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ABSTRACT. A description is given of the fish remains from six settlement mounds located along the Senegal River that cover an occupation of approximately 1800 years. The 22 fish taxa found at the sites are described and attention is focussed on their spatial and, especially, temporal distribution. The place and season of capture are established and the possible fishing techniques are reconstructed. Using diachronic trends seen in the size distribution of the fish, it is argued that the ichthyofauna of the Middle Senegal Valley already shows effects of overfishing during the course of the first millennium AD.

Introduction

The Middle Senegal Valley (Figure 1) is a relatively narrow floodplain dotted with traces of ancient villages that received attention from archaeologists since the 1970s (Martin and Becker, 1974, 1981, 1984; Bocoum, 1993). During surveys carried out in a stretch of about 400 km along the river, between Dagana and Dembakane, hundreds of sites have been discovered some of which were also excavated. It appears that floodplain settlement is exclusively Iron Age in date. Besides large flat sherd scatters and iron smelting sites, the area comprises a large number of extensive settlement mounds. Renewed site survey and excavations carried out in the 1990’s (McIntosh et al. 1992; Bocoum et al. 1999) aimed at understanding the nature and chronology of human settlement in the central sector of the region. On that occasion large habitation mounds, offering the possibility of controlled excavations at deeply stratified sites, were selected for excavation in the area of Cubalel and Siouré. This allowed obtaining a sequence of material culture and the establishment of a chronology. A detailed monograph dealing with all aspects of the excavations and reconnaissance along the Middle Senegal Valley is forthcoming (McIntosh et al. in preparation).

At the 10 ha Siouré mound, three 3 x 4 m units were sunk (S1, S2, and S3). The site of Cubalel is in fact a complex of eight occupation mounds of varying heights, scattered over an area of more than 1 km². In five of them—C1, C2, C3, C6, and C8—excavation units were sunk (3 x 4 m except in the highest mound (C3) where the unit was 10 x 6 metres). The faunal remains were hand-collected in the trench, but in addition, all the sediment was sieved through a 2 cm mesh (R. McIntosh, pers. comm.). The fauna consists mainly of fish and mammals, and among the mammals ovicaprines dominate (McIntosh et al. 1992). Domestic cattle were found, along with wild bovids. Apparently this society was practising a mixed economy of herding, fishing, occasional hunting and most likely farming (McIntosh et al. 1992).

Intra- and intersite comparisons of the fish fauna have been carried out in an attempt to detect possible human adaptive strategies responding to environmental changes or to other factors such as the influx of new groups. The archaeofaunal data have therefore been considered in relation to the ceramic chronology (McIntosh et al. 1992; McIntosh and Bocoum 2000:30; Susan McIntosh, pers. comm.) and of the possible effect that changing climatic conditions (Roderick McIntosh, pers. comm.) may have had on the available fishing grounds. Ceramic phase I (AD 0–400) roughly corresponds to the second half of a sustained dry period. Improving precipitation is supposed for the period AD 400–700, followed by a stable optimum lasting until about AD 1100. During this whole period of slightly more humid conditions, ceramic phases II (AD 400–600) and III (AD 600–950) were recognised. The ceramic phase IV (AD 1000–1500) is poorly represented in the excavated sequence. It has been identified mainly on the basis of surface assemblages and more or less coincides with a period of unpredictability and aridification that lasted until AD 1500, when a return to more humid conditions started again (ceramic phase V: AD 1500–1800). The mounds cover an occupation of approximately 1800 years, but, as will be shown below, the majority of the bones are from the first millennium AD.
The inhabitants of the mounds near Cubalel and Siouré had a variety of aquatic habitats at their disposal (Figure 1). All mounds, for which fish bones had been made available for study, were situated on 9–10 m levees that were less than 1 km west of the Senegal main river bed. These levees are nowadays always above the annual flood levels. Further west from the main river, a moderately wide floodplain was present that extended towards the Doué river bed. To the south and southwest of the Cubalel mounds, large basins were present within walking distance. Such deep basins within the floodplain were also available south of Siouré. In addition, smaller floodplain ponds were present that could be exploited for their fishes. Other suitable fishing places would have been the temporary channels through which fish migrated towards the floodplain at the beginning of the rains and through which they returned to the main river when water levels dropped.

Figure 1. The Middle Senegal Valley region with a detail of the study area. 1 = floodplain; 2 = uplands; 3 = levees; 4 = deeper basins (map compiled from McIntosh et al. 1992, Bocoum 1993, McIntosh and Bocoum 2000 and field notes provided by Roderick McIntosh).
Of the other settlement mounds excavated thus far in the Middle Senegal Valley, faunal data are limited to those of the first millennium AD sites of Sincu Bara for which only qualitative data are available (McIntosh and Bocoum 2000), and of Tulel-Fobo with quantitative data (Van Neer and Bocoum 1991). A brief comparison with the latter fish fauna will be carried out in the discussion.

