Late 17th century AD faunal remains from the Dutch 'Fort Frederik Hendrik' at Mauritius (Indian Ocean)

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ABSTRACT: The fauna is described from a refuse layer, excavated at Fort Frederik Hendrik on the island of Mauritius and dating to the last quarter of the 17th century AD. The animal remains enable the reconstruction of the food procurement strategies of the Dutch inhabitants of the fort and document the fauna at a time when the island's original fauna had apparently already suffered heavily from human interference and from the negative impact of introduced species. The animal remains do not include any bones from the dodo, or other endemic birds, and neither is there evidence for the exploitation of the large, endemic terrestrial tortoises, also now extinct. Dugong, which are locally extinct nowadays, and marine turtles were also exploited as food, but the major meat providers were the introduced mammals: cattle, pigs, and especially, goat and Java deer. Fish was also a regular food resource and must have been caught in the local lagoon and estuaries. The absence of parrotfish and the relatively small size of the groupers suggest avoidance of these food items, probably out of fear of fish poisoning.

KEYWORDS: INTRODUCTION, EXTINCTION, FAUNAL TRANSLOCATIONS, CIGUATERA

RESUMEN: Se describe la fauna de un basurero, fechado en el último cuarto del siglo XVII, excavado en el fuerte Frederik Hendrik de isla Mauricio. Los restos faunísticos permiten inferir algunas estrategias de obtención de alimento de los colonos holandeses y documentar la fauna de la isla en un momento en el cual la indígena había ya sido duramente castigada por el hombre y las especies animales por él importadas. Los restos no incluyen piezas del dodo ni de otras aves endémicas, así como tampoco evidencias sobre el aprovechamiento de las tortugas terrestres gigantes, que hoy también están extinguidas en la isla. Los principales suministradores de carne parecen haber sido los animales introducidos, tanto domésticos –vacuno, cerdos y, sobre todo, cabras– como silvestres, donde destaca el ciervo de Java. Los peces fueron un alimento recurrente y parecen derivar de pesca local en la laguna y estuarios que circundan al fuerte. La ausencia de peces-loro, así como la talla relativamente pequeña de los meros, apuntan a una evitación de estos peces, quizás por miedo al envenenamiento por ciguatera.

PALABRAS CLAVE: TRANSLOCACIÓN DE FAUNA, INRODUCCIÓN, EXTINCIÓN, CIGUATERA

INTRODUCTION

The island of Mauritius, located in the southwestern Indian Ocean, east of Madagascar and south of the Seychelles, has a relatively short history of human occupation (Moree, 1998). Mauritius was known to Arab traders and to the Portuguese from at least the 13th-16th centuries, but the Dutch were the first to settle here in the 17th century. From early reports it is known that the island, which is volcanic in origin, was originally completely covered with forests, even in its coastal and lowland areas (Cheke & Hume, 2008: 32). The lagoons along most of the coastline were fringed with coral reefs, as today (Figure 1), but the mangrove that was originally present along the east coast has to a large extent disappeared.

Written accounts and palaeontological finds yield a wealth of information on the fauna that was present on the island from the first contacts onwards, when it was still in pristine condition. The effect on the island's ecology of the contact with passing ships and of the first settlements is described in great detail in the recently published monograph by Cheke & Hume (2008). The information that they compiled from historical documents and palaeontological papers will be confronted below with the archaeozoological evidence. Unless mentioned otherwise, the data mentioned on the pristine fauna of the island, on the introduced species, their provenance and their effect on the original fauna, are taken from this monograph. The pristine fauna of Mauritius lacked terrestrial mammals, but there were numerous reptiles and birds. As a result of human interference – mainly a combination of overexploitation, the release of domestic animals and the involuntary introduction of rats– many of those, often endemic, species died out. The most famous of these extinct animals are the dodo (*Raphus cucullatus*) and two giant tortoise species of the genus *Cylindraspis*. The dugong, which originally lived in the lagoons, became locally extinct later on.

The first Dutch contact with the island dates from AD1598, but it was only in 1638 that the Dutch East India Company (Verenigde Oost-Indische Compagnie or VOC) decided to take possession of Mauritius. A bay in the southeastern part of the island, used for anchoring merchants' ships going to and from East India, was chosen as the site for a fort. The first Dutch occupation period ended in 1658, but was resumed later on in 1664. This second occupation period lasted until 1710, after which date the Dutch left the island for good. Later on the French took possession of the island and built, at the same location, a governor's house that was occupied between 1721 and 1806.

At the beginning of the early period, when ships were only stopping for food, water and wood, the human impact was still limited, except near the landing places. Already at that time the most vulnerable taxa of the original fauna were under heavy pressure due to their unsustainable use as a food resource. Written accounts mention, for instance, that dodos and other birds were killed in large numbers to serve as food for the crew of the passing ships, and that giant tortoises were often hauled on board as a live food reserve. In addition there were sometimes mass kills of animals that were not, or only partially, consumed. The human impact became more significant when domestic animals (pigs, goats and cattle) were released, adding to the ship rats that were already present. The presence of feral pigs and rats on the island had an especially dramatic effect on the survival of the ground nesting birds and the tortoises by predating on their eggs. After the small fort and settlement were established in 1638, the human impact became even more severe. Food needed to be produced for the provisioning of the ships that passed and for the subsistence of the Dutch colonists. The major activities of the Dutch on the island were exploitation of the forests for ebony and collecting ambergris on the beaches, both meant for export. Besides the intensive ebony cutting, there was also the effect of clearance for agriculture, and the permanent presence of a few hundred people on the island who needed to obtain their food through the keeping of livestock, arable farming, extensive hunting and fishing. The inhabitants of the island consisted of the people living in the fort itself, i.e. commanders and their family, and soldiers. Besides these there were planters and people employed in wood cutting living near the fort. Escaped slaves and convicts sheltered in the interior of the island and sometimes raided the fort (Moree, 1998).

During the second Dutch settlement period (1664-1710), which is the focus of this paper, passing ships no longer needed to be revictualled with supplies from the island. Dutch ships would only rarely stop by after the base at Cape of Good Hope was established in 1652. The ebony cutting was resumed, however, this time without restrictions. The faunal remains dealt with in this paper are

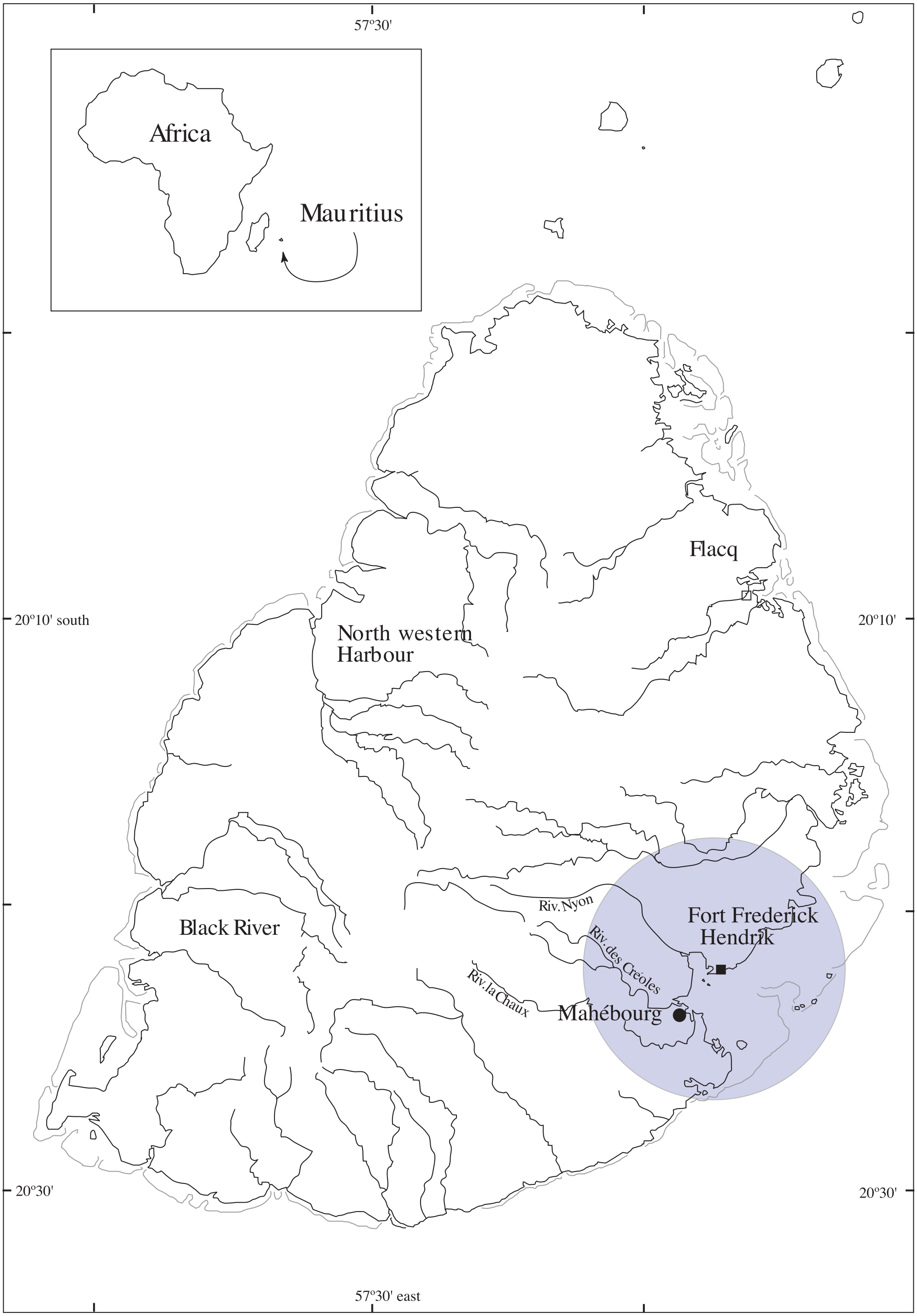

FIGURE 1
The island of Mauritius with indication of the location of the Dutch fort, the main rivers, and some important geographical landmarks. The grey lines along the island indicate the fringing reefs.

from the last quarter of the 17th century, i.e. the second occupation period, and represent the first detailed archaeozoological data for Mauritius. Although an archaeological survey has been carried out on the island (Chowdhury, 2003), there is as yet no other archaeozoological information available, with the exception of the dodo bones described from two cave shelters in the south west part of the island (Janoo, 2005). This material is believed to represent food remains of fugitive slaves that took refuge in these high perched shelters. Faunal remains pre-dating the human occupation are more numerous and have also received more attention in the scientific literature. The richest fossil deposits occur south of Mahébourg, at the Mare aux Songes, where palaeontological material has been collected since the 19th century. Even recently these deposits, dated to around 4000 years ago, have continued to yield abundant remains of the pristine fauna (Rijsdijk *et al*., 2009).

