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A Preliminary Survey of the Late Stone Age Faunas from Gihayu (Khor Umayra Lagoon, Republic of Yemen)

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ABSTRACT: An overview of the faunal assemblage retrieved during preliminary excavations of the Neolithic site of Gihayu is presented. The analysis, the first of its kind carried out on a site from Yemen, reveals a series of similarities and differences with contemporaneous sites in Oman on the eastern corner of the Arabian Sea. Within the former, a heavy reliance on marine resources is noted that testifies both to the collecting of shellfish along an open shore as well as the fishing of large pelagics in the open sea. The differences relate to the exploitation of molluscs along the shore rather than in lagoons or mangroves as appears to be the case in Oman. They may also reflect phenomena not so straightforwardly related to the availability of certain biotopes. Among these an apparent dominance of carangids (jacks) over scombrids (tunas) could be taken to indicate a less seasonal focused fishery a hypothesis that will require verification once systematically sieved samples become available.

KEYWORDS: FAUNA, MOLLUSCS, FISH, FISHING, SHELLFISH GATHERING, SUBSISTENCE, YEMEN, LATE STONE AGE, 5th-4th MILLENNIUM B.C

RESUMEN: Se presenta una revisión de la fauna recuperada en excavaciones preliminares en el yacimiento neolítico de Gihayu. El análisis, el primero de su género llevado a cabo en un yacimiento del Yemen, revela una serie de similitudes y diferencias con yacimientos contemporáneos de Omán en el extremo oriental del Mar de Arabia. Dentro de las primeras, un uso intenso de los recursos marinos que atestigua la colecta de moluscos en una costa abierta al igual que la pesca de grandes pelágicos en el mar. Las diferencias se refieren a la explotación de moluscos en costa más que a la llevada a cabo en lagunas o manglares como parece ser el caso en Omán. También reflejan fenómenos no tan directamente relacionados con la disponibilidad de determinados biotopos. Entre éstos, a destacar una aparente dominancia de carángidos (jureles) sobre los escómbridos (atúnes) que podría tomarse como indicativa de una pesquería menos estacional, hipótesis que requerirá verificación una vez se disponga de muestras cribadas de forma sistemática.

PALABRAS CLAVE: FAUNA, MOLUSCOS, PECES, PESCA, RECOLECCIÓN DE MOLUSCOS, SUBSISTENCIA, YEMEN, TARDÍA EDAD DE PIEDRA, 5º-4º MILENIO a.C.

INTRODUCTION

The Tell of Gihayu, unique among sites lying on the coast of southern Arabia in terms of size, depth of cultural deposits and richness of finds, was discovered in a 1999 survey undertaken by a joint German and Russian archaeological team led by B. Vogt and Kh. A. Amirkhanov. Located in the Khor-Umayra lagoon, 150 Km west of the capital city of Aden and near the mouth of the Wadi Markha, it is surrounded by several other sites that range from the Bronze Age to the Middle Ages (Amirkhanov *et al.*, 2001; Figure 1).

The right bank of the Wadi Markha, consisting of alluvial conglomerate, forms a small terrace 4-5 m high. Where the Wadi joins the lagoon, this alluvium forms one of the coastal terrace levels as well. Some 2 Km north of the Wadi, the Al-Kharza mountain range approaches the coast delimiting the mouth of the Wadi Markha. Gihayu is located ca. 1.6 Km south of the Wadi and ca. 2 Km west of the modern bank of the lagoon. Its shortest distance to the sea, from which it is separated by a smooth stretch of coast, is of approximately 1 Km.

Most elevated point of the entire coastal area with 13.5 metres, Gihayu's base lies 2-3 metres above sea level, the hill being a combination of some 7 metres high cultural deposits lying on top of a 4 metres high dune that corresponds to the level of a Holocene paleo-terrace. The length of this hill is of 215 metres at the base and of 110 metres at the top, its corresponding maximum widths being of 135 and 30 metres. At the time of the formation of the site the seashore was lying close to the base of the dune the possibility existing that the hill might have been an islet separated from the coast by a shallow strip of water several dozen metres wide.

Like similar sites in the Gulf of Aden coast, Gihayu exhibits a distinct layout with areas differing according to function. Both its external features and the structure of its deposits suggest that the site was actually a Tell and not simply a shell midden. Three tops along the longitudinal axis of the hill separated from one another by trenches ca 1 m deep suggest that the foci of human habitation were stable at least during the final stage of the occupation.

Although neither signs of seasonal occupation nor fishing implements were found during this preliminary survey, the excavators believe that the settlement was a village of fishermen. This is indicated not only by the large proportions and vertical development of the shellmidden but also by its toolkit and the presence of unprocessed pebbles, whose rounded edges and epifaunal remains convey the impression of having been repeatedly placed underwater (Amirkhanov *et al.*, 2001).