Description of the Taxa

The total number of analysed fish bones was 3723 of which 2803 or 75% were identifiable. Identifications were carried out by comparison with the modern reference collection housed at the Royal Belgian Institute of Natural Sciences. For each identifiable bone the skeletal element and taxon were noted by level or feature. Fish lengths were reconstructed for each well preserved bone by comparison with modern fish of known length. The lengths are expressed in centimetres and correspond to standard lengths (SL), i.e., the length of a fish from the tip of its snout to the base of the caudal fin. The bone finds, that were initially recorded by level and feature, have been lumped by ceramic phase for the individual mounds (Table 1).

At least 22 different fish taxa have been identified (Figure 2); they will be briefly described in the following paragraphs. Information on the present-day distribution of species in the Senegal River was borrowed from, amongst others, Reizer (1988) and Lévêque et al. (1990, 1992). Data on the ecology and behaviour of the fishes have been com-

Table 1. Number of fish remains found in the various mounds and grouped by ceramic phase within each mound.

| mound   | C1    | C2    | C3    | C6    | C8    | 1S    | 2S    | 3S    |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|
| ceramic phase | II    | IIIA  | end II | IIIA | IA | IB | II | IIIA | IIIB | IIIA | IB | mixed with IV and V | IB | II | mixed with V | V |
| Protopterus annectens | – | – | 1 | – | – | – | – | 1 | – | – | – | – | – | – | – | – | – |
| Polypterus sp. | – | 7 | – | 1 | – | 1 | 2 | 5 | – | 5 | 1 | – | 2 | – | – | – | 2 |
| Heterotis niloticus | 2 | 5 | 11 | 1 | – | 4 | 2 | 4 | 2 | 9 | – | 2 | 3 | 3 | 2 | 1 |
| Gymnarchus niloticus | – | 1 | – | 1 | 3 | – | 4 | 3 | 3 | 3 | 4 | – | 3 | 2 | – | – | 4 |
| Mormyridae | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Cyprinidae (cf. Barbus) | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Cyprinidae (cf. Labeo) | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 |
| Citharinus sp. | 1 | 5 | – | 4 | – | 3 | 1 | 1 | 2 | – | – | 2 | 2 | – | – | – | 3 |
| Distichodus sp. | – | 2 | – | – | – | 1 | – | – | – | – | – | 1 | – | – | – | – | 1 |
| Citharinidae | – | 13 | – | – | – | 3 | – | 6 | – | – | 1 | – | – | – | – | – | – |
| Hydrocynus sp. | 1 | – | – | 2 | – | – | 2 | – | – | – | – | 2 | 1 | – | – | – | – |
| Alestes/Brycinus | – | – | – | – | – | – | 1 | – | – | – | – | – | – | – | – | – | – |
| Bagrus sp. | 4 | 7 | – | 3 | 1 | 13 | 5 | 7 | 3 | – | 10 | 2 | 2 | 2 | 1 | – | 2 |
| Clarotes laticeps | 1 | – | – | 1 | 1 | 1 | 1 | 1 | 1 | – | – | 1 | 2 | – | – | – | – |
| Chrysichthys sp. | – | – | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Auchenoglanis sp. | 3 | 3 | – | 17 | 1 | – | 11 | 1 | 13 | 3 | – | 5 | 1 | 2 | 6 | 5 | 8 | 2 | 8 |
| Synodontis sp. | 8 | 56 | 1 | 56 | – | 2 | 14 | 7 | 24 | 9 | 2 | 24 | 9 | 9 | 3 | 5 | 4 | 18 | 16 |
| Clariidae | 219 | 251 | 8 | 82 | 6 | 6 | 193 | 120 | 179 | 72 | 12 | 96 | 9 | 63 | 46 | 75 | 42 | 36 | 25 |
| Tilapiini | 3 | 39 | 2 | 20 | 1 | – | 6 | 10 | 15 | 5 | – | 6 | 1 | – | 1 | 1 | 5 | 5 | 2 |
| Lates niloticus | 22 | 53 | 3 | 35 | 7 | 1 | 96 | 15 | 70 | 17 | 4 | 19 | 2 | 46 | 18 | 66 | 25 | 16 | 10 |
| Parachanna sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Tetraodon lineatus | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| total identified fish | 264 | 445 | 14 | 236 | 21 | 10 | 352 | 170 | 329 | 114 | 21 | 182 | 22 | 129 | 85 | 162 | 91 | 80 | 76 |
| unidentified fish | 51 | 183 | 5 | 156 | 1 | – | 104 | 32 | 98 | 40 | 14 | 58 | 14 | 35 | 21 | 52 | 17 | 13 | 26 |
Lungfish are represented by two jaw fragments which are the most durable parts of their skeleton. They have been attributed to *Protopterus annectens* which is the only species present in western Africa. Typical for lungfish is their preference for shallow waters and their ability to use atmospheric oxygen. They can survive in a cocooned state in burrows that they dig on the floodplain at the onset of the dry season. Capturing lungfish can involve fishing in shallow waters or digging them out of their burrows when the floodplain is dry. In areas where *Protopterus* is abundant, fishermen can specialise on them as has been demonstrated in the Sudanese site El-Zakiab, north of Khartoum (Tigani el-Mahi 1981). Densities of this species are low in the Senegal Valley today and apparently this was also the case in the two previous millennia.

The genus *Polypterus* consists of two species in the Senegal River: *P. bichir* and *P. senegalus*, but the recovered remains—mainly vertebrae and rhomboid scales—do not...

