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# Fishing at Minoan Pseira: Formation of a Bronze Age fish assemblage from Crete

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ABSTRACT: Recent excavations at a Minoan (Late Bronze Age) trading settlement on Pseira, a small island off the eastern end of the north coast of Crete, yielded an assemblage of fish remains consisting primarily of sagittal otoliths from a single genus, *Spicara*, the picarels. Various factors that may have contributed to the formation of this assemblage are evaluated here.

KEYWORDS: CRETE, FISHING, LATE BRONZE AGE, MINOAN, OTOLITHS, PSEIRA, TAPHONOMY

RESUMEN: Las recientes excavaciones en el yacimiento minoico (Bronce tardío) de Pseira, enclave comercial situado en una pequeña isla en el extremo nororiental de la costa cretense, proporcionaron un peculiar acúmulo de restos de peces dominado por otolitos (sagitas) de chuclas (género *Spicara*). Los varios agentes que pueden haber intervenido en la configuración de esta muestra ósea son evaluados en este trabajo.

PALABRAS CLAVE: CRETA, PESCA, BRONCE TARDÍO, MINOICO, OTOLITOS, PSEIRA, TAFONOMÍA

## INTRODUCTION

First inhabited in the Final Neolithic, Pseira, a small island in the Gulf of Mirabello on the north coast of eastern Crete (Figure 1), was occupied continuously into the Late Bronze Age (Seager, 1910; Davaras & Betancourt, 1986, 1988, 1990, 1991, 1995; Davaras *et al.*, 1992; Betancourt, 1995). The Late Minoan I (1675-1500 B.C.) settlement consisted of ca. 60 structures, mostly situated around and above a sheltered harbour facing the coast of Crete, 2.5 km away. Destroyed near the end of Late Minoan IB (ca. 1500 B.C.), the settlement was briefly reoccupied after a hiatus of 50 years or more (in Late Minoan IIIA2), then abandoned. Some Late Minoan IIIC (1190-1125/1100 B.C.) activity at the site is attested by pottery, but there are no buildings from that period. A small Early Byzantine monastery built over the Minoan town in the sixth century A.D. was in ruins by the ninth century. The island is uninhabited today. Pseira was probably a trading center on the eastwest route along the north coast of Crete. The Minoan settlement of Mochlos is 3 km to the east and the Minoan town and palace at Gournia are on the mainland, 13 km to the southwest. Building DA, from the LMIII Cretan reoccupation, has pottery from Cyprus, Syro-Palestine, and elsewhere on Crete. Other structures of note include BS/BV (the Plateia Building), which was possibly the residence of a local chieftain, and BY, which had an LMI obsidian workshop (Dierckx & Floyd, 1995).

The 1985-1991 excavations, directed by Philip Betancourt of Temple University and Costis Davaras of the University of Athens, produced fish bones, otoliths, and teeth from Bronze Age and Medieval contexts, most of which were water sieved (Rose, 1994, 1995b, in press). Remains from

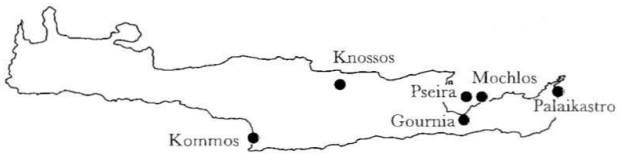


FIGURE 1
Map of Crete showing sites mentioned in text.

37 Minoan contexts (414 bones and bone fragments, 426 otoliths and otolith fragments) are discussed here.

## ASSEMBLAGE COMPOSITION

Most of the fish remains from Pseira are poorly preserved; few bones are intact, and identifiable cranial and facial elements are scarce (Table 1). Out of a total of 414 bones and bone fragments only 154 (37.2%) could be identified taxonomically. The salient feature of the Pseira assemblage is the abundance of otoliths, most of which derive from a single taxon (Centracanthidae: *Spicara*). Otoliths constitute 50.7% of all fish remains, and the 388 *Spicara* otoliths alone amount to 46.1%.