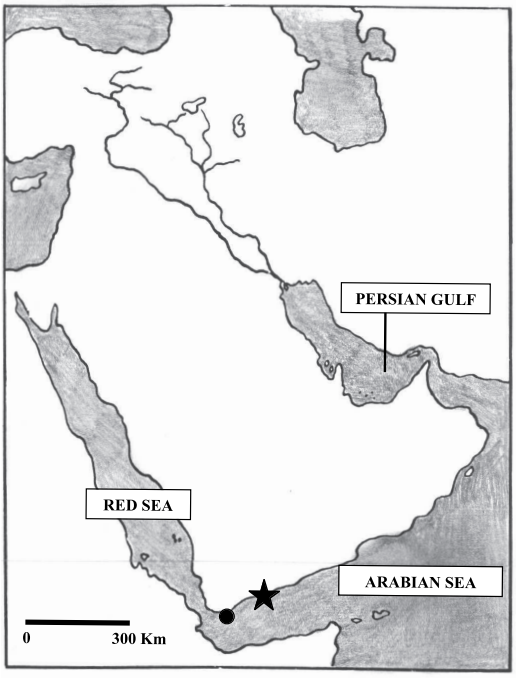

FIGURE 1

Location of Gihayu within the Arabian Peninsula (black dot; black star indicates the location of the city of Aden.

Despite the incipient stage of the research both the early date and the faunal richness of Gihayu merit some further comments also since this is one of the first archaeozoological studies in the area of SW Arabia (Uerpmann, 1989; Desse, 1995).

MATERIAL AND METHODS

During the reconnaissance survey a preliminary excavation was undertaken in order to testify the importance of what appeared to be a very old assemblage. A 48 m long x 3 m wide probe trench that run from the top to the bottom of the tell was excavated. The excavation revealed a well-stratified sequence of 21 habitation levels that we will identify from here onwards by an "L" followed by its corresponding number. Although no pottery or bone implements were found (no sieving of the sandy horizons was carried out), the technical and lithological features of the site reveal a Neolithic

chronology but these features are different from those found at coeval sites attributed to the desert Neolithic in the inland regions of Arabia of whom Gihayu represents an independent, and still undescribed, variant (Amirkhanov *et al.*, 2001). These stone implements included vessels, grindstones, pestles, scrapers and points as the most frequent categories.

Three non calibrated ^{14}C dates taken on shell samples [(çèi-11394: 4780 ± 80 (Level 1); çèi-11392: 5490 ± 90 (Level 14?); çèi-11393: 4430 ± 110 (Level 21?)] indicate that, broadly speaking, the timespan covered is of roughly one millennium (i.e., late 5th to late 4th mill BC)(Amirkhanov *et al.*, 2001 and verbal communication). The data at hand do not allow one to decide whether this occupation was permanent throughout this time period or intermittent.

Close to 1000 Kg of faunal remains were retrieved in the probe trench. Although not sieved, this retrieval included parts of the matrix and along with it remains of very small size. Only 18 of the 21 cultural horizons included faunal remains (Table 1). Their study followed two different procedures (Morales & Roselló, 2003a):

1. Vertebrates were analyzed according to conventional protocols in terms of NISP and MNI estimation, measuring, weighting and recording of surface features (Grayson 1984; Roselló, 1989). Their estimated weight errors are of ± 0.05 g. Incomplete comparative collections forced many of the identifications to remain at a tentative level (Table 2).
2. For molluscs, weights of cleaned shells were used for the quantification (the intensive fragmentation of most of the identified specimens rendered fragment counts meaningless) (Moreno, 1994). The estimated error for weights is of ± 50g. This was also the reason for not weighting the marginal taxa (Table 3).

Size estimations have been carried out through direct comparison with the reference specimens. Biological inferences are based on published data (Ross & Barwani, 1982; Collette & Nauen, 1983; Quero, 1984; Bianchi, 1985; Sheppard, 1985; Crossland *et al.*, 1987; Ernst & Barboar, 1989; Gross, 1989; Kingdon, 1990; Harrison & Bates, 1991; Sheppard & Sheppard, 1991; Sheppard *et*

PARAMETER	L1	L2	L3	L4	L5	L6	L7	L8	L10	L11	L13	L14	L15	L16	L17	L18	L20	L21	TOTAL
Molluscs (weight)	143	6	19	26	23	20.5	34	138	103	7.8	19	92	33	102	71	31	63	16.5	947.8
Molluscs (% of total weight)	15	0.6	2	2.7	2.4	2.1	3.5	14.5	10.8	0.8	2	9.7	3.5	10.8	7.5	3.4	6.6	1.7	100%
Ch. townsendi (Kg)	120	4	15	22	18.5	14	20	100	89	4	14	70	25	90	63	30	55	15	768.5
Ch. townsendi (% weight of level)	83.9	66.6	79	84.6	80.4	68.2	58.8	72.5	86.4	51.2	73.7	76	75.7	88.2	88.7	96.7	87.3	91	Average (81%)
Frequent molluscs (combined weight)	22.2	1	3.55	3.45	4.6	6	12.3	34.1	12.4	3.2	4.7	19.8	8	11.8	7	0.9	7.5	1.35	164.1
Frequent molluscs (%weight of level)	15.6	16.6	18.4	13.2	18.7	29.2	36.1	24.7	12	41	24.7	21.5	24.2	11.5	9.8	2.9	12	2.4	Average (17%)
Molluscs (number of species)	42	12	21	20	28	19	22	23	20	9	13	24	16	28	16	13	14	8	59
Molluscs (main species)	7	6	5	7	7	5	7	7	7	6	6	7	6	7	7	5	7	4	7
Molluscs (marginal taxa)	35	6	16	13	21	14	15	16	13	3	7	17	10	21	9	8	7	4	52
Vertebrates (NISP)	6	35	12	23	-	4	-	7	4	-	2	6	9	8	2	-	-	-	118
Vertebrates (Taxa)	3	3	5	8	-	3	-	3	3	-	2	3	6	6	2	-	-	-	14
Vertebrates (weight)	.04	.01	.01	.05	-	+	-	.07	.01	-	.02	.07	.1	.06	.08	-	-	-	.47
Fishes (NISP)	1	6	11	20	-	4	-	4	3	-	1	3	4	6	1	-	-	-	64
Fishes (Taxa)	1	2	4	6	-	3	-	1	2	-	1	1	4	4	1	-	-	-	9

TABLE 1

Gihayu: Overall view of the animal assemblages (Weights expressed in kilograms to the nearest 0.05 Kg).