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*Figure 2.* Fish taxa represented in the Middle Senegal Valley sites.
allow a species identification. Size reconstructions carried out on the vertebrae show that most captured specimens were between 40–50 and 50–60 cm SL, with fewer fish measuring 30–40 or 60–70 cm SL. *Polypterus* have a preference for shallow habitats with sandy bottoms and aquatic vegetation.

*Heterotis niloticus* is another species preferring muddy bottoms with abundant aquatic vegetation. Because of its spawning behaviour this fish is extremely vulnerable to human predation: on the floodplain it uses plant material to construct circular nests of up to more than 1 metre diameter. They stay in these nests, made in marginal areas, during spawning, but also after hatching when one of the parents guards the young. The fact that this fish is sensitive to overfishing is noted in several rivers of the Nilo-Saharan ichthyofaunal province and is reflected in a decrease in size and finally in rarefaction or even local extinction (pers. obs. in Niger, 1985). The number of *Heterotis* remains in the Middle Senegal Valley sites is relatively low and it was therefore impossible to verify if a size decrease occurs through time. Reconstructed sizes vary between 20–30 and 70–80 cm SL, but most specimens measured between 40–50 and 60–70 cm SL.

*Gymnarchus niloticus* is also a vulnerable species because of its more or less comparable reproduction behaviour. It builds large floating nests from stalks of *Echinochloa stagnina* that usually float near the edges of ponds or pools. The specimens found during the excavation are all from large individuals. Most of the *Gymnarchus* measured between 1 and 1.5 m, but there was one specimen of 90–100 cm SL and one of approximately 2 m. Again, bone numbers are too low to document size distributions through time, but the overall sizes suggest that this fish was not overexploited. The family of the Mormyridae is represented by a single bone. A caudal vertebra of a fish measuring 50–60 cm SL was found in mound C1. This element was not diagnostic enough for a more detailed identification, but based on the reconstructed size it is likely that it is from *Mormyrus* or *Mormyrops*. These fish are bottom feeders that can be captured in the main channel, but which are also abundant in isolated pools on the floodplain.

Cyprinids are poorly represented. On the basis of the number of trabeculae, two vertebrae could be identified as *Barbus* and another one as *Labeo*. One of the *Barbus* measured 40–50 cm SL, the other one 60–70 cm SL, whereas the *Labeo* bone was from an individual of 50–60 cm. Because of their large size, the recovered specimens may have been captured in the main channel, but it is not excluded that they have been taken from the floodplain since cyprinids usually can survive in waters with rather low oxygen content.

The Citharinidae genera *Citharinus* and *Distichodus*, have a quite distinct osteomorphology for a number of isolated bones, but there is overlap in shape for several elements. In those cases the bones were labelled as ‘Citharinidae’. Most of the fish found in the mounds had a reconstructed size of 30–40 to 40–50 cm SL, occasionally a specimen of 50–60 cm SL occurred. Fishes of this size are usually captured in the main river, but they can also be caught in the floodplain. They have a preference for slow running waters and are essentially plant and detritus feeders.

The occasional finds of tigerfish of the genus *Hydrocynus* include four vertebrae, a jaw fragment, a tooth, a hyomandibular and a keratohyal. Six out of the 8 specimens are from fish measuring between 50 and 60 cm SL. In addition there is one bone corresponding to an individual of 40–50 cm SL and another one from a fish measuring 60–70 cm SL. The preserved bone elements do not allow us to make a distinction between the two species *Hydrocynus brevis* and *H. forskali* that occur in the Senegal basin. These *Hydrocynus* species prefer open water and usually stay rather briefly on the floodplain.

One precaudal vertebra has been designated as *Alestes/Brycinus*. Because this specimen corresponds to an individual of 30–40 cm SL, it must belong to one of the larger species living in the Senegal River, i.e., *Alestes dentex*, *Alestes baremoze* or *Brycinus macrolepidotus*. These species are encountered both in the main channel and on the floodplain. Smaller specimens can be very numerous in residual pools.

At least 7 catfish taxa have been identified from the Middle Senegal Valley mounds. The most abundant group are the clariid catfish among which the presence of both the genera *Clarias* and *Heterobranchus* has been attested. Identifications based on the pectoral spines (cf. Gayet and Van Neer 1990) show that of the 15 well preserved specimens 8 belong to *Heterobranchus* and 7 to *Clarias*. Each genus is represented by two species in the Middle Senegal River, but an identification to that level could not be carried out. The skeletal element distribution of the clariids is comparable to what is found at most other African sites, namely an overrepresentation of head bones and an underrepresentation of vertebrae. It has been shown elsewhere that this ratio is related to preservation chances rather than an effect of decapitation and subsequent removal of catfish bodies (Gautier and Van Neer 1989; Van Neer 2004). The reconstructed sizes vary between 20–30 cm and 120–130 cm SL and it is striking that very large individuals are rather nu-
merous. Since the clariids are so abundant, it was possible to look at the size distribution through time for a number of mounds (see 3.3 below). Claridiids are typical inhabitants of shallow waters that occur in vast numbers on floodplains during the inundation. At the beginning of the floods these catfish migrate laterally towards the spawning grounds that are preferably in marginal, shallow areas. When the waters recede, the larger individuals return to the main river, later on followed by smaller individuals. A substantial number of smaller fish usually gets caught in residual pools on the floodplain where they are subjected to increased predation by man and other vertebrates.