That *Spicara* remains are relatively abundant at Pseira is not surprising given that these fish make up 26.7% of the Cretan catch today (National Statistical Service of Greece 1967-69). There are three species of picarel in the Pseira region: golden picarel (*S. flexuosa*), blotched picarel (*S. maena*), and picarel (*S. smaris*). *Spicara* are small schooling fish in littoral waters, whose maximum size is 25 cm in standard length (Whitehead *et al.*, 1986). The size frequency distribution of the 347 measurable *Spicara* otoliths from Pseira is presented in Figure 2. The mean height is 1.93 mm. For comparison, three modern reference specimens of picarel from the Argolic Gulf, Greece, with otoliths heights of 2.4-2.5 mm were 11.3-12.5 cm in total length. *Spicara* are taken primarily in nets, including trawls (39.6%), purse seines (3.9%), and seines (46.5%). The balance of the catch (9.9%) is made with small ring nets and lines (National Statistical Service of Greece, 1967-69). Historically, Faber (1883) records the catch of *Spicara* using ground nets with diagonal meshes of 2.6-3.8 cm and cast nets, as well as hand lines with 3-10 small hooks. Guest-Papamanoli (1985: 186-187) observed them in catches from set net traps (taliani) along coast in the Pagassitikos Gulf. The small size of the *Spicara* represented by the otoliths and Sparidae/Centracanthidae vertebrae at Pseira suggests they were caught using fine-meshed nets. Stone and clay weights are common at the site, but

| TAXON | Cranial/facial | Otoliths | Vertebrae | TOTAL |
|---|---|---|---|---|
| *Anguilla anguilla* | | | 3 | 3 |
| *Micromesistius poutassou* | | 1 | | 1 |
| SERRANIDAE | | | 1 | 7 |
| cf. Serranidae | | | 1 | [1] |
| *Epinephelus* sp. | 2 | 1 | | [3] |
| cf. *Epinephelus* | 1 | | 1 | [2] |
| SCIAENIDAE | | | | 3 |
| *Sciaena umbra/Umbrina cirrosa* | 2 | | | [2] |
| *Sciaena umbra* | | 1 | | [1] |
| SPARIDAE/CENTRACANTHIDAE | | 28 | 135 | 163 |
| SPARIDAE | 1 | | | 7 |
| cf. Sparidae | 4 | | | [4] |
| cf. *Pagellus erythrinus* | | 1 | | [1] |
| cf. *Pagrus pagrus* | | 1 | | [1] |
| *Spicara* sp. | | 388 | | 388 |
| LABRIDAE | 1 | | | 1 |
| MUGILIDAE | | | 1 | 2 |
| cf. Mugilidae | 1 | | | [1] |

TABLE 1

NISP for taxa identified in Minoan contexts at Pseira.

the lead net weights known from many Late Bronze Age sites in the Aegean and eastern Mediterranean (Rose, 1994) have not been found. At Kahun, Egypt, 18th Dynasty (1570-1293 B.C.) nets have been found that have 0.5-1.5 cm meshes (Brewer & Friedman, 1989). A bronze fishhook (Betancourt & Davaras, 1995: AG 12) was found in a disturbed context at Pseira.

The skewed anatomical distribution of the Pseira assemblage can be seen by comparing the expected and actual counts of *Spicara* skeletal elements, assuming that 200 individuals were present, based on the number of right otoliths (200 of the *Spicara* otoliths were from the right side, 188 were from the left; 7 fragments of small otoliths, sparid or centracanthid, could not be determined to side). For each of the paired cranial and facial bones, represented here by the premaxillae and dentalia, 400 could be expected, but none are present. For the Sparidae/Centrancanthidae vertebrae, at least 4800 might be expected (based on 24 per fish [Nelson, 1994: 362]), but only 135 are present. Thus the assemblage consists of otoliths, but no other elements from the head, and a scattering of vertebrae. The vertebrae are present in numbers not vastly out of line with what might be expected based on their normal anatomical proportions and a general tendency for caudal vertebrae to be underrepresented at Aegean sites (Rose, 1994, 1995a) (Table 2).

