contexts. The success of this strategy, which considers species, size, shell condition and modification as a means by which to explore regional and chronological trends, has been demonstrated in a West African context (Haour and Christie 2019). However, there is significant opportunity to expand on our existing knowledge were this method to be applied to new finds in the region and across the continent more widely.

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organisms, probably spionid polychates. In this case the dorsum has been removed. This shell would be coded as: W, Fr-3b. Photos: Authors

Figure 10: Live collected intact *M. annulus* from Karfi, Nigeria (with thanks to Abubakar Sule Sani, Ahmadu Bello University Zaria) showing some deterioration to the outer shell surface. Note the surface appears to be flaked rather than pitted, and the shell is still smooth. This shell was recovered from the surface, which likely accounts for its bleaching. Left: dorsal side; right: ventral side. This shell would be coded as: I. Photos: Authors

Figure 11: Intact *M. annulus* in good condition from Molla, Benin (Amoussou et al. 2018). Note that the shell retains it smooth, shiny surface and pigmentation, indicating that it was collected live. Left: dorsal side; right: ventral side. This shell would be coded as: I. Photos: Authors

Figure 12: Burnt cowries: Left two are dorsal and ventral images of an *M. anulus* from Savè, Benin (with thanks to Andrew Gurstelle, Wake Forest University), Right two are dorsal and ventral images of a *M. moneta* from Toutoukayeri (Nikis et al. 2018). Note the black discolouration. In both cases the shells would be coded B, Fr-3b as the dorsum has been removed. Photos: Authors

Figure 13: *M. annulus* Group 1 specimen – note the wide dorsal hole with rugged edge – from Saclo. Benin (with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville). Photos: Authors

Figure 14: Group 2 specimen of *M. annulus* – note the smaller dorsal hole with straight edge – from Saclo, Benin (with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville). Photos: Authors

Figure 15: Group 3 specimen of *M. annulus* – note the 'keyhole' shape to the dorsal hole and the straight edge – from Saclo, Benin (with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville). Photos: Authors

Figure 16: a) Linear incisions on the columellar side of the aperture: *M. annulus* coded IN-1A. Shell from Ijebu Ode, Nigeria (with thanks to Gérard Chouin, College of William & Mary, and Adisa Ogunfolakan, Obafemi Awolowo University Ile-Ife); b) Linear inicisions on the labial side of the aperture, *M. annulus* coded IN-1B. Shell from Karfi, Nigeria (with thanks to Abubakar Sule Sani, Ahmadu Bello University Zaria); c) Shell with incision on both the labial and columellar sides of the aperture, *M. moneta* coded IN-1C. Shell from Karfi, Nigeria (with thanks to Abubakar Sule Sani). Photos: Authors

Figure 17: a) Partially perforated *M. annulus* shell - likely the result of natural taphonomy c.f. b) Partially perforated *M. annulus* shell, likely anthropogenic - note the scalloped edges; and c) Partially perforated *M. annulus* shell, likely anthropogenic, note that the perforation extends around the edge of the dorsum. a) and b) from Karfi, Nigeria, with thanks to Abubakar Sule Sani, Ahmadu Bello University Zaria; c) from Saclo with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville. Photos: Authors

Figure 18: Progressive perforation of *M. annulus* evidenced by scalloped edge to the perforation (Zoomed in Left). Shell from Saclo (with thanks to Cameron Monroe, University of California Santa Cruz, and Barbara Heath, University of Tennessee Knoxville.). Photos: Authors

Figure 19: *M. annulus* shell from Karfi, Nigeria, with smoothed dorsal perforation showing bevelled edge to the hole (With thanks to Abubakar Sule Sani, Ahmadu Bello Universoty Zaria). Photos: Authors

Figure 20: a) *M. annulus* perforated by PTC - note the characteristic straight edge to the dorsal hole, sloping inward. b) *M. annulus* perforated by PTC with the initial perforation made at the anterior end – note the characteristic notch and keyhole shaped dorsal hole alongside the straight edge, coded PTC-A; and c) *M. moneta* perforated by PTC with the initial perforation made from the posterior end. Note the characteristic notch at the poterior end of the dorsal hole alongside the characteristic straight edge of the perforation, coded PTC-P. a) from Toutokayori (Nikis et al. 2018); b) Savè surface collection, with thanks to Andrew Gurstelle, Wake Forest university; c) Ede Ile, with thanks to Akin Ogundiran, University of North Carolina Charlotte. Photos: Authors

Figure 21:a and b) Examples of shells that have been ground - a - *M. moneta* from Tichitt, (MAU68-85) with thanks to IFAN; b – *M. moneta* from Ede-Ile, with thanks to Akin Ogundiran, University of North Carolina Charlotte. c and d) *M. moneta* ground through experimental archaeology – note the visible striations on the surface. Photos: Authors

Figure 22: *M. moneta* where grinding has been used to alter the shape - here the grinding has been localised to the columellar side of the posterior, as indicated by arrow. Shell from Doguéme, Benin, with thanks to Inga Merkyte, University of Copenhagen. Photos: Authors

Figure 23: Comparative analysis of different sized shells from the ecological and archaeological assemblages from the Maldives and East Africa - showing shell sizes for *M. annulus* (top), *M. moneta* (middle) and combined (bottom). The archaeological assemblage of known East African provenance was sourced from Songo Mnara, a 14th – 16th c.AD site in Tanzania (see Sulas et al. 2016).

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