Another abundant group of catfishes are the *Synodontis*, mainly represented at the sites by the elements that typically have the best preservation chances, i.e., pectoral and dorsal spines, skull roof fragments and parts of the pectoral girdle (cleithrum and coracoid). More than 10 species occur in the Senegal basin, but no attempts have been made to carry out specific identifications because the reference material at our disposal does not include all species. Size reconstructions indicate a preponderance of specimens measuring between 10–20 and 20–30 cm SL, but fish smaller than 10 cm SL and individuals of 30–40 cm SL occur as well. Adult *Synodontis* typically occur in open waters and are usually found in large numbers on sites where open water fishing is also indicated by the presence of Nile perch (Van Neer 1994). They migrate, however, also into the floodplain during the inundations for reproduction. Smaller individuals (below 10–15 cm SL) can be numerous in residual pools. Judging from their size and because capturing adults in the inundated plain is difficult, the majority of the *Synodontis* at the Middle Senegal Valley sites seem to be individuals captured in the main channel.

In terms of the total number of remains found, *Auchenoglanis* is the third most important catfish taxon at Cubalel and Siouré. In the Senegal basin two species occur namely *A. bicutatus* and *A. occidentalis* for which thus far no diagnostic criteria were described for isolated skeletal elements. Reconstructed sizes vary between 10–20 and 50–60 cm SL. Both species prefer muddy substrate and they can occur in both the main river and the floodplain.

*Bagrus* is another fairly well represented catfish genus. Two articulars can be attributed to *Bagrus bimak* using the diagnostic criteria, described by Boessneck and von den Driesch (1982), which distinguish it from *Bagrus docmak*, the second species of this genus occurring in the Senegal basin. The reconstructed fish lengths vary between 10–20 and 80–90 cm SL, with most specimens in the size classes 40–50 and 50–60 cm SL. Except for the smallest individuals, these catfish were probably captured in the main river. During the spawning season the mature individuals stay only for a very short period on the floodplain when the water levels are maximal. The juveniles undergo their first growing season on the floodplain and can be found in residual pools.

*Clarotes laticeps* is another species belonging to the Bagridae family. Reconstructed sizes vary from 20–30 to 60–70 cm SL with the majority of the specimens measuring 30–40 cm. Little information on the ecology of this species is available. Still another member of the bagrid family is *Chrysichthys*, a genus represented in the Senegal River by at least 3 species (*C. nigroditatus*, *C. mauro* and *C. auratus*). The latter species does not attain the large sizes (50–60 and 60–70 cm SL) that were reconstructed for the pectoral spine and the Weberian apparatus found at the sites.

Tilapia are another rather well represented group of fishes. Numerous species, belonging to the genera *Tilapia*, *Oreochromis* and *Sarotherodon*, occur in the Senegal basin and no attempt has been made to identify the tilapia bones to species. The recovered specimens vary in size from <10 cm to 30–40 cm, but most individuals fall in the size class 20–30 cm. The number of bones available by phase is too low to construct valuable graphs illustrating size variation through time. Tilapia are typical floodplain dwellers that can be captured most effectively during their spawning season and, later on, in residual pools on the floodplain in which they can occur in large quantities.

The Nile perch (*Lates niloticus*) is very abundant at all mounds and it certainly was one of the major food fishes. It attained sizes of up to 140–150 cm SL, but very small individuals were also occasionally encountered. Nile perch are typical inhabitants of the main river and larger individuals occupy the deeper parts of the main channel. Spawning usually takes place in the main river from where the larvae migrate onto the floodplain to undergo their first growing season. Occasionally adults venture into the flooded plain when water levels are at their maximum. The maximum size of the first year’s generation is 30 cm SL when they enter the main channel at the end of the floods. This means that all fish larger than 30 cm SL must have been captured in the main channel. A few specimens smaller than 30 cm SL were encountered in the excavated sites indicating that they had been taken from the floodplain.

*Parachanna obscura* is represented by two specimens only. A dentary corresponding to an individual of 30–40 cm SL was found in mound C3, and a fish of similar size is represented by a precaudal vertebra in mound C6. This species
is typical of shallow water habitats and has a preference for well vegetated areas.

The puffer fish *Tetraodon lineatus* is represented by two jaw fragments of individuals measuring 20–30 cm SL and by one such element of a fish of 30–40 cm. This species is edible on the condition that the toxic liver is removed soon after capture of the fish. It occurs in the main river as well as on the floodplain.

**Discussion**

As the number of identifiable fish bones was relative small within each level or feature distinguished in the various excavated mounds and as the number of taxa is high (at least 22), chance fluctuations can play an important role in the representation of the various fish. Within the individual mounds no significant trends in the spatial or temporal distribution could be detected when the material was considered by separate level or feature. It was therefore decided to conduct further analysis after lumping the material from each mound by ceramic phase. Even then, it appears that intra- and intersite comparisons are difficult because occupation has been episodic and because mounds lack continuous occupation and large samples from all time periods.