Among the undiagnostic bones, many of the fragments of cranial/facial bones (29), vertebrae (67), and other elements from the axial skeleton (164) may also be from *Spicara* or small sparids. Three unidentified otoliths, in poor condition, are probably not *Spicara*, while 2 unidentified otolith fragments may be. Details of these are published in the descriptions of the bones from each context that appear in the final reports (Rose, 1995b, in press, and in preparation).

| | PSEIRA | | ANATOMICAL |
|---|---|---|---|
| | PRESENT | RATIO | PROPORTION |
| First | 6 | 1 | 1 |
| Thoracic | 4 | 0.67 | 3 |
| Precaudal | 47 | 7.8 | 4 |
| Precaudal/caudal | 12 | | |
| Caudal | 50 | 8.3 | 16 |
| Thoracic-caudal | 16 | | |

TABLE 2
Anatomical distribution of Sparidae/Centracanthidae vertebrae at Pseira (n=135).

Certainly there is variation in the distribution of fish remains within the site. Not all contexts yielded fish remains, and in those that did, the remains vary in terms of quantity and skeletal elements represented. The recent work at Pseira, however, includes both cleaning of areas investigated early in this century and full excavation of other areas. So contexts at the site are not necessarily equivalent in either their excavation history or original function in the Late Bronze Age (e.g., roadway or fill within residential building). Calculation of the density of bone by context (the weight of bone per liter of deposit excavated) may facilitate comparison of contexts, but that is beyond the scope of this paper. Here, for the 37 contexts with fish remains, it can be pointed out that the majority (27) have 10 or fewer remains, while 8 contexts have between 11 and 50, and 2 contexts have substantially larger numbers. There is some variation in the skeletal representation among the smaller contexts (e.g., contexts with 6, 7, and 19 otoliths and no other remains), and the general impression is of a background scatter and small groups of remains that may represent individual depositional events. Of the two larger contexts, one has a total of 366 remains of which 288 are otoliths and otolith fragments, the other has 165 remains of which 104 are vertebrae and fragments. Undoubtedly there are real differences in the contexts that could relate to deposition events (from tipped over pot of fish

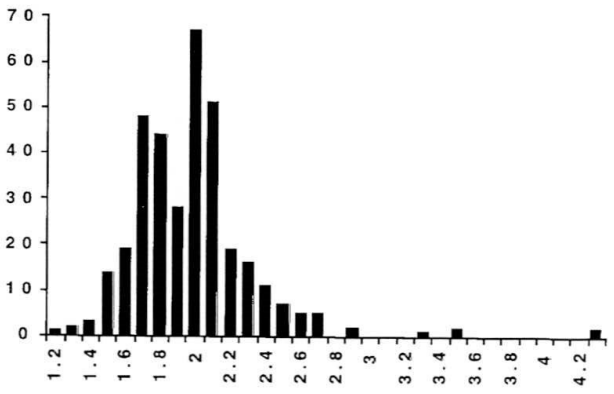


FIGURE 2
Frequency of *Spicara* sagittae at Pseira by height (MM) (n=347)

There are few studies of Cretan archaeological fish remains assemblages from sites with adequate recovery to compare with Pseira. Excavations at Kommos, a Minoan harbour town on the south-central coast of Crete, produced an assemblage of about 1,100 bones, bone fragments, and otoliths of which 512 were identified taxonomically (Rose 1995a). Vertebrae were the most abundant skeletal element at Kommos, amounting to 64.6% (331) of the identified remains. Otoliths constituted 24.8% (127) and cranial and facial bones 10.5% (54) of the identified remains. In addition to this difference in anatomical representation between Kommos and Pseira, the majority of the otoliths (79 or 62.2%) were from sea bream, chiefly *Pagellus erythrinus*. Two assemblages from sites closer to Pseira, now under study, are apparently more simliar to Pseira. Mochlos, a Minoan settlement on a small offshore island and the adjacent coast 3 km east of Pseira, also has abundant *Spicara* otoliths but not perhaps to the extreme seen at Pseira (Rose, unpublished data). Palaikastro, a large Minoan town and nearby peak sanctuary on the east coast of Crete some 40 km from Pseira, has numerous otoliths of small sparids or centracanthids (Dimitra Mylonas, pers. comm.). Perhaps there is a distinct east Crete fish assemblage in which otoliths of small sparids and centracanthids are abundant for whatever reason, e.g. a regional fishery or similar physical conditions at the sites.