The animal remains described below reflect the subsistence strategies of the inhabitants of the fort and will be confronted with the historical information (Staub, 1993; Cheke & Hume, 2008) documenting the original fauna, the extinction of species, and the intentional or accidental translocations of animals.

PROVENANCE AND DATING OF THE MATERIAL

The faunal remains described in this paper have been recovered from Fort Frederik Hendrik, where six archaeological field campaigns were carried out between 1997 and 2005. This research took place within the framework of the *Frederik Hendrik Archaeological Project* initiated by the *Amsterdam Archaeological Center* and the *State University of New Jersey* in collaboration with the *Mauritius Institute,* the *National Heritage Trust of Mauritius* and the *Mauritius Museums Council*, the latter being the legal custodian of the archaeological monuments on Mauritius.

The site investigated is located on the south-eastern coast of the island, near the present day village Vieux Grand Port. The bay of Grand Port, along which the fort is located, was used as a harbour that was accessible from the sea through an opening in the fringing reefs. The plateau on which the Dutch fort and, later on, the French governor's building stood is situated at the foot of Mount Lion and lies about 7 m above sea level (Figure 2). The substrate consists of red clay and weathered basalt, with locally an admixture of coral sand and mortar that was used for levelling and construction. The plateau slopes strongly towards the sea at its eastern and southern side. To the west and to the north it is bordered by a small river that has its source in the mountain and reaches the sea west of the site. Larger rivers that empty in the lagoon are the Nyon, at about two kilometres west of the site, and the Rivière des Créoles and the La Chaux River near Mahébourg.

During the first soundings in 1997 it was confirmed that the remains of Fort Frederik Hendrik were present underneath the ruins of the French governor's building (Floore & Schrire, 1997). During the excavations carried out in 1999, 2000, 2003, 2004 and 2005, a total of 31 loci were investigated with the aim of establishing the nature and extent of the archaeological features from the Dutch and French periods. Features that were recorded include levelling layers, pits, ditches for fences and for walls of the wooden buildings, and foundations of brick and basalt. All the sediment was dry sieved on a 2 mm mesh. The finds material mainly consists of building debris and household refuse including pottery, glass, metal and animal remains (Floore & Jayasena, in prep.).

Thus far, two major areas have been discovered where waste material was dumped (Figure 3). The faunal material presented here derives from the 2003 and 2004 excavation seasons and comes from inside the fort, in what appears to be a levelling layer that is stratigraphically situated between a wooden building (building 1 on Figure 4) and a stone building (building 2 on Figure 4). The traces of fire that are linked to the destruction of building 1 are related to the historically recorded fire of 1694 (Barnwell, 1948: 72; Sleigh, 1993: 654). Building 2 corresponds to a drawing made in 1723 by the French governor, de Nyon (Archives Nationales, Paris, VII NFO 9/602). A historical record mentions its construction in 1698 (Barnwell, 1948: 72). The levelling layer itself yielded two coins minted in The Netherlands in 1683 and 1689, and, in addition, there are clay pipes and Japanese and Chinese porcelains that are datable to the last quarter of the 17th century. All these dating elements indicate that the faunal assemblage can be securely placed in the last quarter of the 17th century, possibly even between 1694 and 1698.

FIGURE 2

Aerial view of the site taken in 2005. 1: nearby small river; 2: ruins of the French governor's building; 3: excavation trenches. The north-side is at the top of the picture.

DESCRIPTION OF THE FAUNAL REMAINS

The species lists of the molluscs and the vertebrates are given in Tables 1 and 2. The identifications of the molluscs were carried out with the aid of the personal reference collection of Sofie Debruyne and the following field guides: Drivas & Jay (1988), Michel (1988), Steyn & Lussi (1998), and Griffiths & Florens (2006). The mammal and chelonian remains were initially analysed at the Museum Naturalis in Leiden, the Archeologisch Centrum Amsterdam (AAC), and the Archeologisch Centrum Eindhoven (ACE). The fish remains were identified with the aid of the reference collections housed at the Royal Belgian Institute of Natural Sciences (Brussels), where the identifications of the other vertebrate remains were also verified. The measurements given for the birds and mammals are in millimetres and have been taken according to the methods described by von den Driesch (1976).

Molluscs

At 10.6 % (n=27) of the identifiable molluscs (Figure 5), the terrestrial gastropods are not a conspicuous part of the study sample. All specimens

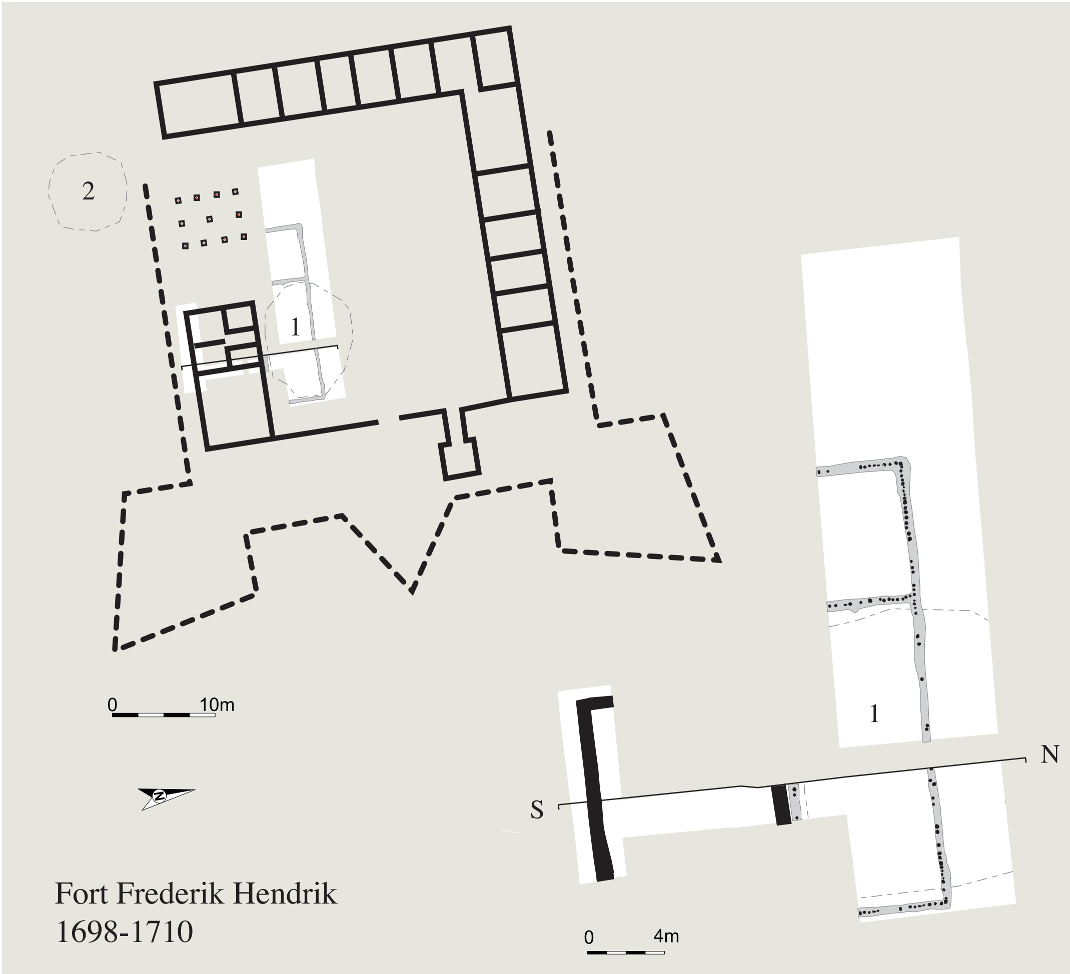

FIGURE 3

Reconstruction of the groundplan of the fort during the period AD1698-1710 after a drawing made by de Nyon in 1723 (Archives Nationales, Paris, VII NFO 9/602). The excavation trenches are indicated in white. Locus 1 indicates the provenance of the faunal remains discussed here. The fauna from the refuse dump (2), outside the fort, has not yet been analysed.

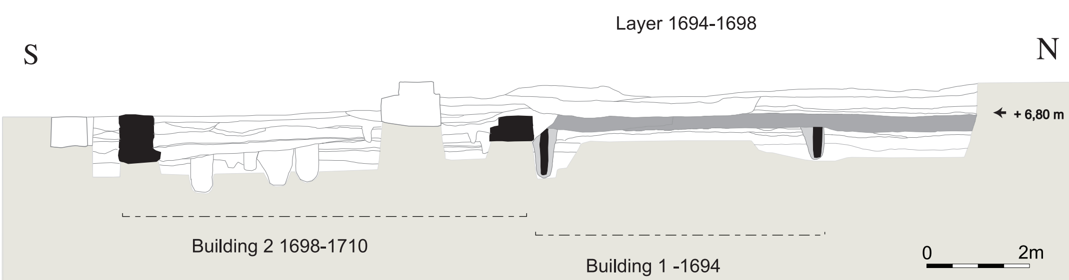

FIGURE 4

Stratigraphy of the north-south profile indicated on Figure 3.