In the following paragraphs, the data are evaluated with the aim of establishing place and season of capture of the fish, and of reconstructing fishing methods. The physical setting of the mounds, climatic conditions, the possible influx of new groups with different subsistence strategies or fishing techniques, the establishment of food exchange networks, the presence of processing concentrations are all factors that can have an influence on the composition of the recovered fish fauna.

**Place and Season of Capture of the Fish**

As already mentioned in the introduction, the inhabitants of the mounds near Cubalel and Siouré had a wide variety of aquatic habitats at their disposal, i.e., the Senegal and Doué rivers, the deep basins and small ponds on the floodplain and the temporary channels towards the floodplain (Figure 1). It is obvious from the fish species lists and from the ecological information given above on the individual species that people exploited fish both from the main river and from the floodplain. The extent to which the various habitats were exploited may have been influenced by the environmental conditions, which changed over time. The length of the flood season varied with climate, as did also the period during which the floodplain held water. The deeper basins may have held water for perhaps 6 to 8 months during the beginning of Phase II and throughout Phase III, which is 2 or 3 months longer than today. It is unclear if permanently flooded conditions might have existed; some of the deeper basins may exceptionally have been flooded all year (Rod McIntosh, pers. comm.). The medium bathymetry floodplain ponds were also larger during the climatic optimum and may have held water for 4 to 6 months, which is 1 or 2 months longer than today. Probably, most parts of the floodplain would have been dry for at least 3 or 4 months each year, even during the climatic optimum.

Another effect of wetter climate was that the waters of the Senegal and Doué would have flowed faster and higher during its non-flood stage. During extremely dry years, the water levels of the main river may have been extremely low, making the Senegal River wadable at various places. Such conditions have been described for the 1968–73 period and occurred, amongst others, at Bogué, just west of Siouré (Reizer 1988:118).

The type of fish, their sizes, the place where they were captured and the fishing techniques must have varied seasonally. During the period that the floodplain was dry, fishing was necessarily restricted to the main river. Good indicators for this exploitation are the large Nile perch, *Hydrocynus*, *Synodontis*, *Bagrus* and *Auchenoglanis*. It is not excluded, however, that some of the typical floodplain dwellers (e.g., the large clariids) were also captured in the main river, especially during dry years.

When the floods started, a lateral migration occurred of fish that use the floodplain as spawning grounds and it is also in this part of the river system that the juveniles underwent their first rapid growth season. Clarid catfish are among the first species that start migrating and they usually are captured in large quantities in the splays through the levees (the channels leading towards the floodplain) and, later on, in the marginal areas of the floodplain where they spawn in shallow waters (Bruton 1979). When the water levels decrease, the larger specimens migrate first towards the main river through channels that can again be worked to retain fish. Judging from their large numbers and the size of the clarids (Figure 3) this type of exploitation was an important activity throughout the considered period. Also today the clarids are one of the major fish species landed (Reizer 1988). *Tilapia* are another group of fish that typically favour shallow water habitats for reproduction, but they seem to have been exploited less frequently than the clarids. The same is true for the poorly represented lungfish and for the cyprinids.

When the waters recede from the floodplain, residual pools and ponds are formed in which the fish are retained that
did not join the main channel in time. These constitute reservoirs that can be exploited for several months until they finally dry out completely. These residual waters typically contain smaller fish, a phenomenon that can be used in the analysis of fish bones to identify the fishing grounds (cf. Gautier and Van Neer 1989; Van Neer 2004). The presence of small fish in the mounds, albeit in small numbers, is indicative of the exploitation of interior seasonal creeks (marigots) and floodplain ponds. Also typical of rather shallow aquatic habitats are Gymnarchus niloticus, Heterotis niloticus, Parachanna obscura and species of the genus Polypterus. These fish prefer abundant vegetation, and may have been captured in marginal, shallow parts of the main river, or—more likely—on the floodplain in inundated areas where floating plants, especially Echinochloa stagnina can be found (Reizer 1988:86–94).

Figure 3. Size distribution of clarid catfish. The relative importance (%) is given for size classes of 10 cm SL. Sample sizes are as follows: C1, phase IIIA: 72; C1, phase II: 39; C3, phase IIIA: 50, C3, phase II: 62; C6, phase IIIB: 39; C6, phase II: 23.
In order to estimate the extent to which the various aquatic environments were exploited by the inhabitants of the Middle Senegal Valley settlements, the fish taxa were grouped according to their habitat preferences (Table 2).

As mentioned above, the category of open water species includes Nile perch, *Bagrus*, *Auchenoglanis* and *Synodontis* catfish and the tiger fish (*Hydrocynus*). Typical floodplain dwellers are the clarid catfish, tilapia, cyprinids and the lungfish. There are additional inhabitants of the floodplain that can be considered as a sub-group comprising species preferring well-vegetated, often marshy waters on the floodplain, i.e., *Gymnarchus niloticus*, *Heterotis niloticus*, *Parachanna obscura* and species of the genus *Polypterus*.