## ASSEMBLAGE FORMATION

The survival of only *Spicara* vertebrae and sagittae, and the categoric dominance of the latter element, invite comments about the taphonomic and cultural agents that might be responsible for this distribution. The distribution of remains, however, argues against butchery or discard: we have otoliths and some vertebrae, but no cranial or facial bones. Scavenging may have played a role in the assemblage formation, but the limited data on otolith survival in mammalian digestive tracts is ambiguous. Three of five otoliths ingested in experiments with dogs survived, but two were acid polished, one severely (Jones, 1984, 1986; Wheeler & Jones, 1989: 74). Species involved included snapper (*Lutjanus* sp.), haddock (*Melanogrammus aeglefinus*), plaice (*Pleuronectes platessa*), and herring (*Clupea harengus*). The one snapper otolith ingested and two haddock otoliths survived, although they were diminished in size and exhibited an acid polish, which the Pseira otoliths do not. In another study most of the bones of ten herring heads fed to a dog were nearly completely destroyed (Jones, 1990). Otic bullae were the most abundant element to survive, but were scarcely identifiable; the report makes no mention of otolith survival.

Processing for consumption by humans may also have affected the composition of the assemblage at Pseira. *Spicara* are used for soup in traditional Mediterranean cuisine today; they are also fried or simply dried (Davidson, 1981: 90-91, 247, 373). Given their small size, the *Spicara* at Pseira could have been eaten whole. As with scavenging, experiments on human digestion of whole *Spicara* might elucidate the durability of otoliths compared to other skeletal elements.

Were the Pseira fish prepared by boiling? None of the remains has outward indications of burning but boiling would leave none. The bones have not been tested for collagen deformation indicative of heating (Richter, 1986). It may be worth recalling that Sir Arthur Evans found fish bones, otherwise unidentified, in a Middle Minoan III tripod vessel at Knossos (Evans, 1921: 554-556). A deep vessel suitable for use in boiling food, the tripod cooking pot is the most common cooking vessel at Pseira and elsewhere on Minoan Crete (Betancourt, 1980; Martlew, 1988). Perhaps boiling was a common method of preparing fish.

Nicholson's (1992a, 1992b, 1995) studies of the survival rates of fish remains are relevant here. Using a lapidary tumbler to simulate abrasion in archaeological deposits, Nicholson compared fragmentation of cooked and uncooked remains of haddock, plaice, and herring, and observed that boiled bones were destroyed more rapidly than uncooked bones (Table 3, adapted from Nicholson, 1992a: 82, table 2, and 83, fig. 1). For otoliths, Nicholson states that when tumbled with sand and gravel they became polished but that they broke when tumbled with pebbles or ballbearings. She does not report if there were differences between survival rates of boiled and uncooked otoliths. In another experiment, which may be significant for Pseira, Nicholson found that after two hours of constant trampling otoliths of boiled fish survived whole while the bones were mostly destroyed (Nicholson, 1992a: 88). More recent experiments by Nicholson (1995) confirm that cooking makes fish bones more fragile than otoliths.

| | BOILED ONE HOUR | | UNCOOKED | |
|---|---|---|---|---|
| | GRAVEL | SAND | GRAVEL | SAND |
| Haddock | 23 | 69 | 95 | 98 |
| Plaice | 55 | 78 | 97 | 98 |
| Herring | 10 | 32 | 61 | 95 |

TABLE 3

Percentage survival of fish bones after 300 hours in lapidary tumber (otoliths excluded).