TAXON	L1	L2	L3	L4	L6	L8	L10	L13	L14	L15	L16	L17	TOTAL
Epinephelus cf. bleekeri	-	-	-	-	-	-	1	-	-	-	-	-	1 (0.8%)
Carangoides cf. fulvoguttatus	-	-	-	1	-	-	-	-	-	-	-	-	1 (0.8%)
Caranx cf. heberi	-	-	-	2	-	-	-	1	-	1	1	1	6 (5%)
Caranx cf. melampygus	-	-	-	4	-	-	-	-	-	-	-	-	4 (3.4%)
Caranx sp.	1	2	2	7	1	-	-	-	3	1	2	-	21 (17.8%)
Caranx/Carangoides	-	-	-	-	1	-	-	-	-	-	-	-	1 (0.8%)
CARANGIDAE	-	-	2	2	-	-	-	-	-	1	2	-	5 (4.2%)
Euthynnus affinis	-	-	3	-	-	4	2	-	-	1	1	-	14 (11.8%)
SCOMBRIDAE	-	4	4	3	2	-	-	-	-	-	-	-	10 (8.5%)
Pisces indet.	-	-	-	1	-	-	-	-	-	-	-	-	1 (0.8%)
CHELONIIDAE	2	-	1	1	-	1	1	-	2	-	1	1	10 (8.5%)
Phalacrocorax nigrogularis	1	-	-	-	-	-	-	-	-	-	-	-	1 (0.8%)
Capra hircus	-	-	-	-	-	1	-	-	-	-	-	-	1 (0.8%)
Ovis aries/Capra hircus	-	29	-	-	-	-	-	-	-	1	-	-	30 (25.5%)
Gazella cf. gazella	2	-	-	-	-	1	-	-	1	1	1	-	6 (4.8%)
Cetacea indet.	-	-	-	-	-	-	-	1	-	3	-	-	4 (3.4%)
Unidentified	-	-	-	2	-	-	-	-	-	-	-	-	2 (1.6%)
TOTAL	6	35	12	23	4	7	4	2	6	9	8	2	118
%	5	29.6	10.1	19.5	3.4	6	3.4	1.7	5	7.6	6.7	1.7	100%

TABLE 2
Gihayu: NISP distribution of the vertebrate taxa according to level.

al., 1992; Dipper & Woodward, 1993; Baldwin, 1995; Coles, 1995; Hill, 1995/1996; Randall, 1995; Vine & Al Abed, 1996; Debelius, 1998).

RESULTS

As can be seen from Table 1 the large majority of the faunal remains at Gihayu are molluscs, vertebrates representing a mere 0.05% by weight. On account of the less intensive mineralization and higher water content of bone such differences indicate a combination of destructive agents that presumably included intensive weathering along with a low rate of sedimentation. The latter appears to be in accordance with the length of the occupation indicated by the radiocarbon dates but does not quite agree with what has been postulated by the excavators. According to them, the accumulation process at Gihayu was rapid due to: "*….the small surface area, the large mass of stone manuport, the abundance of kitchen waste (shells), and heavy winds that have blown much coastal sand into the site"* (Amirkhanov *et al.*, 2001: 11). Rapid accumulation could specifically be taken to refer to the speed of the sedimentation process during each of the occupation episodes with independence of the overall length of the occupation but this does not seem to be what the excavators think either (see below). In connection with such differential preservation, it should be mentioned that a large fraction of the bones (42%; up to 60% in the case of the fish samples) where burned or charred. Such a phenomenon undoubtedly contributed to diminish the preservation chances of vertebrate remains in the sediments.

Although differences among the horizons are important in terms of bulk of the faunal remains (i.e., from 8 Kg (L11) - 143 Kg (L1)) and may be taken to reflect varying intensities of deposition through time, there does not seem to exist any

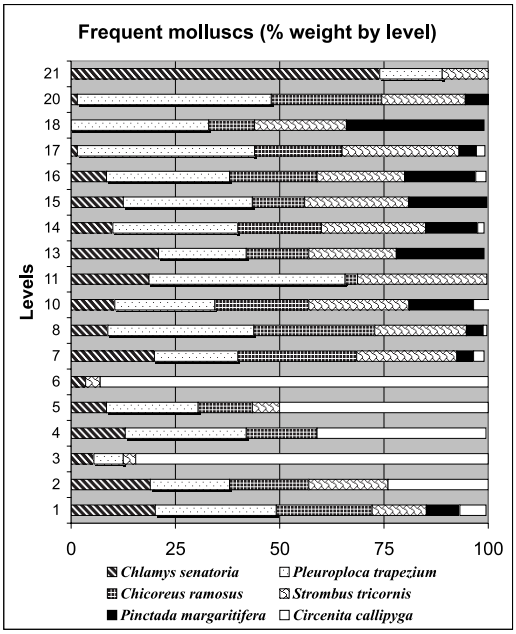

FIGURE 2

Frequencies, expressed as percentage weight (in kilograms) per level, of the frequent molluscs from Gihayu (CS= *Chlamys senatoria*; PT= *Pleuroploca trapezium*; CR= *Chicoreus ramosus*; ST= *Strombus tricornis*; PM= *Pinctada margaritifera*; CC= *Circenita callipyga*).