A few remarks should be made here concerning the attribution of the fish taxa to a particular group. It has been mentioned in the description of the taxa that in several species juveniles and adults occupy different parts of the river system. For instance, Nile perch smaller than 25–30 cm typically live on the inundated plains, whereas larger specimens almost exclusively stay in the main river. Similarly, larger *Synodontis* are considered as indicators of fishing in the main river. Such large specimens can be found for a short period of time on the floodplain while spawning, but it are mainly smaller *Synodontis* that can be harvested from floodplain ponds. The size distributions (Figures 3–5) show an underrepresentation of smaller

![Figure 4. Size distribution of Synodontis catfish. The relative importance (%) is given for size classes of 10 cm SL. Sample sizes are as follows: C1, phase IIIA: 53; C1, phase II: 7; C3, phase IIIA: 7, C3, phase II: 13; C6, phase IIIB: 18: C6, phase II: 9.](image-url)
individuals in all fish taxa. This would mean that the exploitation of shallow waters, with their relatively smaller fish, was not extensive. It is believed that the opposite was the case, and that the poor representation of small fish is related to sampling methods. Due to the lack of running, uncontaminated water, dry sieving had to be practised and, because the clays were highly flocculated, a 2 cm mesh size was the smallest that could be used. It appears from certain contexts, especially features of an ashy nature, that very small fish were captured as well. The fine sediment in these ashy contexts and the special attention that may have been given during the excavation of features may have favoured the preferential recovery of small bones. This means that the exploitation of shallow waters must have been more intense than reflected in the assemblages available for study. It is indeed likely that in the past, as today, juvenile fish were captured in large quantities during the period of falling water (Welcomme 1975). However, since the bone recovery during the excavations can be considered as more or less consistent it is judged acceptable to analyse the dataset for trends within and among mounds.

Figure 5. Size distribution of Nile perch. The relative importance (%) is given for size classes of 10 cm SL. Sample sizes are as follows: C1, phase IIIA: 49; C1, phase II: 15; C3, phase IIIA: 15, C3, phase 73: 62; C6, phase IIIB: 15; C6, phase II: 13; 1S, phase II: 14, 1S, phase IB: 38.
From the Cubalel mounds, Phase IA and Phase IB material is only available at C3, but the small sample sizes only allow to conclude that both main river and floodplain were exploited. The transition of Phase II and IIIA can be followed in mounds C1, C2, C3, and C6, but in both C2 and C6 sample size is small in one of the phases. Sufficient sample sizes are available for the transition of Phase IIIA to Phase IIIB in mound C3. The transition from IIIA to IIIB in C6 cannot be sufficiently documented since IIIA material is rare.

From the Siouré mound, only unit 2S allows one to study diachronic changes through Phases IB and II. It is striking that opposing trends are seen at C1 and C3 when the material from Phases II and IIIA is considered: in mound C1 an increase in open water species is noted in Phase IIIA, but in mound C3 the open water species decrease in Phase IIIA. Since C1 and C3 are in the same geomorphological position, other factors must account for the opposing trends. The important variation in proportions are also illustrated if material from the same ceramic phase of different mounds are compared. The contribution of open water fish during Phase II varies significantly between C1 (14.5%), C6 (28.6%) and C3 (39.2%) and also during Phase IIIA an important variation is seen between C3 (17.9%), C1 (28.1%) and C2 (49.3%).

In some cases, the physical environment may have had an influence on the composition of the fish fauna which is illustrated by a comparison of the Cubalel and Siouré data with those from Tulel-Fobo (Van Neer and Bocoum, 1991). That site, with deposits ranging in age from Phase II to late Phase III (AD 400–950), is located on the Jeeri (uplands) and thus farther away from the main river than the Siouré and Cubalel mounds. The ichthyofauna of Tulel-Fobo is characterised by a high proportion of floodplain species dominated by clariids (Table 3). Typical open water species such as Nile perch and Synodontis, that must have been derived from the more distant main river, are poorly represented. In the mounds located on the levees near Cubalel and Siouré, a low contribution of open water species is only seen in Phase II of C1and in Phase IIIA of C3 (see Table 2). For the site of Sincu Bara, also located on the Jeeri at about 100 km upriver from Cubalel, only a few fish taxa have been mentioned: *Lates, Clarias*, Tilapiini and *Gymnarchus* (McIntosh and Bocoum 2000:30). Since their proportions are not indicated it cannot be verified if floodplain dwellers predominate here as well.

No indications are available in the skeletal element distribution that point towards processing concentrations, and the fishing gear discovered at the mounds does not suggest any kind of shift in fishing technology. Theoretically, the existence of trade or exchange mechanisms resulting in the selective removal of particular taxa may have played a role but such processes cannot be documented within the studied faunal context. A possible explanation for the observed differences are natural variations in the fish fauna due to minor climatological changes (even on an annual scale, as observed today, see Reizer 1988). For instance, the number of days that the floodplain was inundated at Bogué, west of Siouré, varied enormously between 1967 and 1971: 101 days in 1967, only 27 days in 1968, 92 days in 1969 and 72 days in both 1970 and 1971. The duration of the fishes’ stay on the floodplain has an influence on the number of spawnings that can take place in multiple spawners, and also on the length of the first growing season of the larvae. It is clear that such factors have an impact on the composition of the fish faunas of the following years.