family	taxon	NISP	%ISP	MNI	M%I	com-plete	bro-ken	frag-ment
terrestrial gastropods								
Subulinidae	*Allopeas* cf. *gracile* (Hutton, 1834)	27	10.6	15	20	14	10	3
freshwater gastropods								
Neritidae	*Neritina gagates* Lamarck, 1822	16	6.3	1	1	-	2	14
Thiaridae	*Thiara amarula* (Linnaeus, 1758)	1	0.4	1	1	-	-	1
marine gastropods								
Cerithiidae	*Clypeomorus bifasciata* (Sowerby, 1855)	33	12.9	18	24	7	9	17
Cerithiidae	Cerithiidae sp.	1	0.4	1	1	-	-	1
Cypraeidae	Cypraeidae sp.	4	1.6	1	1	-	-	4
Nassariidae	*Nassarius* sp.	1	0.4	1	1	-	-	1
Naticidae	Naticidae sp.	1	0.4	1	1	-	1	-
Neritidae	*Nerita albicilla* Linnaeus, 1758	16	6.3	2	3	1	2	13
Neritidae	*Nerita polita* Linnaeus, 1758	51	20.0	1	1	-	-	51
Neritidae	*Nerita* sp.	5	2.0	1	1	-	-	5
Neritidae	Neritidae sp.	1	0.4	1	1	-	-	1
Planaxidae	*Planaxis sulcatus* (Born, 1780)	43	16.9	17	22	3	8	32
Pyramidellidae	*Otopleura mitralis* (A. Adams, 1855)	1	0.4	1	1	-	1	-
Pyramidellidae	*Pyramidella acus* (Gmelin, 1791)	1	0.4	1	1	1	-	-
Turbinidae	*Turbo argyrostomus* Linnaeus, 1758	1	0.4	1	1	-	-	1
marine bivalves								
Arcidae	*Barbatia foliata* (Forsskål, 1775)	1	0.4	1	1	-	1	-
Isognomonidae	*Isognomon* sp.	2	0.8	2	3	1	-	1
Mesodesmatidae	*Paphies striata* (Gmelin, 1791)	1	0.4	1	1	-	1	-
Mytilidae	*Brachidontes variabilis* (Krauss, 1848)	1	0.4	1	1	-	1	-
Ostreidae	*Saccostrea cucullata* (Born, 1778)	32	12.5	1	1	-	3	29
Pectinidae	*Chlamys senatoria* (Gmelin, 1791)	3	1.2	1	1	-	-	3
Pectinidae	Pectinidae sp.	8	3.1	3	4	-	-	8
Tellinidae	*Quidnipagus palatam (*Iredale, 1929)	3	1.2	1	1	-	-	3
Veneridae	*Gafrarium pectinatum* (Linnaeus, 1758)	1	0.4	1	1	-	-	1
total identified		**255**		**76**		**27**	**39**	**189**
unidentified		218		5		1	2	215
total		**473**		**81**		**28**	**41**	**404**

TABLE 1

Taxonomic identifications, quantities and completeness of the shell material excavated at Fort Frederik Hendrik. NISP = Number of Identified Specimens; %ISP = percentage of the total NISP; MNI = Minimum Number of Individuals (= minimum number of valves for bivalves); M%I = percentage of the total MNI; broken = more than half of the complete shell or valve; fragment = less than half of the complete shell or valve.

were identified as *Allopeas* cf. *gracile* of the family Subulinidae. The high frequency of complete shells, complemented by the occurrence of specimens of different sizes (heights between 4 and 12 mm), indicates that these terrestrial molluscs inhabited the site. Gastropods of the genus *Allopeas* are not native to Mauritius; they were introduced by humans and still occur on the island today. Leaf litter in dry and coastal areas is their favoured habitat. Though the coastal plains in the east and southeast of Mauritius, where Fort Frederik Hendrik is located, have a wetter climate than the western shores of the island, they still receive less rainfall than the mountainous interior and central plateau, which makes their environment dry enough for snails that prefer less moisture (Baissac *et al*., 1962: 254-255; Griffiths & Florens, 2006: 25, 90, map between 32 and 33).

In the study sample the freshwater molluscs are even more poorly represented than their terrestrial counterparts. Only 17 specimens (6.7%), almost all fragments (n=15), were identified. They represent two gastropod species: *Neritina gagates* (Neritidae) (n=16) and *Thiara amarula* (Thiaridae) (n=1). Both species are native to Mauritius and still inhabit the island today. *Neritina gagates* is found in rivers several kilometres inland and in coastal

fish	
spotted eagle ray (*Aetobatus narinari*)	1
requiem sharks (Carcharhinidae sp.)	4
hammerhead shark (*Sphyrna* sp.)	1
moray eels (Muraenidae sp.)	1
hound needlefish (*Tylosurus crocodilus*)	1
needlefishes (Belonidae sp.)	1
groupers and rockcods (Serranidae sp.)	206
trevallies and jacks (Carangidae sp.)	3
silver-biddy (*Gerres* sp.)	2
emperors (Lethrinidae sp.)	472
twobar seabream (*Acanthopagrus bifasciatus*)	17
goldlined seabream (*Rhabdosargus sarba*)	12
seabreams (Sparidae sp.)	41
mullets (Mugilidae sp.)	8
surgeonfishes (Acanthuridae sp.)	4
reptiles	
sea turtle (Cheloniidae sp.)	93
birds	
domestic fowl (*Gallus gallus* f. domestica)	2
mammals	
black rat (*Rattus rattus*)	74
dog (*Canis lupus* f. familiaris)	4
cat (*Felis silvestris* f. catus)	6
dugong (*Dugong dugon*)	53
horse (*Equus ferus* f. caballus)	3
pig (*Sus scrofa* f. domestica)	75
Java deer (*Rusa timorensis*)	220
cattle (*Bos primigenius* f. taurus)	22
goat (*Capra hircus* f. aegagrus)	150
unidentified fish	1040
unidentified birds	13
unidentified mammals	47

TABLE 2

List of the identified vertebrate species. Figures represent numbers of identified specimens (NISP).

areas, and tolerates fresh and brackish water. *Thiara amarula* used to be common in freshwater lakes and rivers, but is becoming increasingly rare (Griffiths & Florens, 2006: 47, 55-56).

The large majority of the studied shells are of marine origin (n=211, 82.7%). This group is not only the most abundant, but also the most varied: eight gastropod and eight bivalve families are represented. With 73 specimens the Neritidae are by far the best represented gastropod family. Only six fragments could not be identified further; the remaining ones belong to *Nerita albicilla* (n=16) and *Nerita polita* (n=51). Also common are the Planaxidae, with the species *Planaxis sulcatus* (n=43), followed by the Cerithiidae, with one unidentified species and 33 specimens of *Clypeomorus bifasciata*. Less well represented are the Cypraeidae (n=4), commonly known as cowries. Also poorly represented are the Pyramidellidae with one specimen of *Otopleura mitralis* and one of *Pyramidella acus*. Finally, the collection studied held one member each of the families Nassariidae (*Nassarius* sp.), Naticidae and Turbinidae (*Turbo argyrostomus*). Among the bivalves fragmented remains of Ostreidae (n=32), or oysters, all *Saccostrea cucullata*, are the most abundant category. Also well represented are the scallops, or Pectinidae (n=11). The sample contained a few fragments (n=3) of *Chlamys senatoria*; the other remains could not be identified to species-level. Next in line are the Tellinidae with the species *Quidnipagus palatam* (n=3), closely followed by the Isognomonidae with two specimens of *Isognomon* sp. Almost negligible are the Arcidae (*Barbatia foliata*), Mesodesmatidae (*Paphies striata*), Mytilidae (*Brachidontes variabilis*) and Veneridae (*Gafrarium pectinatum*), with one specimen each.

The molluscan remains indicate that the coastal environment at the time of the construction of the fort, in 1638, was similar to that of today (cf. Fagoonee, 1990). The shore held a diverse range of biotopes: coral-sand beaches, rocks, brackish estuaries, mangroves and lagoons. The study sample indicates the presence of beaches with sandy mud, rather than pure sand. This is shown by the presence of Tellinidae and *Gafrarium pectinatum*, and the absence of typical sand-dwellers such as Donacidae (Baissac *et al*., 1962: 279, 282, 284). The high frequency of *Nerita polita* in the sample shows that exposed rocks, with small beaches at the bottom, were present on the coast near Fort Frederik Hendrik. On the other hand, *Nerita albicilla, Planaxis sulcatus*, *Brachidontes variabilis*, *Turbo argyrostomus* and Cypraeidae suggest the occurrence of more sheltered rocky substrates, crevices and rock-pools (Baissac *et al*., 1962: 262-263, 266-267, 281-284; Taylor, 1971: 198). Also the absence of Littorinidae and limpets shows that the coast was rather sheltered. Several species occur that prefer brackish estuaries bordered by mangrove swamps. A common inhabitant of such environments is *Saccostrea cucullata* (Angell, 1986: 13; Baissac *et al*., 1962: 285), which was well represented in the sample. Other species that tolerate brackish water include the freshwater snail *Neritina gagates* and the marine molluscs *Planaxis sulcatus*, *Clypeomorus bifasciata* and *Brachidontes variabilis* (Baissac *et al*., 1962: 280-281; Griffiths & Florens, 2006: 47). Finally, one species is indicative of lagoons, i.e. *Chlamys senatoria* which is often found in meadows of phanerogam seagrass, where it is attached to the roots or base of the plants (Baissac *et al*., 1962: 275-276, 285).

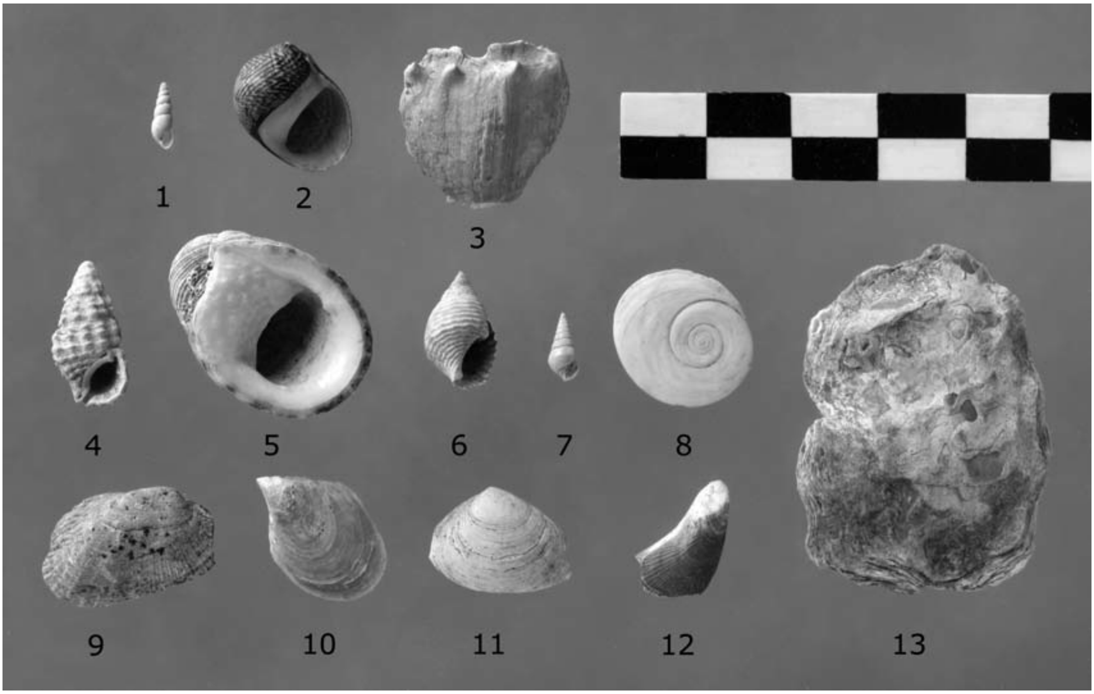

FIGURE 5

Mollusc species identified: 1: *Allopeas* cf. *gracile*, 2: *Neritina gagates*, 3: *Thiara amarula*, 4: *Clypeomorus bifasciata*, 5: *Nerita albicilla*, 6: *Planaxis sulcatus*, 7: *Pyramidella acus*, 8: operculum of *Turbo argyrostomus*, 9: *Barbatia foliata*, 10: *Isognomon* sp., 11: *Paphies striata*, 12: *Brachidontes variabilis*, 13: *Saccostrea cucullata*. The subdivisions on the scale are 1 cm. (Photograph by H. Denis, Flemish Heritage Institute, Belgium).