clear trend in terms of taxonomic shifts within the sequence, species apparently fluctuating through the various levels (Table 1; Figure 2). Such a phenomenon is coincident with the archaeological data that spot no appreciable differences in terms of typology, technology and raw materials through time. Such homogeneity was, in fact, taken as yet another indication that the accumulation process was rapid (Amirkhanov *et al.*, 2001: 6). From our standpoint, however, the homogeneity merely conveys the impression that the economy remained stable through time. Whether the time lapse was short or long or whether such stasis implies satisfactory living conditions and/or minimal stress on the surrounding ecosystems are questions that will require further data in order to be verified.

The molluscs have been arbitrarily divided into four categories:

a) *Dominant* species, found in all of the horizons, where they constitute a significant fraction of the total weight.

b) *Frequent* species, found in all or most of the horizons, were they constitute an appreciable but not really significant fraction of the total weight (Table 1; Figure 2).

c) *Secondary* species (Table 3), were one could still distinguish between

c.1: those of rather regular distribution throughout the sequence (i.e., at least recorded in half of the horizons) and

c.2: truly *Marginal* species found in less than half of the horizons.

Only the scallop *Chlamys townsendi* qualifies in the first category. With an average of 81% of the total weight, this species inhabits the lower shore where it lives either among rocks or attached to them (Bosch *et al.*, 1995).

Of the frequent species the murex, *Chicoreus ramosus*, the scallop *Chlamys senatoria* and the Pearl mussel *Pinctada margaritifera* (the main source for mother of pearl in the region), are also rocky shore inhabitants. The former is an intertidal form, the latter two reach down to the lower shore and below. Taken together, the species from rocky environments provided the majority of the weight of molluscs (i.e., some 90%; Table 1).

Sandy habitats are indicated, within these frequent species, by the Tulip shell *Pleuroploca trapezium* (second in importance at Gihayu with 5% of the biomass), the conch *Strombus tricornis* and the venus clam, *Circenita callipyga* (Bosch *et al.*, 1995).

The list of the secondary species with a rather regular distribution is restricted to six taxa, two of which (the thorny shell, *Spondylus marisrubri,* and the ark shell, *Barbatia obliquata*) live attached to rocks. The remaining species, all bivalves, represent a mixture of bottoms that include clean sand (*Tivela ponderosa & Acanthocardia pseudolima*) and mixed sediments (*Acrosterigma assimile & Glycymeris pectunculus*) ranging from the intertidal to offshore waters (Bosch *et al.*, 1995). The possibility always exists that a minority of these shells were washed ashore after death.

The fact that most of the relevant species are rather large (*P. trapezium* recorded at 30 cm and the main scallop plus the Pearl mussel reaching to 20 cm), still consumed in the area and some even subjected to commercial exploitation to this day (i.e., the Pearl mussel and Venus clams), constitute additional lines of evidence corroborating the meal refuse nature of the mollusc assemblages at Gihayu.

The truly marginal molluscs incorporate 46 species whose environmental requirements reinforce the spectra evidenced by the dominant and secon-