Thus far attention has been focussed on the lateral movements of fish, but there are also important up- and downstream migrations within the riverbed itself (Reizer 1988:129). It is obvious from modern observations that the extent of the horizontal migrations of freshwater fish is extremely variable and that it depends on the annual variation in run off. The composition of the ichthyofauna in the different parts of the river basin is thus also depending on this type of migrations. This may be an additional factor accounting for the fact that no clear diachronic pattern can

| Table 3. Proportion of marsh fishes, floodplain dwellers and open water species at Tulel-Fobo (sample size: 1220 fragments) |
| % |
| --- |
| **Polypterus sp.** | 0.7 |
| **Gymnarchus niloticus** | 0.1 |
| **total marsh species** | 0.8 |
| **Cyprinidae (cf. *Labeo*)** | 0.1 |
| **Clariidae** | 87.1 |
| **Tilapiini** | 0.9 |
| **total floodplain** | 88.1 |
| **Bagrus sp.** | 0.3 |
| **Auchenoglanis sp.** | 0.3 |
| **Synodontis sp.** | 3.8 |
| **Lates niloticus** | 6.6 |
| **total open water** | 11.1 |
be observed in the ichthyofauna of the studied mounds. The seasonal differences in run-off also determine how far the brackish water front enters the Senegal River and this in turn has an effect on the extent to which several marine fish species migrate the Senegal River in an upward direction during the dry season. Some of these fish even enter fresh water. *Elops lacerta*, *Polydactylus quadrifilis*, *Cynoglossus senegalensis*, *Mugil sp.* have been observed in Podor and *Cynoglossus senegalensis* has been captured at Cascas (near Siouré) (Reizer 1988:98). None of these so-called euryhaline, marine species has been encountered in the studied bone assemblages. The absence could indicate that these species did not reach the Middle Senegal Valley at the time the mounds were occupied, which would mean that conditions were more humid on average than today. However, it should be kept in mind that the absence may be an effect of the low densities in which the euryhaline species occurred, thus reducing the chances for their capture. Moreover, preservation conditions may have played a role. *Elops lacerta* bones, for instance, have relatively low chances of preservation due to their fragility. In the material from Poudioum, a shell midden situated closer to the Senegal River mouth, this fish is only sporadically represented (Van Neer, unpublished data) despite the fact that it is a common species in that part of the river (Reizer 1988).

**Fishing Techniques**

The overall species composition of the ichthyofauna from the Cubalé and Siouré mounds is comparable to that previously described from Tulel-Fobo (Van Neer and Bocoum 1991) and there is even a great similarity with the fish fauna from Jenné-Jeno and related sites in the Niger Inland Delta (Van Neer 1995). More or less the same species were exploited in the Sudanese part of the Nile (e.g., Caneva et al. 1993). This shows that similar strategies, involving the exploitation of both floodplain and main river, were applied in the whole Nilo-Saharan ichthyofaunal province. It was demonstrated in the Egyptian Nile, that a shift occurred around 8000 BP from fishing exclusively in the floodplain (with clariid catfish and tilapia as the major species) towards an exploitation of both floodplain habitats and the main river (Van Neer 1994, 2004). Fishing in the main river became possible as a result of the development of new fishing techniques involving the use of nets and rafts or dug-outs. This resulted in a wider spectrum of species that could be captured and, in addition, successful fishing was no longer limited to the beginning of the floods or to the period of receding waters and formation of residual pools. Once the main river started to be exploited, fishing could also be practised during the period that the floodplain was dry, thereby extending the availability of fish as a food resource. Fishing may thus have been successful all year round, except during the maximum of the floods when the fish were very dispersed. Because of the lack of older sites with faunal remains in western Africa it is unclear from what period onwards main river exploitation occurred. It is likely, however, that the techniques practised at the Middle Senegal Valley sites had already had a long tradition.

A good description of present-day traditional fishing methods in the sub-Saharan part of Africa is found in Blache and Miton (1962) and von Brandt (1984). These techniques include simple methods such as the capture of fish in shallow waters by hand, or the use of sticks or other wounding and striking gear in marginal waters during the spawning season or in drying out pools. Fish can also be captured by a system of barriers and traps placed on the channels through which the lateral migration towards the floodplain takes place at the beginning of the floods and the same activities can occur when fish return to the main river. In the residual pools and ponds a variety of techniques can be applied by groups of people once the waters become wadable: spears and various kinds of wounding or striking gear, cover pots, scoop baskets etc. In such isolated waters, deoxygenation can be caused by stirring up the mud or ichthyotoxic plants can be thrown in the water to stun the fish. Both in the floodplain and in the main river, hooks can be used as well as nets. Harpoons are nowadays mainly used in shallow water for the capture of breeding fish such as tilapia, *Heterotis*, *Gymnarchus* and large *Heterobranchus* (Reizer 1988:233).