Conditions at the site affecting the preservation of fish remains must also be considered. Micromorphology studies at the site indicate the sediments are considerably reworked rather than primary deposits (unpublished studies by Paul Goldberg, Boston University). Given the fragility of small *Spicara* cranial and facial bones, it is not surprising that none survived. The relative scarcity of vertebrae may be explained for the same reason. Otoliths, however, may be more durable than once believed (cf. Wheeler & Jones, 1989: 63; Lyman, 1994: 435-436). Perhaps their small size and shape, an elongate lentoid form, protected them from physical processes that destroyed the cranial and facial bones and most of the vertebrae. Favorable soil conditions at the site may have limited chemical destruction of the otoliths. The soils on the island are alkaline (pH 7.4 -8.2), medium-texture sandy silt loams (unpublished studies by Julie Clark, RADARSAT International, Inc., Richmond, British Columbia).

## CONCLUSIONS

The assemblage from Pseira is marked by an abundance of otoliths of a single taxon and few other remains. This abundance may have several causes. *Spicara* may well have been more commonly caught than other fish to begin with. The *Spicara* present in the assemblage are quite small, and their cranial and facial bones would have been delicate, making them susceptible a combination of strong destructive mechanical forces (shifting and consolidation of deposits, trampling, etc.) and Minoan cooking practices (boiling). Cooking would have affected the *Spicara* otoliths less, and once deposited they survived because of their compact shape and favorable soil conditions. Dominance of the assemblage by sagittae is as likely to be the result of these factors as other causes, whether human activities (e.g., butchery, discard, or consumption) or scavenging by dogs or other animals. Future experimental studies of the survivability of *Spicara* skeletal elements and comparisons with fish remains from nearby sites may help to clarify what taphonomic factors created the Pseira assemblage.

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## REFERENCES

BETANCOURT, P. 1980: Cooking Vessels from Minoan Kommos, A Preliminary Report (Institute of Archaeology, Occasional Paper 7). University of California, Los Angeles.

BETANCOURT, P. 1995: Pseira, Crete: The Economic Base for a Bronze Age Town. In: Laffineur, R. & W.-D. Niemeier (eds.): *Politeia, Society and State in the Aegean Bronze Age (Aegaeum, Annales d'archéologie Égénne* 12:1): 164-167. Université de Liège. Liège.

BETANCOURT, P. & DAVARAS, C. 1986: Excavations at Pseira, 1985 and 1986. *Amaltheia* 68-69: 183-200 (in Greek).

BETANCOURT, P. & DAVARAS, C. 1988: Excavations at Pseira, 1985 and 1986. *Hesperia* 57: 207-225.

BETANCOURT, P. & DAVARAS, C. 1990: Excavations at Pseira, 1987-1989. *Amaltheia* 82-85: 20-37 (in Greek).

BETANCOURT, P. & Davaras, C. 1991: Haven for Minoan Mariners. *Archaeology* 44: 32-35.

BETANCOURT, P. & DAVARAS, C. (eds.) 1995: Pseira I. Buildings at the West Side of Area. University of Pennsylvania, Philadelphia.

BREWER, D. & FRIEDMAN, R. 1989: Fish and Fishing in Ancient Egypt. Aries and Phillips, Warminster.

DAVARAS, C.; BETANCOURT, P. & FARRAND, W. 1992: Pseira. In: Myers, J.; E. Myers & T. Cadogan (eds.): *The Aerial Atlas of Crete*: 262-267. University of California Press, Berkeley.

DAVIDSON, A. 1981: Mediterranean Seafood. Louisiana State University Press, Baton Rouge.

DIERCKX, H. & FLOYD, C. 1995: A Late Minoan I Obsidian Workshop at Pseira, Crete. *American Journal of Archaeology* 99: 334 (abstract).

EVANS, A. 1921: Palace of Minos I. Macmillan, London (reprint New York 1964).

FABER, G. 1883: *The Fisheries of the Adriatic and the Fish Thereof.* Bernard Quaritch, London.