Fish

The fish remains are the most common finds category in terms of number of identified specimens. At least 13 taxa are present, most of which belong to the bony fish. Cartilaginous fish are mainly represented by vertebral centra: one such element of hammerhead shark (*Sphyrna* sp.) was found that belonged to an individual of which the total length is estimated at 1-1.2 m. Three species of hammerhead shark are reported for the region; the smooth hammerhead (*Sphyrna zygaena*), the great hammerhead (*Sphyrna mokarran*) and the scalloped hammerhead (*Sphyrna lewini*). Depending on the species, these fish can reach maximum sizes of 4 to 6 m. Although these sharks are mainly pelagic-oceanic, they can also be found close inshore and *Sphyrna lewini* has been reported to even enter enclosed bays and estuaries. *Sphyrna makarran* is a reef-associated species that also can enter lagoons (Campagno, 1984). The four additional shark centra that were found are from requiem sharks (Carcharhinidae) that could not be identified to species. Eighteen species of Carcharhinidae are reported from Mauritian waters today (FishBase; Froese & Pauly, 2008) with maximum reported sizes varying between 1 and up to around 4 m. For one species (*Galeocerdo cuvier*, Tiger shark), a total length of even 7.5 m has been recorded. The vertebral centra found at the site are from sharks of (relatively) small to medium size; reconstructed sizes indicate two specimens with a total length of 1.5 to 1.7 m, one fish of 1-1.2 m and one of 0.8 to 1 m. Another cartilaginous fish that occurs in the assemblage is the spotted eagle ray (*Aetobatus narinari*), attested by a single tooth plate fragment from an individual with a disc width of approximately 110 cm. This species, which can reach a disc width of over 3 m, occurs frequently in shallow, inshore, waters and can enter estuaries. Because this ray feeds mainly on bivalves, its presence may be linked to the oyster beds that were available in the lagoons.

A single, precaudal, vertebra attests the presence of a moray eel (Muraenidae) measuring about 100-120 cm standard length (SL). FishBase (Froese & Pauly, 2008) lists forty-two species of Muraenidae for Mauritius of which at least 16 reach lengths of over a metre. Moray eels are typically associated with reefs or rocky bottoms; several of the Mauritian species can also occur in lagoons or estuaries.

Two precaudal vertebrae of needlefishes (Belonidae) were found, of which one could be identified as a hound needlefish (*Tylosurus crocodilus*) of about 70-80 cm SL. The other vertebra is morphologically different from *Tylosurus*, but could not be identified beyond family level because the reference collection does not include all the needlefish species from Mauritius. The size of the fish corresponding to that vertebra is estimated at 60-80 cm SL. Needlefish live in surface waters and can be found in coastal waters and in estuaries.

The second most common fish taxon at the site is the family of the Serranidae (groupers and rockcods). Identification beyond family level was not attempted given the extreme richness of this group in Mauritian waters. About 40 species of commercial value are known, mainly belonging to the genera *Epinephelus* and *Cephalopholis* (Froese & Pauly, 2008). The skeletal element distribution (Table 3) shows that both head and vertebral column are present, which indicates that whole fish were brought to the site. The distribution of the reconstructed sizes, depicted in Figure 6, shows that most serranids were between 30-40 and 50-60 cm SL and that large individuals were rare. The maximum reported total lengths for *Cephalopholis* species range between 24 and 60 cm, but within the genus *Epinephelus* there are at least six species with maximum total lengths above 90 cm. The largest species reported from the region is *Epinephelus lanceolatus* which can reach lengths of up to 2.7 m. Possible explanations for the relative-

	Serranidae	Lethrinidae	*Acanthopagrus*	*Rhabdosargus*	Sparidae
skull fragments	12	13	-	-	-
posttemporale	3	1	-	-	1
articulare	6	37	-	-	1
dentale	12	39	8	3	1
ectopterygoideum	11	13	-	-	-
maxillare	14	50	3	3	-
palatinum	3	34	-	-	2
praemaxillare	18	58	6	5	2
quadratum	10	28	-	-	2
teeth	-	3	-	1	-
basihyale	1	-	-	-	-
ceratohyale	12	19	-	-	-
epihyale	3	8	-	-	-
hyomandibulare	5	21	-	-	-
hypohyal ventrale	-	2	-	-	-
interoperculare	4	10	-	-	1
operculare	2	4	-	-	-
preoperculare	8	20	-	-	-
suboperculare	5	-	-	-	-
branchial element	1	1	-	-	-
cleithrum	12	-	-	-	-
scapula	-	3	-	-	-
supracleithrale	9	5	-	-	-
precaudal vertebrae	28	27	-	-	9
caudal vertebrae	27	76	-	-	22
total	206	472	17	12	41

TABLE 3

Skeletal element distribution of the major fish taxa. Figures represent numbers of identified specimens (NISP).

ly small size of the serranids will be discussed below.

Only three bones belong to the Carangidae family: a quadrate of an individual measuring 40-50 cm SL and two caudal vertebrae, one of a fish of 20-30 cm long and the other one measuring 30-40 cm SL. These elements did not allow a more precise identification. At least 37 species of this family can be found in Mauritian waters. Although most species are typical of open waters, there are several carangids that occur closer inshore, albeit often only seasonally.

The presence of the silver-biddy is indicated by a premaxilla and a hyomandibula belonging to a fish of 20-25 cm. Both elements were found in the same context and may belong to the same individual. There are three species of silver-biddy in Mauritius (*Gerres oyena*, *Gerres longirostris* and *Gerres filamentosus*) that all inhabit shallow water over sandy substrates along the coasts and in estuaries.

The Lethrinidae family (emperors) is numerically the best represented taxon in the assemblage of fish bones. The skeletal element distribution is given in Table 3 and the size reconstructions are illustrated by Figure 6. At least 15 lethrinid species occur in Mauritius. Because of this great diversity, and the incompleteness of the reference collection, no attempts were made to identify these fish any further. Emperors are typical inshore, reef-associated species that are found over reefs and adjacent sandy bottoms and seagrass areas. Several species occur in lagoons.

Among the seabreams (Sparidae), another rather well represented fish family, specific identifications were possible on more than 40% of the bones. This is due to the fact that this family has only eight species in Mauritian waters and that there is a good representation of very diagnostic elements such as premaxillae, maxillae, and dentaries (Table 3). The distribution of the reconstructed sizes of the captured fish (Figure 7) show that the twobar seabream (*Acanthopagrus bifasciatus*) were larger on average than the goldlined seabream (*Rhabdosargus sarba*). Both species are abundant in shallow, coastal waters and enter estuaries.

Mullets (Mugilidae) are represented by four caudal vertebrae, a maxilla, a preopercular, a hyomandibular and a cleithrum. With the exception of one element from a fish measuring 20-30 cm SL, all remains are from individuals between 30 and 40 cm SL. Because nine mugilid species are listed for Mauritian waters (Froese & Pauly, 2008), and not all of them are represented in the reference collection, no specific identifications of the archaeological material have been attempted. Mullets are coastal fish that often enter estuaries and rivers.

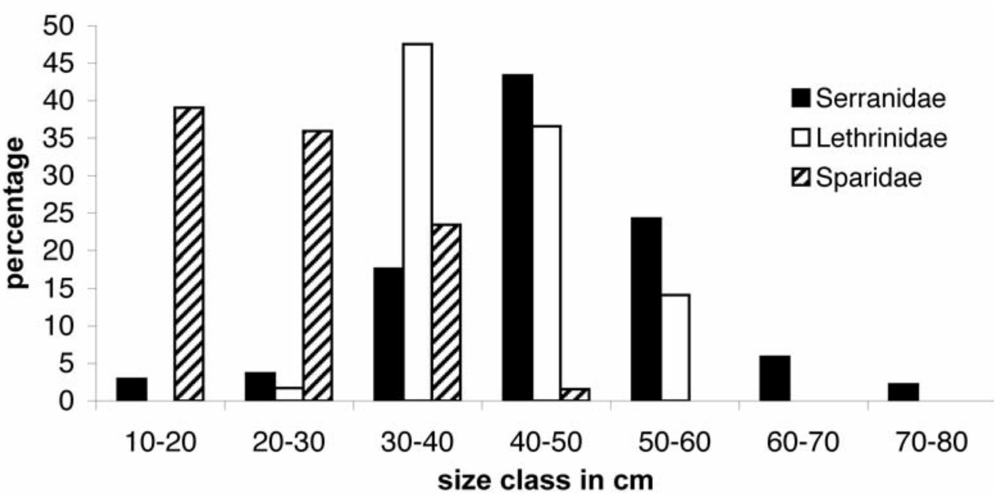

FIGURE 6

Distribution of the relative frequencies of the reconstructed sizes for the Serranidae (n=136), the Lethrinidae (n= 410) and the Sparidae (n=64).

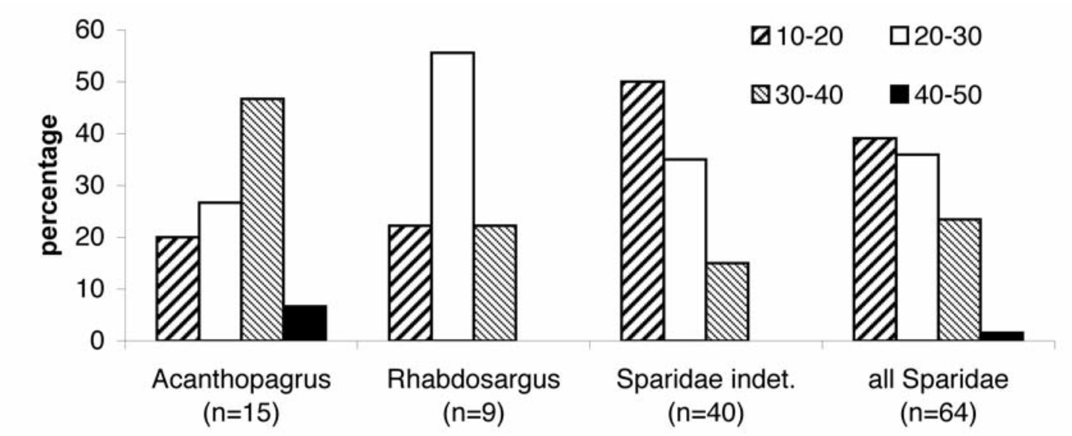

FIGURE 7

Distribution of the relative frequencies of the reconstructed sizes for the Sparidae family separately, in order to illustrate the different size distributions for twobar seabream (*Acanthopagrus bifasciatus*) and goldlined seabream (*Rhabdosargus sarba*).