TAXON	LEVEL (NISP)
Arca ventricosa	1 (3), 3 (2)
Arca avellana	16 (1)
Barbatia obliquata	1 (40), 2 (3), 3 (8), 4 (2), 5(23), 6 (4), 7 (10), 8 (10), 10 (13), 14 (3), 15 (2), 16 (8), 18 (1), 20 (2)
Barbatia setigera	1 (2)
Barbatia foliata	8 (1), 14 (1)
Anadara sp. erythraeonensis	1 (2), 5 (1), 8 (1), 10 (2), 16 (1)
Anadara uropigimelana	1 (77), 4 (1), 5 (1), 15 (1), 16 (2)
Anadara ehrenbergi	1 (72), 5 (1), 6 (1), 7 (1), 10 (3), 15 (2), 16 (1)
Scapharca inflata	1 (2), 3 (1), 6 81) 8 (5), 13 (2), 14 (2), 15 (1), 16 (1), 18 (2), 20 (3), 21 (2)
Sheldonella lateralis	1 (1)
Cucculaea labiata	8(1)
Glycymeris pectunculus	1 (55), 2 (2), 3 (3), 4 (10), 5 (8), 6 (2), 7 (.2 kg), 8 (.2 kg), 10 (4), 13 (2), 14 (5), 15 (1), 16 (6), 20 (2)
Perna picta	1 (8), 2 (2), 3 (10), 4 (3), 5 (15), 6 (5), 15 (8)
Pinna sp.	14 (1)
Pinctada radiata	1 (45), 5 (+), 6 (1)
Malleus albus	10 (+), 13 (1)
Lopha cristagallii	1 (6), 5 (1), 8 (1kg), 11 (1), 17 (1)
Saccostrea cucullata	1 (2), 2 (1), 3 (3), 4 (2), 5 (20), 7 (4), 14 (5), 16 (10), 17 (10)
Ostrea sp.	1 (3), 3 (1), 5 (2), 16 (1)
Plicatula australis	10 (1)
Decatopecten plica	10 (1)
Spondylus marisrubri	1 (83), 4 (1), 5 (3), 6 (1), 7 (70), 8 (80), 10 (10), 11 (2), 13 (5), 14 (7), 15 (5), 16 (7), 17 (3), 18 (2), 20 (1), 21 (3)
Spondylus sp.	4 (1)
Megacardita bicolor	1 (1), 4 (2), 5 (3), 8 (3)
Chama brassica	1 (30), 3 (1), 7 (6), 8 (6), 13 (3), 15 (2), 18 (2)
Chama reflexa	18 (1)
Acrosterigma assimile	1 (48), 3 (4), 4 (4), 5 (13), 7 (7), 8 (50), 10 (10), 13 (6), 14 (7), 15 (12), 20 (2)
Acanthocardia pseudolima	1 (81), 4 (1), 5 (3), 6 (3), 7 (3), 8 (5), 10 (3), 14 (10), 16 (8), 17 (4), 20 (4), 21 (1)
Asaphis violascens	1 (60), 2 (10), 3 (10), 4 (10), 5 (10), 6 (14), 7 (20), 8 (62), 16 (10)
Circe rugifera	5 (1), 14 (1)
Tivela ponderosa	1 (86), 2 (4), 3 (3), 4 (11), 5 (8), 6 (95), 7 (.2kg), 8 (85), 10 (90), 14 (10) 15 (2), 16 (8), 17 (5), 20 (5), 21 (1)
Callista erycina	1 (2), 16 (1)
Sunetta effossa	1 (1)
Protapes sinuosa	8 (1), 16 (1)
Tapes sulcarius	1 (1), 3(1), 16 (3)
Tectus dentatus	16 (1), 17 (1)
Trochus erythreus	1 (4), 3(2), 16 (3)
Lunella coronata	1 (10), 3 (14), 4 (3), 6 (4), 7 (1), 10 (4), 14 (3), 15 (1)
Nerita albicilla	1 (2), 3 (1), 5 (1)
Tonna dolium	16 (1)
Turritella maculata	1 (2)
Strombus gibberulus	1 (2), 5 (2)
Cypraea grayana	1 (1), 7 (1), 11 (1), 14 (1)
Cypraea turdus	1 (3), 5 (2) 7 (2), 14 (3), 18 (1)
Cypraea sp.	17 (1), 18 (1)
Thais savignyi	6 (1)
Rapana rapiformis	8 (3), 14 (1)
Babylonia spirata	1 (1), 17 (1)
Volema paradisiaca	6 (1), 7 (1)
Oliva bulbosa	1 (4), 5 (1), 6 (1), 7 (2), 10 (2), 14 (1), 18 (1)
Conus betulinus	13 (1), 14 (2), 16 (5), 17 (1)
Conus sp.	1 (2)

TABLE 3

NISP(number of remains) through levels for the molluscan taxa of secondary importance.

dary taxa though occasionally incorporating additional habitats such as mangroves (*Anadara*) (Table 3). Overall, the assemblages appear consistent with an exploitation of molluscs being carried out on the open shore rather than in putative lagoons or mangroves at the mouth of the Wadi Markha. In fact, since Gihayu was in operation during one of the Holocene transgressions when the sea level was 2-2.5 m above the present-day one, it is even possible that the lagoon we see today was nonexistent.

The vertebrate samples from Gihayu constitute a very small though highly diversified lot dominated by marine taxa (Table 2). Although the terrestrial mammals constitute a full 25% of the NISP and close to 40% of the vertebrate weight, one gets the impression that their importance is overrated on account of two factors:

a) 29 of the 35 identified remains come from a couple of caprine fawns (2-6 months old) retrieved from L2.
b) 120 g (60% of the total) correspond to three horncores from adult Mountain gazelle males whose presence may have little to do with meat procurement as such (manufacture refuse?) (Morales & Roselló, 2003a, 2003b).

Several remains from caprines could be identified though only one down to species level. The goat mandible from L8 exhibited a tooth wear stage of the M_1 of 15A (Payne)/m (Grant) the corresponding values for the M_2 being of 10A/h. The estimated age for this animal would be of at least six years, thus an adult past its prime age. A third caprine find (a mandible's articular process from L15),although undoubtedly from a subadult/adult in terms of size, could neither be aged nor identified down to species. Though infrequent, domestic caprines appear to have been present throughout the sequence.

Fishes are the only regular item found in the 12 horizons featuring vertebrates with marine turtles coming in a close second position (Table 2). These fishes represent pelagic taxa for the most part although the presence of a grouper indicates that demersal species were taken occasionally. The fishery –if one is allowed to use such a term- was apparently of a specialized type focusing on scombrids (tunas) and carangids (jacks or trevallies) but it should be stressed that these are non-sieved samples that systematically bias data in favour of larger fishes. It remains to be seen whether such conclusion still holds once sieved samples become available.