GUEST-PAPAMANOLI, A. 1985: One pêche a guet: le Taliani, origines et distribution géographique. In: *L'Exploitation de la mer* (Vèmes Rencontres internationales d'archéologie et d'histoire, Antibes, Octobre 1984): 185-203. Éditions A.P.D.C.A., Juan-les-Pins.

JONES, A. 1984: Some effects of the mammalian digestive system on fish bones. In: Desse-Berset, N. (ed.): *2nd Fish Osteoarchaeology Meeting* (Notes et Monographies Techniques 16): 61-65. Éditions du C.N.R.S., Paris.

JONES. A. 1986: Fish bone survival in the digestive systems of the pig, dog, and man: some experiments. In: Brinkhuizen, D.C & A.T. Clason (eds.): *Fish and Archaeology*. B.A.R. (International Series) 294: 53-61. Oxford.

JONES. A. 1990: Experiments with fish bones and otoliths: implications for the reconstruction of past diet and economy. In: Robinson, D. (ed.): *Experimentation and Reconstruction in Environmental Archaeology*: 143-146. Oxbow Books, Oxford.

LYMAN, R. 1994: *Vertebrate Taphonomy*. Cambridge University Press, New York.

MARTLEW, H. 1988: Domestic Coarse Pottery in Bronze Age Crete. In: French, E. & K. Wardle (eds.): *Problems in Greek Prehistory*. Papers Presented at the Centenary Conference of the British School of Archaeology at Athens, Manchester, in April 1986: 421-424. Bristol Classical Press, Bristol.

NATIONAL STATISTICAL SERVICE OF GREECE 1967-1969: Results of Sea Fishery by Motor Vessels, 1967 (for 1964 and 1965), 1968 (for 1966), 1969 (for 1967 and 1968). National Statistical Service of Greece, Athens.

NELSON, J. 1994: *Fishes of the World*. 3rd edition. John Wiley, New York.

NICHOLSON, R. 1992a: Bone Survival: the Effects of Sedimentary Abrasion and Trampling on Fresh and Cooked Bone. *International Journal of Osteoarchaeology* 2: 79-90.

NICHOLSON, R. 1992b: An Assessment of the Value of Bone Density Measurements to Archaeoichthyological Studies. *International Journal of Osteoarchaeology* 2: 139-154.

NICHOLSON, R. 1995: Fish bone diagenesis in different soils. Paper presented at the Eighth Meeting of the I.C.A.Z. Fish Remains Working Group, Madrid (Cantoblanco), Spain. October 1995.

RICHTER, J. 1986: Experimental study of heat induced morphological changes in fish bone collagen. *Journal of Archaeological Science* 13: 477-481.

ROSE. M. 1994: With Line and Glittering Bronze Hook: Fishing in the Aegean Bronze Age. Ph.D. diss., Indiana University, Bloomington.

ROSE, M. 1995a: Fish Remains from Minoan Kommos. In: Shaw, J. & M. Shaw (eds.): *Kommos I, The Kommos Region and Houses of the Minoan Town 1, The Kommos Region, Ecology, and Minoan Industries*: 204-239. Princeton University Press, Princeton.

ROSE, M. 1995b: Fish Remains, Building AD Center. In: Betancourt, P. & C. Davaras (eds.): *Pseira I. Buildings at the West Side of Area*: 130-132. University of Pennsylvania, Philadelphia.

ROSE, M. (in press): Fish Remains, Building AC. In: Betancourt, P. & C. Davaras (eds.): *Pseira II.*

SEAGER, R. 1910: Excavations on the Island of Pseira, Crete (Anthropological Publications III: 1). The University of Pennsylvania Museum, Philadelphia.

WHEELER, A. & JONES, A. 1989: *Fishes. Cambridge Manuals in Archaeology*. Cambridge University Press, New York.

WHITEHEAD, P.; BAUCHOT, M. L.; HUREAU, J. C.; NIELSEN, J. & TORTONESE, E. (eds.) 1984-1987: *Fishes of the North-eastern Atlantic and of the Mediterranean*. U.N.E.S.C.O., Paris.