Four elements, a pterygiophore and three caudal vertebrae, have been attributed to the Acanthuridae, the family of surgeonfishes and unicornfishes, which includes at least 27 species in Mauritius. Two of the vertebrae are from fish between 30 and 40 cm SL, the third one is from an individual of 40-50 cm SL. The Acanthuridae are a typical reef-associated group.

Other vertebrates

The majority of the chelonian remains are carapace fragments (Table 4), many of which are of considerable thickness (up to 10 mm and more). The bony plates do not have the smooth appearance of tortoises, but are pitted and grooved as in the marine species occurring in the region today. This excludes an identification as one of the extinct, terrestrial, taxa *Cylindraspis inepta* and *Cylindraspis triserrata*. Because of the lack of sufficient comparative specimens and due to the sometimes very fragmentary nature of the material, it was not possible to assign the carapace fragments, or the other remains (ribs, limb and foot elements), to one of the three turtle species that can be expected in the region, i.e. the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys imbricata*) or the loggerhead turtle (*Caretta caretta*).

Bird remains are rare and comprised only two identifiable bones, a coracoid and a proximal tarsometatarsal (Bp 14.6 mm) of domestic fowl (*Gallus gallus* f. domestica).

Among the mammal remains both wild and domestic species are present. The skeletal element distribution of the black rat (*Rattus rattus*) is indicated in Table 4. The bones of this species often occur in clusters, indicating that they represent the remains of animals that were complete when they entered the deposit. The minimum number of individuals (MNI) corresponding to these remains is seven, and three of them were very young animals. Although the remains of dog (*Canis lupus* f. familiaris) probably also derive from carcasses of animals that died naturally, no concentrations of bones have been found. The four skeletal elements found are all small bones (an astragalus, two calcanei and a second phalanx) that may represent reworked elements from at least two skeletons that were initially deposited elsewhere. The best preserved calcaneus could not be measured accurately, but its size corresponds to an animal of about 55 cm shoulder height. The few remains of cat (*Felis silvestris* f. catus) also are from two individuals. One of these is a juvenile, represented by a metatarsal and two metacarpals. The other material includes a proximal ulna fragment, a fused proximal femur (DC 9.2 mm) and a lumbar vertebra of an older animal. Another domestic animal for which there are no indications for human consumption, is the horse (*Equus ferus* f. caballus). This species is represented by three elements only:

a proximal metacarpal (Bp 50.6 mm), a distal metapodial (Bd 43 mm) and an os tarsale quartum.

The remainder of the mammal species are represented by consumption refuse, including both wild (dugong and Java deer) and domestic animals (pig, goat and cattle). The dugong (*Dugong dugon*) is mainly represented by skull bones and ribs; vertebrae are almost completely lacking (see Table 4). In addition, there are numerous bone fragments that look like dugong from their general appearance, but that have not been retained in the table because the exact skeletal element could not be determined. The preponderance of the massive head bones and the pachyostotic ribs is explained by their better resistance to destruction, a phenomenon that was also noted at the dugong butchery site of Akab Island in the United Arab Emirates (Jousse *et al*., 2002). Vertebrae, together with pha-

	Cheloniidae	*Rattus*	*Dugong*	*Sus*	*Rusa*	*Bos*	*Capra*
skull fragments	-	11	23	2	1	-	-
horncore	-	-	-	-	-	-	1
mandible	-	5	1	2	2	-	3
incisor	-	7	-	11	17	4	6
jugal teeth	-	6	5	6	21	-	50
cervical vertebrae	-	-	1	-	2	1	-
thoracic vertebrae	-	-	-	-	4	1	2
lumbar vertebrae	-	-	-	1	7	3	1
sacrum	-	-	-	-	1	1	1
caudal vertebrae	-	-	-	1	-	-	-
vertebrae	-	-	-	-	-	-	1
ribs	4	12	21	-	6	-	-
scapula	-	2	-	1	9	1	4
humerus	2	7	-	11	10	1	5
radius	-	1	-	2	13	2	13
ulna	1	3	-	3	9	2	1
carpals	1	-	-	4	13	-	5
metacarpal	6	1	1	2	1	-	4
pelvis	-	3	-	6	8	-	8
femur	-	12	-	3	22	-	4
patella	-	-	-	-	7	-	-
tibia	-	3	-	3	16	-	7
fibula/malleolar	1	-	-	-	1	-	-
astragalus	-	-	-	1	12	2	5
calcaneus	-	-	-	1	6	1	2
other tarsals	-	-	-	-	4	2	1
metatarsal	1	1	-	2	4	-	6
metapodial	4	-	-	4	3	-	-
phalanx 1	1	-	-	2	7	-	12
phalanx 2	-	-	-	5	10	1	5
phalanx 3	1	-	-	2	4	-	3
phalanx	4	-	1	-	-	-	-
phalanx/metapodial	2	-	-	-	-	-	-
carapace	65	-	-	-	-	-	-
total	93	74	53	75	220	22	150

TABLE 4

Skeletal element distribution of the turtles and the major mammal taxa. Figures represent numbers of identified specimens (NISP).

langes, are the skeletal elements that have the lowest bone density (de Buffrénil & Schoevaert, 1988). The animal bones at Fort Frederik Hendrik are generally rather heavily weathered (see taphonomy below) which may have reinforced the process of differential preservation. To explain the skeletal element distribution of the dugong in the fort, it is therefore not necessary to invoke a scenario involving dugong butchering at the shore, whereby the spine was left behind (although this scenario cannot be excluded).

Of all the terrestrial species found in the assemblage, the Java deer (*Rusa timorensis*) is the best represented animal. All body parts are present (Table 4) suggesting that the animals were butchered at the fort. The measurements taken on the postcranial material (Table 5) show a wide variation illustrating the sexual dimorphism. The most striking aspect of the Java deer remains is that they consist only of bones from adult and subadult animals and that no juveniles occur (Table 6). Fusion states of the long bones indicated in Table 6, are listed in the chronological order in which they fuse in goat, sheep and cattle. No data exist on the age of fusion in *Rusa timorensis* and those that are given for *Cervus elaphus* and *Dama dama* by Habermehl (1985) are rather incomplete or imprecise. When the ages of long bone fusion of cattle are compared to those of sheep (see Silver, 1969: 285-286) and goat (Habermehl, 1975), it appears that the order in which the bones fuse is the same and that, moreover, the time of fusion is similar or only slightly later in cattle, compared to the smaller ruminants. For that reason, the data of both Java deer and goat are arranged together in Table 6 in three broad age categories, namely 'less than 1 year or around 1 year', 'between 1 and 2 years' and '3 years and older'. Finally, it is also worth mentioning a pathology seen on Java deer: an ankle joint consisting of an astragalus, naviculocuboid and cuneiform that has the latter two bones fused, a condition that is reminiscent of spavin.

Among the domestic animals, the most frequently slaughtered species was the goat (C*apra hircus* f. aegagrus). Among the ovicaprid material not a single bone could be identified as sheep (*Ovis ammon* f. aries), all the diagnostic material belonged to goat. The historical records do not mention sheep either. Possibly they were not brought in, because they were less likely to thrive in an environment that was mainly forested. No cranial material is available to indicate what type of goat breed was available, but the measurements (Table 7) suggest a rather homogenous population of medium-sized animals. The fusion state of the long bones (Table 6), shows that mainly juvenile and subadult animals were slaughtered. In the case of the pigs, mainly young animals were slaughtered according to the long bone data (Table 8), although the cranial material also includes two third molars. Despite the rather limited number of measurements that could be taken, there seems to be a large variation in size (Table 9 and Figure 8). In the case of the distal humeri (Bd 36.3 and 43.0 mm, and BT 29.6 and 36.7 mm), sexual dimorphism could explain the observed extremes. Such an explanation can probably not be retained when the measurements of the proximal radii are also considered. These skeletal parts, which articulate with distal humeri, are from animals that are considerably smaller (Bp 21.5 and 21.3 mm) than the pig represented by the smallest distal humerus. Table 9 compares the measurements from the Mauritian specimens with the corresponding metrical data available from the large collections of the medieval site of Haithabu (Becker, 1980). This clearly shows that the Mauritian pig material includes bones from individuals that are both at the maximum and minimum range of a population. The fourth metacarpal and the astragalus even yielded measurements that are below the minimum values for Haithabu. These two bones were complete and allowed estimates of withers heights of 60.6 cm and 59.6 cm respectively, using the conversion factors compiled by von den Driesch & Boessneck (1974). At Haithabu the minimum withers height obtained on a sample of 640 metacarpals IV was 63.7 cm; the minimum value among 1343 astragali was 57.5 cm. The fact that the Mauritian material shows such a large size variation despite the small sample size makes it highly unlikely we are seeing the variation of a single population. The possible meaning of these observations will be discussed below. Finally, cattle (*Bos primigenius* f. taurus) is the least abundant food animal but, because of its high meat yield, it may have been an important meat provider. Most body parts are represented, indicating that the animals were slaughtered and consumed nearby. Only a few measurements could be taken to document the size of the cattle (Table 10). They are slightly larger than the mean values given for the Haithabu cattle, which are on average about 110 cm at the shoulders (Johansson, 1982). In the 1670s, oxcarts were brought in to Mauritius to haul ebony (Cheke & Hume, 2008: 79), but the cattle bones found do not show any pathologies (Bartosiewicz *et al*., 1997; De Cupere *et al*., 2000) that can be related to heavy duty work.