It is obvious that of all the methods listed above, only few leave archaeological traces. At the Middle Senegal Valley sites iron hooks and ceramic net weights have been found (Susan McIntosh, pers. comm.). An iron fish hook was found in a Phase IIIA level of C1 and two possible fish hooks occur in C3 in Phase IIIA levels. Other iron objects were found which may have been used as fishing gear although other functions are not excluded: several spears or arrow heads occur in 2S, 3S, C3, and C6. Net weights have been found in mounds 1S (Phase IB), 2S (Phase IB), 3S (Phase V), C3 (Phases IA, IB and II), and C6 (Phases II and IIIA). They hence occur in all phases for which fish remains are available. There is a remarkable concentration of these objects in level 42 of C3A and in level 34 of C3B, but the fish remains in those and adjacent levels are rare. No inferences can be made from the comparison of archaeological and faunal data in terms of spatial or functional differentiation. Possibly, the concentration of these net weights can be explained as the result of the disposal of nets or parts of nets that were badly damaged. Maintenance of nets may have been an important activity, given the damage that occurs while using them. Not only the entangling of floating plants and branches is harmful to nets, but also the capture and removal of fish can result in severe damage.
Especially catfish can destroy large parts of nets because they get entangled with their spines.

**Possible Overfishing**

It should be noted that no significant differences in species composition occur within or between mounds that would suggest any changes in fish procurement strategies. However, when the length distributions are considered, it appears that, in those assemblages where sufficient bones were present to obtain a significant size distribution, a decreasing trend occurs through time for a number of taxa. Figure 3 shows the reconstructed body lengths for the claridiid of mounds C1, C3, and C6. A decrease in the average size is seen in all three mounds at the transition of phases II and III. It is clear that the largest individuals become scarcer through time, possibly indicating an effect of overfishing. Figure 4 shows the size distributions through time for *Synodontis* from the same mounds C1, C3, and C6. At C1 and C3 an average size decrease is noticed at the transition of Phase II towards Phase IIIA. No such clear trend is seen for mound C6, but the sample size is rather small. The size distribution through time for *Lates niloticus* in mounds C1, C3, C6, and 1S is illustrated in Figure 5. It appears that an average size decrease occurs in Nile perch at the transition of Phase II and Phase III at mounds C1, C3, and C6, whereas such a shift is seen at 1S at the transition of Phase IB and Phase II. No such trend is seen, however, in the other taxa of this mound.

The underrepresentation of smaller specimens in the deeper layers of a mound could theoretically be related to their poorer preservation chances or to a sediment that may have been more difficult to sample and sieve in the deeper layers, thus causing an apparent overrepresentation of the large specimens. However, the state of preservation is similar throughout each sequence and this factor can therefore not account for a loss of smaller elements in the deeper, older layers. Similarly, it is not likely that sampling would have biased the recovery. The same mesh size has been used in all layers and the composition of the sediment is more or less identical throughout the sequence. The lowest levels were sometimes more ashy than the upper ones, which may have facilitated the recovery of smaller bones. This means that any possible sampling bias would have resulted in an increased number of small fish in the lower levels, which is the opposite of what is observed. For this reason and because no changes are seen in the fishing gear, it is likely that the observed decrease in size is a result of a continued fishing effort of a specialised group that resulted in the depletion of the larger specimens of the fish stock.

Fishing pressure may have prevented individuals to survive long enough to attain large sizes. It should be noted that claridiid catfish of more than one metre are a rarity today, but that this does not have an effect on the breeding potential of the population. It is probably no coincidence that overfishing is documented in this part of the Senegal River. Reizer (1988:245) mentions that there is a greater risk of overexploitation of fish stocks in the Middle Senegal Valley, because of the presence of thresholds that prevent the horizontal migration of fish during the low water season. The Senegal River at Siouè is situated between the “seuils” of Demêt-Bogué and the one from Cascas, whereas Cubalel is along a portion of the river that is bordered by the thresholds of Diouldé-Diabé and Abdallah-Moctar. When the water levels are low, the fish that are confined to these stretches can be exploited extensively.

Species such as *Gymnarchus niloticus* and *Heterotis niloticus* are more vulnerable than the aforementioned taxa because of their breeding habits and they suffer easily from overfishing. Observations made by the author in 1985 in the Middle Niger showed that landings of these species were restricted and that the specimens were of a small average size. In certain parts of the Niger basin, they are even considered as locally extinct. No effect of overfishing is seen in the Middle Senegal Valley sites for these species. No significant decrease in numbers is observed and the sizes show that thriving populations of *Gymnarchus niloticus* and *Heterotis niloticus* were still present throughout the first millennium AD.

**Conclusions**

In conclusion, it appears that the observed intra- and intersite differences in species diversity seem to be rather related to variations in the availability of the fish which in turn are linked to environmental factors. Even today, the landings vary annually both in overall quantities and proportions of species, as a result of the variation in flood levels (Reizer 1988). The archaeological material (pottery, metal, architecture) from the Cubalel and Siouè sites does not show any significant changes from Phases IA through IIIB (Bocoum et al. 1999) and the physical setting of the studied mounds is similar. When the reconstructed body lengths are considered, a remarkable common trend appears of decreasing sizes during the first millennium AD. For claridiid and *Synodontis* catfish and Nile perch in sites C1, C6, and C3 this happens each time at the transition of ceramic phases II and III. In another site (1S), a decrease in size is seen for Nile perch at the transition of IB to II.

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