All the fishes retrieved at this point are of fairly large size, their overall means peaking above 80 cm of standard length (SL). In the case of the scombrids, the majority of the remains belong to the Kawakawa (*Euthynnus affinis*) a middle-sized tunny that reaches slightly above 1mSL (Collette & Nauen, 1983). At Gihayu, except for a 50 cm specimen (L3), all Kawakawas (9 bones) clustered at 75-80 cm, a size that is nowadays reached on the seventh year of life for the vicariant *E. alleteratus* (Quero, 1984). Such feature, together with the scattering of Kawakawa remains throughout the sequence might be taken to indicate that the scombrid fishery not only targeted on a single species but on a single cohort as well (Table 2; Morales & Roselló, 2003a, 2003b). By way of contrast, the carangids deriving from no less than three species, range from 60 to +100 cm SL with no clustering at any particular size. One of the vertebrae retrieved in L3 derives from a far larger scombrid (probably from the genus *Thunnus* although it was much too damaged for a positive identification even at that level) whose SL has been estimated at 135-150 cm (Morales & Roselló, 2003a, 2003b).

Most of the turtle bones, like those of fishes, were burned. These included a basioccipital, a caudal vertebra, one pelvis, a radius, 3 metapodials and 3 phalanges indicating that probably complete specimens were taken into the site. All bones appear to derive from adult animals –some of them of exceptional size– although no specific size determination could be accomplished.

The paucity of both cormorant and cetacean remains suggests that they were only occasionally captured. In the case of the cetaceans the sizes of the vertebrae indicate the presence of middle-sized animals (i.e., large dolphins or small whales) something that may also apply to the unidentified splinters from L4, the most diversified horizon in terms of vertebrates (Table 2). None of the cetacean remains were burned.

The almost total absence of unidentified bones most probably relates to the kind of retrieval carried out (Table 2).

DISCUSSION

The relevance of Gihayu's faunal samples requires a referential framework that in this case is provided by the shell middens of Oman a detailed review of which has been recently published by Uerpmann & Uerpmann (2003).

From the standpoint of human nutrition, both the lack of isotopic analysis and the absence of plant remains restrict any evaluation to an assessment of the contributions played by the different animal groups, a task by no means straightforward. Obviously, plants must had played some as yet unspecified although undoubtedly critical role since they were the only source of fiber and one of the few available ones of carbohydrates. The evidence of their consumption is unluckily circumstantial at this moment and restricted to the retrieval of boat-shaped grinders -referred to as querns or milling stones- that, together with a series of mortars, testify to the processing of seeds and fruits at the site.

As stated, the animal samples are biased due to taphonomic agents but are also difficult to interpret from a dietary standpoint due to shifting relationships between skeletal weights and meat yields for the various groups. Despite the huge volume that molluscs represent, some brief calculations evidence that their contribution to the diet was far less relevant than that suggested by their weight values.

In this way, if the meat yield to shell weight ratio for molluscs can be roughly taken to be one of 1:9 (Moreno, 1994), the 950 Kg of shells taken from the probe trench would represent a mere 90 Kg of edible tissue. This would be the equivalent meat yield of 2-3 goats or one of the small-sized dolphins (e.g., *Stenella* or *Delphinus*) (Baldwin, 1995). On the other end of the spectrum one has to consider the "invisible" contributions of domesticates, one goat producing at least three times its own weight in milk in 4-5 reproductive years (Uerpmann & Uerpmann, 2003). These estimation biases render futile any quantitatively reliable inferences on the role played by the various taxa but do not refrain us from postulating that vertebrates were possibly the main elements of the diet at Gihayu and within them, marine taxa –mostly fishes but perhaps also turtles (with a potential "invisible" component themselves in terms of eggs) –far outweighed the contributions of the terrestrial faunas at all times.

The people at Gihayu have been described as fishermen on account of a toolkit that, in the opinion of the excavators, is typical of fishermen and mollusc gatherer settlements (Amirkhanov *et al.*, 2001)[1]. No fishing tackle has been thus far detected and although the pearl mussel, the main source of mother-of-pearl hooks, is one of the important species throughout the sequence (Figure 1) the elements that come closest to being fishing implements are the numerous pebbles with epibionts (i.e., sessile marine animals) attached to their surface. These stones resemble neither the basic net sinkers (N-type) nor the small pebble sinkers with pecked or sawn-in waistline found in the 5th -4th millennium BC shell middens from Oman (Uerpmann & Uerpmann, 2001, 2003). However, both their frequency in the various levels and the fact that the beach never included shingle conveys the impression that these must have been repeatedly submerged over prolonged periods of time. If so, these pebbles would constitute the simplest type of sinkers thus far found in the shores of the Arabian Sea reinforcing the notion of an independent cultural tradition postulated on account of the stone artifacts (Amirkhanov *et al.*, 2001: 11).

Within the framework of the "coastal adaptation theory", it appears that Gihayu represents yet another case of a specialized fishing focusing on tunas and jacks that developed during the Late Stone Age along the southern shores of the Arabian peninsula (Durante & Tosi, 1980; Biagi *et al.*,1984; Uerpmann, 1989; Cartwright, 1994; Desse, 1995; Uerpmann & Uerpmann, 2003). Even though such a statement will require verification once sieved samples become available, the focusing on these two groups of fishes could be taken to indicate that people were not in need of exploiting additional fish species, an inference that, as previously postulated, would mean that fishing conditions were satisfactory throughout the period of occupation.

If conditions at that time were similar to those found today in the area one may assume that fishing concentrated when the density of sardine shoals and of their predators was at its highest. This would correspond to the period from December-April that some authors extend up till the beginning of July (Desse & Desse-Berset, 2000; Uerpmann & Uerpmann, 2003; Beech, 2004). In contrast, the culling of the 2-6 months old caprines from L2 probably took place during the summer assuming that the animals were born in late winter or early spring. Both facts taken together indicate the existence of shifts in the procurement strategies during the year.