scapula	GLP	BG			**femur**	DC	
	-	27.6				26.4	
	42.6	33.6				27.0	
humerus	BT					27.6	
	41.3				**patella**	GH	
	42.3					± 40.5	
	45.7					45.5	
	46.3				**tibia**	Bp	Bd
radius	Bp	BFp	Bd			58.6	-
	38.6	36.5	-			62.4	-
	42.9	40.3	-			-	38.9
	-	42.2	-		**malleolar**	GD	
	-	-	37.4			20.1	
	-	-	41.2				
ulna	LO	SDO			**naviculocuboid**	GB	
	-	38.8				32.1	
	66.1	38.8				38.5	
astragalus	GLl	GLm	Dl	Bd	**metacarpus**	Bd	
	41.4	38.7	22.7	27.7		30.3	
	41.6	39.0	22.1	26.5	**metatarsus**	Bp	
	42.0	38.8	22.7	25.2		28.7	
	42.2	-	23.2	27.2			
	42.7	40.0	22.1	26.8			
	44.4	42.9	24.4	27.5			
	44.8	41.1	24.3	30.1			
	48.0	43.2	26.1	30.9			
	48.7	45.1	26.3	29.0			
phalanx 1	GLPe	Bp	SD	Bd	**phalanx 3**	DLS	Ld
	44.6	16.1	14.4	14.8		34.1	28.8
	45.3	14.6	11.5	12.7		40.9	35.0
	47.9	15.9	13.1	13.8		43.5	38.2
	53.3	17.7	14.2	15.3			
	53.6	12.3	14.8	-			
phalanx 2	GLPe	Bp	SD	Bd			
	33.1	14.3	11.9	11.1			
	33.5	13.7	11.5	10.8			
	35.8	14.7	10.9	11.6			
	35.9	15.2	11.8	11.8			
	37.5	14.7	11.0	11.1			
	37.5	15.6	12.1	11.6			
	38.6	16.8	14.3	-			
	39.5	17.3	13.7	13.0			

TABLE 5

Measurements (mm) taken on the Java deer remains.

	goat		Java deer	
	unfused	fused	unfused	fused
less than 1 year or around 1 year				
radius proximal	-	2	-	3
humerus distal	-	4	-	7
phalanx 1 proximal	1	11	-	5
phalanx 2 proximal	-	2	-	8
between 1 and 2 years				
metacarpus distal	-	-	-	1
metapodial distal	-	-	2	-
tibia distal	-	-	-	1
3 years and older				
calcaneus	2	-	1	-
femur proximal	1	2	2	4
humerus proximal	-	-	-	1
radius distal	1	2	-	4
ulna proximal	-	1	1	3
femur distal	1	-	3	1
tibia proximal	2	-	-	6

TABLE 6

Fusion states of the long bones of goat and Java deer. The elements are arranged according to the chronological order in which they fuse. The absolute ages indicated are the values given by Habermehl (1975) for goat, supplemented with data for sheep from Silver (1969) where data were incomplete.

TAPHONOMIC ANALYSIS

The substrate of this volcanic island mainly consists of basaltic lava and its weathering product, red clay. This type of acidic sediment is not very favourable for bone preservation, but in the case of the fort area, the conditions are better because of the levelling activities that took place. The sediment that was brought up from the sandy beach contains eroded coral and fragments of shells that may have tempered the acidic nature of the original substrate. Nevertheless, some of the bones are rather soft and give the impression of having undergone acid dissolution. Etching of the bone surface due to plant roots is also regularly seen. The bone from the fort is more fragmented than that from the still unstudied samples from the contemporaneous refuse deposit outside the fort. This difference probably results from the degree of trampling, which must have been more intense inside the fort.

Despite the state of preservation of the material, with sometimes considerable surface weathering, some additional traces could be recorded that help with the interpretation of the taphonomic history and the subdivision of the material into taphonomic groups (*sensu* Gautier, 1987). These traces include gnaw marks of dogs noted on a turtle humerus, a pig ulna, and on a proximal ulna and a distal metacarpal of Java deer. Butchery marks were regularly observed and include cut marks on a dugong rib, a goat humerus, an ulna of pig, and on a sacrum, a rib and an ankle joint of Java deer. Chop marks were seen on the scapula, humerus, radius, femur and vertebrae of Java deer. Very pronounced chop marks were observed on the squamosum of a dugong (Figure 9).

The majority of the faunal remains that were recovered can be considered to be consumption refuse. There are, however, some other taphonomic groups present. To the penecontemporaneous intrusives belong the black rats and probably also the *Allopeas* snails that must have lived on and near the site. The second category, the reworked intrusives, contains the mollusc remains that are part of the substrate on which the site was installed. The marine shells are extremely fragmented: of the 211 studied specimens 171 were fragments. Although this could possibly be explained partly by the above-mentioned tram-

scapula	GLP	LG	BG		**femur**	Bp	DC		
	26.3	23.3	18.6			48.1	22.7		
	-	-	18.8		**tibia**	Bp			
humerus	BT					42.4			
	27.9				**astragalus**	GLl	GLm	Dl	Bd
	32.9					25.6	24.8	13.4	17.3
	33.6					27.2	25.3	14.3	17.5
radius	Bp	BFp	Bd			27.7	26.3	14.4	18.1
	27.1	26.1	-			27.9	26.1	14.4	16.3
	27.5	25.8	-			30.2	28.3	15.0	19.2
	-	-	24.7		**naviculocuboid**	GB			
	-	-	27.1			24.8			
ulna	LO	SDO			**metatarsus**	Bp			
	35.2	19.8				18.8			
metacarpus	Bp					19.2			
	27.3					19.6			
phalanx 1	GLPe	Bp	SD	Bd	**phalanx 2**	GLPe	Bp	SD	Bd
	32.3	10.8	8.9	10.8		24.3	12.0	12.0	9.2
	32.9	11.7	10.1	11.3		26.7	13.6	10.2	10.7
	33.3	10.4	8.7	9.8	**phalanx 3**	DLS	Ld		
	33.7	11.9	10.2	12.0		30.8	25.9		
	34.7	11.6	8.9	10.6					
	35.3	11.6	9.0	10.2					
	36.1	11.5	9.6	10.6					
	36.3	13.0	11.5	13.1					
	36.7	11.1	9.3	10.7					
	39.3	13.7	11.4	12.9					

TABLE 7

Measurements (mm) taken on the goat remains.

pling effect, it is more likely that the shells were already fragmented when they were deposited on the site. Marine shell fragments, including small pieces of species that usually inhabit rocky environments, washed onto the beaches and were brought to the site unintentionally with sand or mud for levelling, construction or other purposes. This might also have happened to the single specimen of the freshwater gastropod *Thiara amarula*; dead shells of this species are often recorded washed ashore (Griffiths & Florens, 2006: 56). Possibly the same scenario can explain the presence of the other freshwater snail *Neritina gagates* that also tolerates brackish water. The fragmented remains of the oyster *Saccostrea cucullata* probably also represent reworked intrusives, rather than trampled consumption refuse.

The remains of horse, cat and dog are not considered to be consumption refuse either. The material is seen as parts of carcasses of animals that died on or near the site and that were disposed of. The skeletons are incomplete showing that disturbance occurred, either because the bodies had been left at the surface, or because they were not buried deep enough.

INTRODUCED AND EXPLOITED ANIMALS

Terrestrial fauna

From a biogeographical perspective the presence of the land snail *Allopeas* cf. *gracile* in the sample is an interesting observation. This species is probably from Neotropical origin (Solem, 1964:

	unfused	fused
around 1 year		
radius proximal	-	2
humerus distal	1	4
phalanx 2 proximal	-	1
around 2 years		
metacarpus distal	-	1
phalanx 1 proximal	-	1
metapodial distal	-	-
tibia distal	-	-
calcaneus	1	-
3 years and older		
femur proximal	-	-
humerus proximal	-	-
radius distal	-	-
ulna proximal	-	-
femur distal	1	-
tibia proximal	-	-

TABLE 8

Fusion states of the long bones of pig. The elements are arranged according to the chronological order in which they fuse. The absolute fusion ages indicated are taken from Silver (1969).

134; Cowie, 1998: 356), and has been widely dispersed by humans in the Indo-Pacific region, including Mauritius (Tryon & Pilsbry, 1906: 124-125). Its presence in the sample suggests that it was introduced on the island in the last quarter of the 17th century or earlier. It has been argued that *Allopeas* can be accidentally introduced with plants (Tryon & Pilsbry, 1906: 124; Solem, 1964: 135). Already in 1598, the Dutch planted unspecified species on Mauritius, and in 1606 coconut, oranges, bananas and cotton were planted (Cheke & Hume, 2008: 77), meaning that a possible introduction could even predate the permanent human settlement. The hypothesis of an early introduction can only be retained when it is ascertained that the *Allopeas* are not intrusive. Many land snails are burrowers, and are thus able to enter archaeological levels from above. *Allopeas* lives in habitats where no or very little burying is necessary, such as in leaf litter, under stones or in air spaces between rocks, and usually does not bury itself in compact soil lacking air spaces (Griffiths & Florens, 2006: 90; Vincent Florens, pers. comm.). However, caution is required, especially since the small size of the snails eases intrusion. In order to be sure of the contemporaneity of the remains it would be desirable to carry out an absolute dating. Though often problematic for terrestrial shells, this might be attempted by radiocarbon dating or amino acid racemization (Claassen, 1998: 93-96).

Remains of black rat are relatively abundant in the archaeofaunal sample from Fort Frederik Hendrik. Since this species does not make burrows, it can be assumed that its remains found in the contexts analysed are more or less contemporaneous to the rest of the deposit, dated to the last quarter of the 17th century. Historical records frequently mention the devastating effects the large rat populations had on the crops the Dutch tried to grow (Moree, 1988). Dutch chronicles mention black rat for the first time in 1606, but they must already have been present before the first contact in 1598, as shown by subfossil remains and rat-predated snails (Hume, 2007). The first Dutch visitors did mention a Portuguese shipwreck that may have been the source of these rats. It is assumed that it took some time for the rats to accommodate, but they quickly had a profound impact on the indigenous fauna. They are held responsible for the extermination of a large part of the reptilian fauna, including snakes, prior to permanent human settlement (Hume, 2007). The exact, original, provenance of the black rats is still unknown: it remains to be established whether the *Rattus rattus* came from Europe or rather from East Africa or Madagascar. A review of the archaeozoological finds of black rat (Ervynck, 2002) illustrates the colonisation of the African east coast and southern Africa through Arab traders in early medieval times, but information for Madagascar or the Mascarene islands was lacking. The degrees of contact and the interaction between islands (and the mainland) might be elucidated in the future by ancient DNA analysis (cf. Matisoo-Smith & Robins, 2009). Similarly, aDNA studies might be useful to establish the provenance of the introduced domestic animals (see below). Chickens may have been the first domestic species that was introduced –before 1606– on the island, but they are believed to have disappeared again shortly after.

