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The impact of salting and drying on fish bones: Preliminary observations on four marine species from Parita Bay, Panamá

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ABSTRACT: Actualistic («middle range») studies of present day fishing communities facilitate the reconstruction of fishing methods and fish utilization from archaeofaunal data. Fish dehydration by salting and sun and wind drying is still practised around Parita Bay, central Pacific Panama. This report describes the ways in which two different butchering methods, dependent upon fish size, affect the fish skeleton. Each butchering method leads to different patterns of bone loss and breakage. These data will be useful to archaeologists who wish to distinguish between fish processing and consumption sites.

KEYWORDS: BONE DAMAGE, BUTCHERING METHOD, DRYING, FISH REMAINS, MIDDLE RANGE THEORY, PANAMA, PRESERVATION, SALTING, TAPHONOMY

RESUMEN: Las investigaciones actualísticas en torno a comunidades de pescadores facilitan sobremanera la inferencia de técnicas de pesca y la interpretación de los datos arqueofaunísticos relativos a peces. La deshidratación de peces a través de la salazón y el secado al sol y al viento continúa siendo practicada en el entorno de la Bahía de Parita en el Panamá Pacífico-Central. Este estudio describe los modos en que dos diferentes tipos de procesado del pescado, dependientes de la talla, afectan al esqueleto de los peces. Cada uno de los métodos implica diferentes patrones de pérdida y fracturación de los huesos, datos que sin duda resultarán de interés para aquellos arqueólogos que deseen diferenciar lugares de procesado y de consumo en el registro fósil.

PALABRAS CLAVE: DAÑOS EN HUESO, MÉTODOS DE DESCUARTIZAMIENTO, SECADO, RESTOS DE PECES. PANAMÁ, CONSERVACIÓN, SALAZÓN, TAFONOMÍA

INTRODUCTION

Many coastal fisherpeople around the world dehydrate fish in order to preserve them for future dietary or commercial use (Firth, 1975; Stewart, 1982, 1989; Michael, 1984; Essuman & Diakite, 1990; Belcher, 1994). Dehydration methods, however, vary with regard to fish species and size, season, climate and local cultural tradition. Hence, it is informative to undertake ethnographic studies at different localities in order to gain insights into the impact of specific processing methods on the fish skeleton. Such «middle-range» research (Trigger, 1989: 361-367) underlines differences in bone distribution and modification at sites where fish are processed and consumed.

GEOGRAPHIC AND CULTURAL CONTEXT

This research was conducted near Parita Bay, a small tidal embayment in the north-western corner of Panama Bay (Figure 1). Contemporary coastal

fisherpeople are of mixed Native American-African-European descent, but they probably retain some pre-contact food procurement practices. Pre-Spanish (pre-A.D. 1520) dietary faunal samples from Parita Bay archaeological sites attest to the intensive utilization of estuarine fish, especially marine catfish (Ariidae), croakers (Sciaenidae), grunts (Haemulidae) and thread-herrings (Opisthonema), and their transport inland (Cooke, 1992). The transport of fish in this lowland tropical country implies some kind of preservation (Cooke & Tapia, 1994).

Modern fishing also concentrates on littoral estuarine waters. Individuals or small groups employ throw and gill nets, and hand-lines from dug-out canoes, with and without outboard motors. Although most modern catches are sold fresh, a few families in the coastal settlements of Aguadulce, El Rompio and Boca de Parita still process considerable amounts of fish by salting and wind and sun drying.

Two questions guided the field study:

1. Which butchering methods precede fish drying and salting?

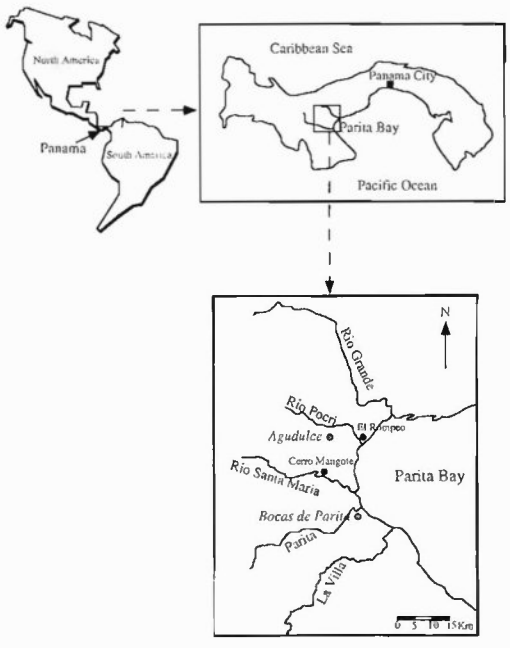


FIGURE 1

Map of Panamá and Parita-Bay, showing location of the study sites.