The presence of the domestic ungulates constituted a stabilizing factor for the foraging strategy of these people. As Uerpmann & Uerpmann so

[1] This toolkit incorporates hammerstones, grinders of various kinds and pebbles with small depressions on the flat surfaces.

aptly stress, domesticates functioned as *"... some sort of insurance against the normal (but not exactly foreseeable) failures of their efforts at sea*" (Uerpmann & Uerpmann, 2003: 249).

Other seasonality indicators are not so evident. Thus, the main nesting season for turtles in the Arabian Sea lasts from summer to the end of the year with a secondary peak in the spring (Ross & Barwani, 1982; Vine & Al-Abed, 1996) and although the specimens at Gihayu are adults it is impossible to decide whether they were captured at sea or while in their nesting grounds. Likewise, the presumable collecting of plants would have taken place in the winter/early spring but is otherwise impossible to prove with the data at hand. Shellfish collecting, hunting and the capture of cetaceans –including that of stranded animals– could have taken place at any time of the year. The same can be said of the culling of adult domesticates. Taken together these activities reinforce the existence of a cycle in the exploitation of living resources that spanned throughout the year characterising a permanent settlement such as those found in the NE corner of the South Arabian coast (Durante & Tosi, 1980; Biagi *et al.* 1984; Bökönyi, 1998; Uerpmann & Uerpmann, 2001, 2003).

The existence of a sedentary population could be further vindicated on account of two additional lines of evidence:

1. The composition of the lithic inventory, that indicates that the entire manufacturing cycle took place *in situ* (Amirkhanov *et al.*, 2001: 8).

2. The fishing practiced at Gihayu, that no doubt required a high investment in bulky and vulnerable technology that must have been difficult to transport.

This is not to say that the whole of the population stayed at the site during the whole year. In fact, the gathering of vegetables and any nomadism that one may postulate for the managing of the domestic flocks must have been partly coincident with the presumed peak in the fishing activity thus should have been carried out by a different sector of the population stationed at Gihayu.

From the paleoenvironmental standpoint Gihayu's occupation is roughly coincident with an arid phase that after 4200BC witnessed the end of the monsoon rains in NE Oman and lasted until 3500BC (Neff *et al.*, 2001). Previous to it, the populations of mobile herders and fishers of the 5th millennium BC in NE Oman had been characterized by a long-distance transhumance to the hinterland that was replaced by a short-circuit version –"*wadi-transhumance*" paraphrasing Uerpmann & Uerpmann (2003)– during the arid first half of the 4th millennium BC.

	Carangidae		*Scombridae*		TOTAL
SITE	**NISP**	**%**	**NISP**	**%**	
Gihayu	38	60	24 (14)	38 (22)	98.5%
RH 4	30	2.3	59 (54)	4.6 (4.2)	4.5%
RH 5	4065	31.5	7596 (6060)	59.7 (47)	91.2%
RH 6	22	38	23 (4)	39.6 (6.8)	77.6%
RH 10	77	26	205 (178)	69.5 (60)	95.5%
KM 1	262	16.4	1048 (23)	65.8 (1.4)	82.2%

TABLE 4

Comparison of the number of remains and their frequencies for the two major groups of fishes for sites lying along the southern coast of Arabia. The numbers in parentheses for scombrids refer to the values of the Kawakawa, *Euthynnus affinis*. Except for Gihayu, all sites are in Oman (RH= Ra's al-Hamra; KM= Khor Milkh). At RH 4, if the clupeids were to be removed, the frequencies of the carangids (30%) and the scombrids (59%) would not deviate from those of the remaining Omani sites with the exception of Khor Milkh (Data taken from Uerpmann & Uerpmann, 2003).

Although there seems to exist a short *hiatus* in the occupations at the very end of the 5th millennium in NE Oman, the later shell-midden people apparently belong to the same cultural tradition as their economies not only maintain but actually strengthen the specialized fishery for tunas and jacks that contrasts with the opportunistic fishing documented throughout the Persian Gulf (Flavin & Sheperd, 1994; Van Neer & Gautier, 1994; Van Neer & Uerpmann, 1994; Desse, 1995; Driesch, 1998; Desse & Desse- Berset, 1999, 2000; Beech, 2000, 2004; Driesch & Manhart, 2000). Along with a marginal hunting activity, these 4th millennium foragers kept the pecked or sawn-in waistline pebble sinkers but lost a series of traditions from the previous period. These included both fishing technology (e.g., N-type sinkers) as well as certain subsistence practices (i.e., dog consumption) that disappear when new practices set in (e.g., turtle consumption, certain formal changes in the mother-of-pearl hooks, etc.; Mosseri-Marlio, 2000). Uerpmann & Uerpmann (2003) believe that during this arid phase, the exploitation of domesticates no longer determined the seasonal cycle and this may explain the presence at Gihayu of different cohorts of capri-

nes. In addition, the aridity determined a more patchy distribution of favorable environments isolating human groups to a far larger extent than had been the case during the previous 5th millennium BC. Such phenomenon probably contributed to the development of cultural isolation and local traditions.