In 1606, 24 goats and 10 to 12 pigs were released and the next year cattle were introduced. This livestock apparently adapted well as in the 1620s pigs, cattle and goats were already described as ‘abundant’ by visiting ships. Once these species were well established, crews of the passing ships would concentrate on the introduced animals, whereas the native birds were from now on largely ignored as food items. Tortoises, turtles and

	Mauritius		Haithabu	
M3 sup	GL occl.		GL occl.	
	27.1		min-max 21.3-32.6 mean 25.5	
	27.8			
M3 inf	GL occl.	GL alv.	GL occl.	GL alv.
	25.6	-	min-max 22.0-35.4 mean 27.5	min-max 22.4-36.6 mean 29.8
	30.8	34.4		
humerus	Bd	BT	Bd	
	36.3	29.6	min-max 30.8-43.8 mean 36.2	
	43.0	36.7		
radius	Bp		Bp	
	21.5		min-max 22.4-33.-8 mean 27.8	
	22.3			
mcIV	GL		GL	
	57.6		min-max 60.5-82.1 mean 68.7	
astragalus	GLl	GLm	GLl	GLm
	33.3	29.7	min-max 34.5-44.0 mean 38.9	min-max 31.6-41.2 mean 36.0

TABLE 9

Measurements (mm) taken on the pig remains compared to those of Haithabu (Becker, 1980). The values indicated for the molars from Haithabu are those from the unsexed specimens.

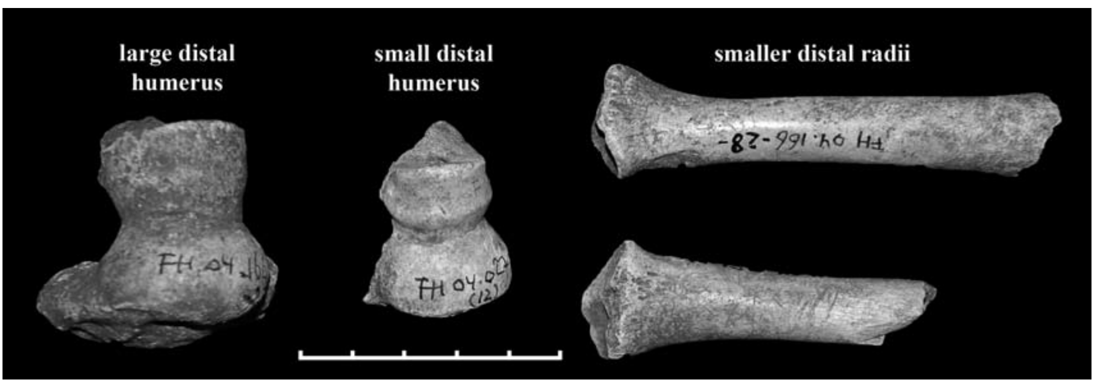

FIGURE 8

A selection of pig bones illustrating the wide size variation. The scale bar is 5 cm.

dugongs continued to be harvested, however. Once the Dutch had settled on the island and the fort was built, an additional ungulate was introduced, namely the Java deer *Rusa timorensis*. This happened in 1639 and at the same time chickens, geese, ducks, pigeons, and rabbits were landed (Staub, 1993). Fifty years later, which corresponds to the period that the studied material dates to, Governor Lamothius reported to his superiors at Cape of Good Hope that deer were abundant. He recommended that the flesh be salted and exported for the benefit of the VOC (Staub, 1993: 53). The

astragalus	GLl	GLm	Dl	Bd
	61.8	56.8	31.8	39.4
	66.9	60.7	-	41.1
phalanx 2 post	GLPe	Bp	SD	Bd
	36.3	24.2	19.1	19.8

TABLE 10

Measurements (mm) taken on the cattle remains.

provenance of these deer is obvious, but in the case of the domestic animals it is not completely clear where they came from.

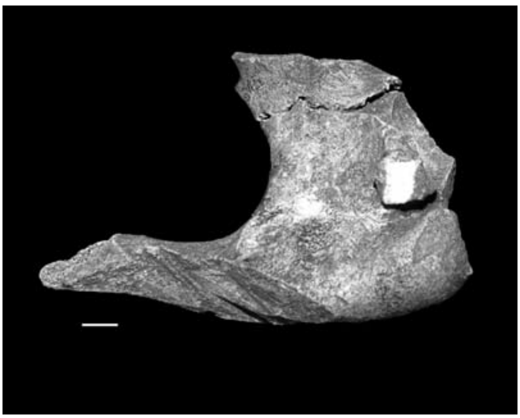

FIGURE 9

Right squamosum of dugong with clear chopping marks on the posterior part of the jugal arch. The scale bar is 1 cm.

A single pig bone from the late 17th century material was used in ancient DNA analysis, but the sampling took place before the size of the corresponding individual could be estimated. This bone yielded a sequence that is identical to the haplotype 'C' as defined by Larson *et al*. (2007) (James Haile, pers. comm.). This is the second most common haplotype amongst European domestic pigs, and is not found on any other continent. This result therefore suggests that pigs were brought from Europe, probably via the Cape of Good Hope where a large Dutch presence had been in place since 1652 (Moree, 1998). However, it is not excluded that pigs were also imported from the Dutch colonies in South-East Asia. As mentioned in the description of the pig bones above, there are some remains of individuals that are extremely small. Although insular dwarfism may have played a role, the observed size variation is much larger than what would be expected in a normal, homogenous, population. This suggests that there may have been multiple introductions, possibly from different regions. Additional DNA-analyses would be useful to try and elucidate these matters.

The provenances of the goat and cattle are unclear as well, but in the case of goat –of which sufficiently large samples are available– the observed size variation does not suggest multiple origins as in the pigs. The number of measurable cattle remains is too small to adequately illustrate the size variation.

No neonate or juvenile animals are present that would be indicative of the domestic species being bred in captivity. Therefore it is supposed that the remains of cattle, pig and goat were from feral animals that had been captured in the wild. However, accounts from the second Dutch occupation period mention that such animals were put in an enclosure near the fort after they were caught in the wild (Moree, 1988: 77, 82). This practice can also explain why all skeletal parts are found, including those of the larger species such as cattle and Java deer.

Cats were never mentioned in historical documents from the Dutch period, but a French crew visiting the island in 1709 saw large feral cats. The cat remains found in the samples from Fort Frederik Hendrik show that the species was present at the island during the last quarter of the 17th century, as was already suspected from written documents mentioning the rapid decline of ground-nesting birds that were previously unaffected by predation by pigs. Since the Dutch authorities never mentioned cats, it has been suggested that the species came from a visiting, possibly English, ship that called at the north-west harbour in the mid-1680s. Dutch freemen might have received cats from visiting sailors in exchange for meat, a deal of which the authorities may have been ignorant (Cheke & Hume, 2008; footnote 88, p. 302). If this theory is correct, cats must have spread rapidly across the island.

During the second Dutch occupation phase, hunting dogs were introduced that, according to the authorities, had little chances of survival when they escaped or were released in the wild. In the 1670s such escaped hunting dogs were reported. However, it is likely that the individuals of which the bones were found during the excavations lived in a close relationship with people. They could survive on the food that they received or that they obtained from scavenging on the consumption refuse of the inhabitants of the fort, as shown by the gnaw marks observed.

A final domestic species of which relatively little information is provided in the reviews by Staub (2003) and Cheke & Hume (2008), is the horse, apparently because it had little impact on the island fauna. The few written records that exist are in agreement with the date of our finds in the last quarter of the 17th century: horses would have been released in the forests in 1672 and they were observed in 'wild' state in 1693 (Staub, 2003: 54). The finds from the excavations in the fort are few and may well all belong to a single individual that was kept near the fort.

Aquatic resources

The large number of fish remains indicates that fishing was carried out regularly and that it thus must have been an important activity in the food procurement. The ecological preferences of the identified fish, mentioned in the descriptive part above, indicate that the majority of the fishing activities took place in coastal waters, most of the taxa being reef-associated fish that occur over reefs or sandy bottoms. Many species also enter lagoons and estuaries. A small proportion of the identified fish is from requiem sharks, hammerhead shark and jacks, which could be indicative of fishing in the open sea. It appears, however, that within each of these groups there are species that are known to occur inshore and even in estuaries. The reconstructed sizes are small in comparison with the maximum reported lengths for these taxa. Because juvenile animals live closer inshore than adult ones, this may be an additional argument to suppose that all the fish found at the fort was captured in or near the lagoon or in the estuary of one of the rivers emptying into it. In addition to fish, the estuaries or their mangrove swamps provided oysters. Although the studied mollusc sample contained no obvious consumption refuse, a contemporaneous, not yet published, context shows that oysters were eaten by the inhabitants of the fort. Inside the fort a pit was found that contained a concentration of well preserved *Saccostrea cucullata* and fragments of glass bottles.

A historical document evoking Dutch life at Mauritius in 1598 (Bonaparte, 1890; see Cheke & Hume, 2008: 24) shows the fishing activities that took place in the bay. The depicted gear includes seine nets, fish spears, and hook and line. From a practical point of view, waters with sandy bottoms may have been more effectively worked with nets than reef areas where nets risk damage. In areas with reefs or rocky bottoms, the use of fish hooks may have been more effective. The fishing gear discovered thus far from the excavations consists of metal fish hooks, while net weights have not yet been found.

Although the species spectrum of the identified fish is very broad, it is striking that parrotfish (Scaridae), a family of which more than 20 species are known from Mauritian waters today, are totally lacking. These are very typical, reef-associated species that are frequently used as food fish today, including in Mauritius, and that are also found in abundance on other historic sites with coral reefs in their vicinity. This is the case, for instance, for Roman Berenike (e.g., Van Neer & Ervynck, 1998) and Roman and Islamic Quseir (Hamilton-Dyer, 2000 & in press) both along the Red Sea coast. Another missing taxon is the snappers (Lutjanidae), although this family was poorly represented in the aforementioned sites. Its absence at the Mauritian site therefore appears less suspicious. The absence of parrotfish in the late 17th century deposits of Fort Frederik Hendrik cannot be related to the lack of coral reefs which, as is also known from written records, surrounded almost the entire island. The fish and the molluscs identified from the archaeological samples also confirm the presence of coral reefs. Because depletion of the parrotfish stocks due to excessive exploitation does not seem a plausible explanation for their total absence, it is more likely that these fish were avoided for consumption. The first possible reason that comes to mind in tropical and subtropical areas with coral reefs is the fear for poisoning. Already in 1601, reference is made to poisonous fish in an account of the Dutch admiral Wolphart Harmansen, and five years later Cornelis de Jonge wrote about a bream-like fish of red colour that made people ill for several days (Wheeler, 1953). These accounts had an influence on the attitude towards fish of later Dutch crews, although they continued to eat them as shown by later 17th century writings. Later historical documents, from the French and the British conquerors of the island, also comment on the edibility of the fish, often with sufficient detail as to allow an identification of the taxa that are meant (Wheeler, 1953). Parrotfish do not seem to figure among the fish that are reported to be possibly toxic in the old accounts and also today parrotfish, and other primary consumers, are safe to eat in Mauritius (Hurbungs, pers. comm.).