2. Which skeletal elements are discarded and/or damaged during butchering?

MATERIAL AND METHODS

We examined 573 fish, belonging to 34 species and 9 families, which we recorded at two salting and drying stations. 431 fish were prepared by Francisco Villarreal at Boca de Parita and 142 fish by Lucia Almendas at Aguadulce. We took standard measurements for each fish before it was butchered (total length-TL, standard length-SL and total weight-BM). We observed two different butchering techniques:

Method 1 (442 fish): A longitudinal cut is made with a steel knife along the ventral mid-line of the fish, starting at the anus. This passes through the branchiocranial region and usually ends near the articular symphysis. The entrails and gills are removed and discarded. Then a few longitudinal or oblique cuts are made on both sides of the fish to facilitate salt penetration. One cut often descends obliquely from the dorsal fin, straightening out over the caudal vertebrae and ending near the caudal peduncle. Butchered fish are salted in a brine tank and then dried whole, strung on a line, with the head still appended (Figure 2).

FIGURE 2

Small fish, butchered by method 1, stung on a line (note the intact skull).

Method 2 (131 fish): A longitudinal cut is made dorsally, starting at the base of the caudal fin and extending to the anterior part of the skull. The first

dorsal spine and predorsal plate of large marine catfish (Ariidae sp.) are removed and discarded before the cut is made. Splitting the skulls of these and other larger fish, such as crevalle jacks (*Caranx caninus*), is sometimes facilitated by hitting the back of the knife with a blunt machete (Figure 3). Thus, the fish is opened from the dorsal region. The exposed entrails are discarded along with the gills. Then the fish is turned over, skin or scales uppermost, and additional transverse cuts are made on the flesh.

FIGURE 3
A large fish (*Arius kessleri)* butchered by the method 2.

We collected 252 fish of the eight commonest species that were butchered by the two informants: *«Arius» kessleri, «Arius» seemani, Sciadeops troschelii, «Cathorops» furthi, «Cathorops» multiradiatus* (Ariidae), *Haemulopsis nitidus* (Haemulidae), *Caranx caninus*, and *Oligoplites altus* (Carangidae). Each species was represented by more than 25 fish (Table 1). 117 fish, belonging to four species, were selected for detailed osteological analysis. These were skeletonised by maceration in warm water and digestive enzymes (Davis & Payne, 1992) at the Smithsonian Tropical Research Institute's archaeozoology laboratory.

Butchered by method 1: (1) 32 silver (or shining) grunt *Haemulopsis* (formerly *Pomadasys nitidus*) (Allen & Robertson, 1994: 153; FAO, 1995: 1161), (2) 29 box (or many-rayed) catfish *«Cathorops» multiradiatus* (Allen & Robertson, 1994: Plate V, 4; FAO, 1995: 881).

Butchered by method 2: (1) 28 Pacific crevalle jack *Caranx caninus* (Allen & Robertson, 1994: Plate VIII, 4; FAO, 1995: 954), (2) 28 sculpted (or Kessler's) catfish *«Arius» kessleri* (Allen & Robertson, 1994: Plate V, 10; FAO, 1995: 869).

We defined our intraspecific index for breakage of individual skeletal elements as the total number of undamaged bones divided by the total number of bones expected in an intact fish. A relative measure of similarity in overall breakage pattern bet-

Station	Family	Species	Total No.	Frequency	Butchering method
Parita Bay	Ariidae	*Arius kessleri*	35	13.9%	1 & 2
		Cathorops furthi	30	11.9%	1
		Arius seemani	25	9.9%	1
		Sciadeops troschelii	39	15.5%	1& 2
	Haemulidae	*Haemulopsis nitidus*	32	12.7%	1
	Carangidae	*Caranx caninus*	29	11.5%	2
		Oligoplites altus	33	13.1%	1
Aguadulce	Ariidae	*Cathorops multiradiatus*	29	11.5%	1

TABLE 1
Frequency distribution for the number of fishes, collected for this study, at each locality.

ween each of the two taxa is expressed as Euclidean distance based on breakage index. The matrix of Euclidean distances was used in Multidimensional Scaling (MDS) to separate butchering methods. MDS is an ordination procedure that compresses multidimensional space onto a simple two-dimensional representation (Borg, 1981). The method has no underlying assumptions about the normality or linearity of the data. The fit to the two dimensional model is evaluated by a stress factor, which ideally should be lower than 0.1.

Since our data are not normally distributed we applied the following non-parametric tests: (1) Chi-square test, for comparing the observed number of bones in a butchered fish with the expected number of bone in an intact fish; (2) Mann-Whitney test for examining the differences in fish size between the two butchering methods, and (3) Kruskal-Wallis test, for comparing the frequency patterns of bone damage and loss among fish species. Statistics were calculated with Stateview 4.5 and SYSTAT 5.2 for Macintosh.

RESULTS

Our initial observations on 573 fish from 34 species (Table 2), which were prepared by Sr. Villarreal and Sra. Almendas for salting and drying, show that the size of the fish, rather than its morphology, determines which of the two butchering methods will be applied (Mann-Whitney test, $P<0.001$). Most fish smaller than 400 g in body weight and 325 mm in length (S.L.) were butchered using method 1. Most fish larger than this size, were prepared using method 2 (Figure 4). The decision, which is based on the informants' knowledge and experience, is statistically significant (Mann-Whitney test, $P<0.001$).