Most of the faunal features predicted by this model are recorded at Gihayu. Thus, the absence of evidence for dog consumption and the importance of the marine resources, along with the regular presence of turtles and minimal importance of hunting appear coincident with the subsistence strategy documented for this arid stage. More inconclusive are the data for the substitution of the long-distance transhumance by a short distance one although, as stated previously, the presence of both infantile and old adult caprines could be taken as evidence for the latter. Finally, various regional specializations at the archaeological level have been invoked as evidence for the –as yet undescribed– independent cultural tradition (Amirkhanov *et al.*, 2001). It remains to be seen whether Gihayu's putative net sinkers do in fact represent one such case in point.

The differences recorded between Gihayu and the sites in Oman are second-order issues having more to do with the taxonomic composition of the samples. In this way, the preferentially lagoon/mangrove taxa that dominate the mollusc assemblages at places such as Saruq, Ra's al-Hamra 5 and Wadi Wutayya are replaced at Gihayu by open water species such as the scallops (Table 1; Figure 1) that, to a large extent, reflect availability of certain biotopes rather than culturally-determined biases.

On the other hand, features such as the dominance of scombrids at the Omani sites are apparently reversed in favor of the carangids at Gihayu and are not so straightforward to explain. While one should expect sound environmental reasons for this being so one wonders to what an extent cultural reasons may also be involved. Uerpmann & Uerpmann, for example, speculated that the higher frequencies of scombrids at the site of Khor Milkh could simply reflect their higher availability as infered from a sandy shore that would create a less varied mosaic of habitats than would be the case for the rocky shores along the Ra's al-Hamra shell middens (2003: 193). Reasoning along such lines one would expect Gihayu to evidence the same pattern when, in fact, apparently the opposite occurs. In order to explore the question further, the specific compositions, in terms of taxa and size distribution, need to be taken into account.

Once this is done, three additional features appear:

1) At Khor Milkh, the youngest of the sites under consideration, the scombrids are basically constituted by the larger fishes of the genus *Thunnus* (true tunas). The Kawakawa only dominates the scombrid assemblages during the 4th millennium [in the 5th millennium site of Ra's al-Hamra 6, despite low sample size, there seems to exist a 1:1:1 ratio for the genera *Euthynnus*, *Thunnus* and *Katsuwonus* (skipjack tunas) (Uerpmann & Uerpmann, 2003: 192)].

2) Whereas at Gihayu almost all of the Kawakawas exhibit a very similar size, in all of the remaining instances (including the carangids from Gihayu) sizes are more normally distributed with peaks at around 75 cm SL (Scombridae) and 55 cm SL (Carangidae) but ranges in excess of 40cm. (Uerpmann & Uerpmann, 2003; Morales & Roselló, 2003a, 2003b).

3) At Gihayu none of the carangids whose size could be estimated coincide with the 75-80 cm SL values given for the Kawakawa.

Since *Euthynnus affinis*, like so many other scombrids, tends to form multispecies schools by size such "de-coupling" between its size and those of the jacks at Gihayu could be taken to indicate that the fishing of these two groups did not occur simultaneously. Also, since jacks, on the whole, tend to be less migratory than the scombrids, could their higher frequencies at Gihayu mean that its fishery was not as seasonal as those from the Omani sites? This question, as well as those putative taxonomic shifts taking place in the "scombrid fishery" from the 5th to the 3rd millennium BC will require a study that is well beyond the scope of the present contribution.

CONCLUSIONS

Although in its details the subsistence strategy at Gihayu is far from complete the overall picture emerging from the analyses of its fauna seems to be consistent with a wealth of other data both zoological and archaeological that encompass this site as well as those from NE Oman.

Thus, it seems clear that the animal exploitation focused at all times on the marine sector and that

the dominant feature of such exploitation consisted of a presumably highly specialized and seasonal fishery with side catches that included cetaceans, turtles or even birds. All these groups might represent – at least partially- alternative exploitation strategies practiced at other times (e.g., stranded animals, catches during the nesting period of turtles, etc.) that the data at hand are unable to determine. In all of its essentials, this exploitation of marine resources substantiates most of the patterns thus far detected in the area of NE Oman during the fourth millennium including the secondary role played by the harvesting of molluscs. It remains to be seen whether some of the differences between the SE and NE sectors of the Arabian Sea shores –in particular the taxonomic composition of the assemblages- are simply a reflection of environmental constraints or have more to do with culture and conscious decisions.

The contributions of the terrestrial faunas are more difficult to interpret because at this stage it remains unclear the role played by the domestic stocks in Gihayu. Their existence testifies to an activity that was not mentioned in the list of subsistence strategies at this site (Amirnakhov et al, 2001: 11) and enlarges the scope and complexity of its economy. The presence of domestic goats, for example, implies that of a nutritional component (fat, in case milk was exploited) that represents another crucial dietary item if energy was to be gained from what one could otherwise label an *over-proteinaceous* diet. In addition, the buffering effect that domesticates undoubtedly represented lends support to the claims of sedentary conditions that the excavators have postulated on account of the archaeological data notwithstanding that some of these domesticates were subjected to seasonal movements of an -as yet- undefined nature.

The local peculiarities that both the stone inventory and the faunas of Gihayu display reflect, to a certain extent, the regime of intense aridity that from the end of the 5th millennium and into the middle of the 4th millennium BC isolated populations along the southern shores of the Arabian peninsula and facilitated the development of cultural variants to an extent not seen previously. It is hoped that the confirmation of these patterns will not only help us define the rationale behind these shellmidden economies in all their details but also the causes for their demise at the end of the 4th millennium BC.

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