There are over 400 species of bony fish that have been reported to be toxic as a result of the accumulation of ciguatoxin, a substance that derives from a dinoflagellate living on other algae and on coral rubble (Van Egmond, 2004). Symptoms are gastrointestinal, neurological and cardiovascular disturbances that in some cases even lead to death (Lewis, 2006). The most dangerous fish are larger carnivorous species from families such as the groupers (Serranidae), emperors (Lethrinidae), jacks (Carangidae), barracudas (Sphyraenidae), moray eels (Muraenidae) and snappers (Lutjanidae). Important vectors in the transfer of ciguatoxins to carnivorous fish are invertebrates that graze on algae, as well as the herbivorous Acanthuridae (surgeonfish and unicorns) and the corallivorous parrotfish (Scaridae) (IPCS, 1984). In general, herbivores such as parrotfishes are safe to eat. However, in certain areas where ciguatera is prevalent, large parrotfishes have been reported as poisonous, for instance at the Gambier Islands, in French Polynesia (Chungue *et al*., 1977). Nowadays ciguatera is very unpredictable and fish may be safely consumed in one part of the world and be listed as ciguatoxic in another (Froese & Pauly, 2008). One may wonder whether parrotfish were avoided by the Dutch because they were confounded with another taxon, or because there had been a case of severe fish poisoning due to scarids that was long remembered but not necessarily documented in the historical written records. An alternative, probably less likely, explanation could be that parrotfish were not appreciated as food fish: in a popular booklet on the fish from Mauritius it is stated that parrotfish have flabby meat, hardly appreciated at the table (Michel, 2004: 108). However, it is hard to imagine that crews tired of eating salted meat would for this reason completely ban the consumption of a food fish that was easily obtained in the coastal waters of Mauritius.

The size distribution of the serranids (Figure 6) shows that most fish measure between 30-40 and 50-60 cm standard length. Possibly the absence of large groupers may also be explained as avoidance of fish that are reputed to be toxic? Fifty percent of the ciguatera outbreaks in the nearby island of Réunion, during the period 1986-1994, were due to serranids (Quod & Turquet, 1996). Alternative explanations for the small size of the serranids consumed at Fort Frederik Hendrik, such as overfishing or restrictions in size due to the fishing gear, are less likely. According to the accounts, fish stocks seem to have been plentiful during the Dutch period with a possible decline during the first decade of the 18th century, according to a report of the last Dutch governor (Wheeler, 1953: 46).

Other aquatic animals that were exploited by the inhabitants of the fort are the marine turtles and dugong. The heavily fragmented nature of the turtle carapaces did not permit a species identification. Cheke & Hume (2008: 390) stipulate that early reports refer to the green turtle (*Chelonia mydas*) or that they do not distinguish the species. The fact that a Dutch official mentioned the manufacture of combs and other objects from turtle carapaces in 1680 would be indicative of hawksbill turtle (*Eretmochelys imbricata*). The loggerhead turtle (*Caretta caretta*) was never mentioned specifically, but has been depicted in a document that refers to the period 1601-1603. The first two species still come ashore in Mauritius to lay eggs, but are rare (Hughes, 1982). Turtles were harvested in large numbers during the early visits of the Dutch, and this also continued in the 1620s and later, when the introduced mammals had already become numerous. However, the major pressure on the turtle populations resulted from the feral pigs digging up the eggs at the beaches, and –during the second occupation period of the Dutch– from cats predating on the young turtles.

The dugong remains found at Fort Frederik Hendrik show that the species, which is nowadays locally extinct, was still present and exploited at Mauritius during the last quarter of the 17th century. A contemporaneous account (from 1673-1675) reports that dugong were numerous in the lagoons of the island. The morphology and nursing behaviour of the animal are accurately described and the quality of the meat and fat that it produces is praised. A somewhat later account (1691-1693) describes how easily dugongs are captured at Rodrigues, another Mascarene island. The animals could be shot, but it was also possible to pull them ashore without firearms, either with bare hands or by using a rope attached around the tail (Cheke & Hume, 2008:

268). Dugong are very vulnerable to predation as a result of their long life span of 50 to 60 years, their late start to sexual maturity (9-10 years), and their low reproduction rate. The single calves are only born with an interval of 3 to 7 years (Marsh *et al.*, 1984). Population modelling shows that an adult survivorship of about 90% per year is needed for population maintenance. This explains their rapid decline at Mauritius: by the 1730s they had become extremely rare, but they were still occasionally observed up to the turn of the 18th century.

Food procurement and diet

Although it is realised that the different animal groups have unequal chances of survival in the archaeological record, an attempt was made to make a rough estimation of the importance of the different food procurement strategies and the contribution of the various animal taxa to the diet (Figure 10). The proportions of the number of identified specimens (NISP) reflect the frequency with which the different activities (fishing, hunting, harvesting) took place. When the NISP-values are multiplied by an average live weight, a rough approximation is obtained of the dietary contribution of the various animal taxa. The average total weights were defined as follows: fish 1 kg, goat 25 kg, pig 40 kg, sea turtle 100 kg, Java deer 120 kg, cattle 250 kg, and dugong 300 kg. Chickens, of which only two bones were identified, have been omitted from these calculations. Although fish yielded the most abundant remains and may have been a regular food resource, their nutritive importance is extremely small (1%) compared to the other animals. In terms of weight, the harvested dugong and marine turtles may have contributed around 40% of the animal food, whereas the rest was provided by the pig, goat, cattle, and Java deer. The deer in particular seem to have been an important source of animal protein.

POSSIBLE FUTURE RESEARCH

The faunal remains described above cover a snapshot of about 25 years maximum. The material did not yield any evidence for the dodo (*Raphus cucullatus*), or other endemic birds that became extinct. The same is true for the endemic tortoises *Cylindraspis inepta* and *Cylindraspis triserrata*.

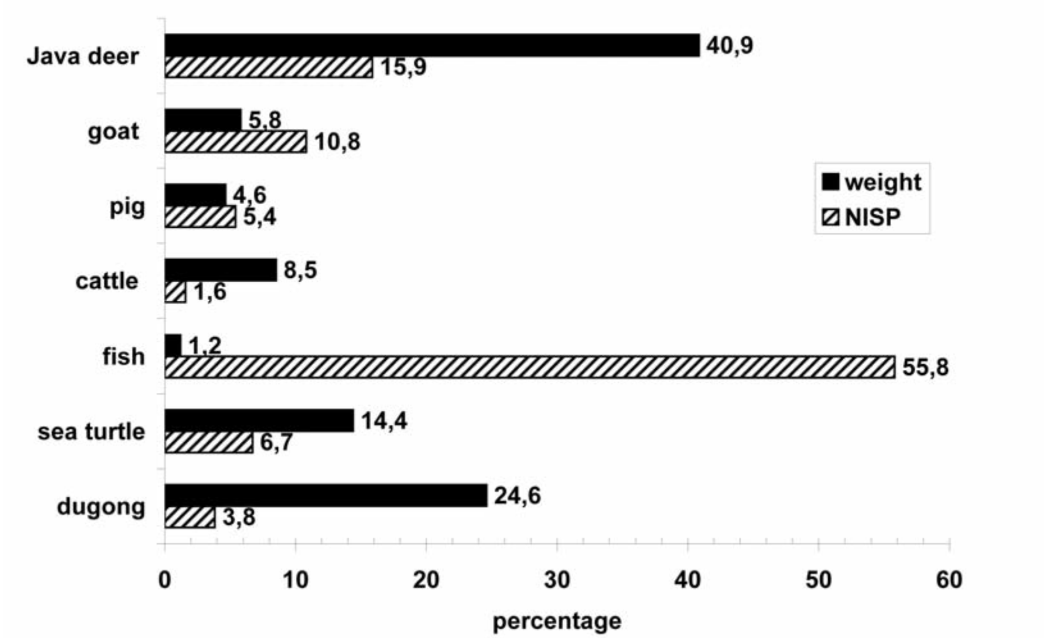

FIGURE 10

Relative importance of the major food animals, expressed as percentages of the NISP (number of identified specimens) and as percentages of the total meat weight represented by the finds collection (see text for an explanation of this estimation).

These were already very rare at the end of the 17th century according to an account of Commander Roelof Diodati, who complained that in five years duration he only got tortoise on the table twice (Cheke & Hume, 2008: 81). These animals were overexploited due to massive slaughtering by the early Dutch crews and settlers, but they were also taken onboard ships as a live source of food. Maybe the few remaining specimens were hauled aboard ships rather than consumed on the island? By 1725 the tortoises are believed to have been extinct on Mauritius and its satellite islets (Austin & Arnold, 2001). The investigation of the second refuse context that is available, from outside the fort, would be worth carrying out in order to increase the sample size for the last quarter of the 17th century and to verify if any remains of the aforementioned, extinct, species can be found. It would be worth verifying what the incidence of these species was in the faunal remains from the first Dutch settlement period (1638-1658), once such faunal assemblages are available, and compare these data to the available information about these taxa obtained from natural (e.g., Rijsdijk *et al*., 2009) and anthropogenic (cf. Janoo, 2005) deposits. To broaden the chronological window even more, it would be desirable to also include faunal material from the French period (1721-1806). Possible lines of investigation, within a diachronic framework, could include the documentation of the species spectrum exploited through time and the relative importance of the taxa in the food provisioning. It might be particularly interesting to try and follow possible effects of overexploitation of the dugong and the marine turtles. Also in the case of the fish, it could be verified if changes in size or species spectrum occur that can be related to pressure on the fish stocks. It would also be worth verifying whether patterns emerge that can be related to the avoidance of certain fish taxa for which evidence was found in the late 17th century assemblage described above.

The study of the molluscan remains would also benefit from a larger, and chronologically and spatially more diverse, sample; not only to verify the environmental interpretations, but also to allow exploration of the archaeological perspective, i.e. the value of molluscs as a food source, or the use of their shells as raw material, tools or currency. In addition, absolute dating of *Allopeas* cf. *gracile* is necessary to verify the contemporaneity of the shells and to reconstruct the timing of their introduction to Mauritius.

In addition, the proportion of the terrestrial animals would be worth documenting through time, with an emphasis on the proportion of the Java deer and the various feral species used as food (pig, goat, cattle). In such a time series, possible changes might be documented in the size of the aforementioned species as a result of their introduction into an insular environment. Besides these traditional archaeozoological analyses, molecular research can also be conducted into the provenancing of the various domestic species and of the rats.

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