More detailed anatomical observations on the silver grunt, box catfish, Pacific crevalle jack and sculpted catfish demonstrate the following differences between the two butchering methods:

1) The body size (body mass and standard length) distribution (Figure 5) of fish butchered by method 1 (*Haemulopsis nitidus*, *Cathorops multiradiatus*) differed statistically from that of the fish butchered by method 2, (*Caranx caninus* and *Arius kessleri*) (Mann-Whitney test; $p<0.001$).

	Butchering method	Body Mass (g)			Standard Length (mm)		
Species		Mean	Count	Range	Mean	Count	Range
B. pammoensis	1	349.1	17	110.0-690.0	271.6	17	180.0-324.0
A. dasycephalus	1	176.7	27	100.0-270.0	229.0	28	192.0-270.0
A. weddlii	1	617.0	2	542.0-692.0	315.0	2	310.0-320.0
C. multiradiatus	1	147.3	51	90.0-238.0	212.5	50	184.0-252.0
C. furthi	1	317.7	63	84.0-600.0	254.5	63	170.0-310.0
A. platypogon	1	183.5	3	148.0-204.0	210.0	3	198.0-233.0
S. insculpta	1	388.7	12	108-567	282.7	14	187.0-308.0
S. insculpta	2	961.2	68	481.9-2409.7	356.2	68	292.0-496.0
C. hypsiphthalmus	1	235.5	25	140.0-384.0	262.2	25	233.0-305.0
A. seemanni	1	246.9	30	104.0-422.0	236.7	30	180.0-282.0
C. taylori	1	130.4	8	60.0-208.0	211.6	8	164.0-298.0
H. nitidus	1	167.6	65	104.0-242.0	186.0	65	163.0-218.0
H. nitidus	2	436.0	1	436.0	565.0	1	565.0
C. caninus	2	2510.3	30	961.0-5760.4	473.4	30	370.0-610.0
P. chongatus	1	125.0	2	102.0-148.0	182.0	2	180.0-184.0
P. punctatissimus	1	206.7	3	200.0-218.0	196.7	3	195.0-198.0
E. biscutus	2	1474.4	1	1474.4	425.0	1	425.0
C. rebollus	1	419.3	3	396.0-452.0	288.3	3	280.0-295.0
P. approximans	1	155.2	5	120.0-206.0	193.8	5	177.0-215.0
P. approximans	2	1077.6	1	1077.6	375.0	1	375.0
C. affinis	1	468.0	4	382.0-534.0	284.0	4	270.0-300.0
C. hippurus	2	4933.0	1	4933.0	810.0	1	810.0
H. flavescens	1	479.0	2	474.0-484.0	293.5	2	292.0-295.0
P. brasiliensis	1	192.0	1	192.0	198.0	1	198.0
L. analis	1	116.0	1	116.0	165.0	1	165.0
A. kessleri	1	351.8	19	113-510	280.0	19	198.0-318.0
A. kessleri	2	756.7	29	453.6-1644.3	362.8	29	320.0-429.0
B. guianensis aluta	1	218.8	4	194.0-262.0	243.8	4	230.0-261.0
O. vulus	1	378.4	76	100.0-792.0	293.9	76	195.0-372.0
T. paiteanus	1	592.7	3	550.0-636.0	304.7	3	295.0-315.0
P. snyderi	1	152.0	1	152.0	183.0	1	183.0
U. sinus	1	297.0	1	297.0	249.0	1	249.0
H. leucurus	1	181.0	1	181.0	208.0	1	208.0
C. inca	1	314.4	5	252.0-378.0	253.0	5	240.0-280.0
A. planiceps	1	190.0	1	190.0	230.0	1	230.0
B. armata	1	128.0	1	128.0	170.0	1	170.0
Haemulopsis sp.	1	172.0	1	172.0	184.0	1	184.0
C. inca	1	206.0	1	206.0	217.0	1	217.0

TABLE 2

Descriptive statistics regarding body mass and standard length (SL) based on 573 fish belonging to 34 species, butchered in two different techniques.

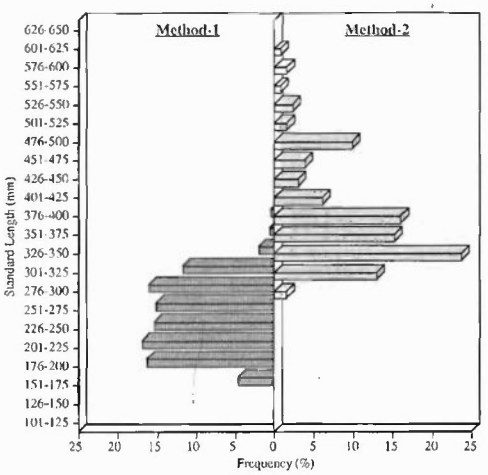


FIGURE 4

Standard length (SL) frequency distribution of 573 fish belonging to 34 species butchered by two different techniques.

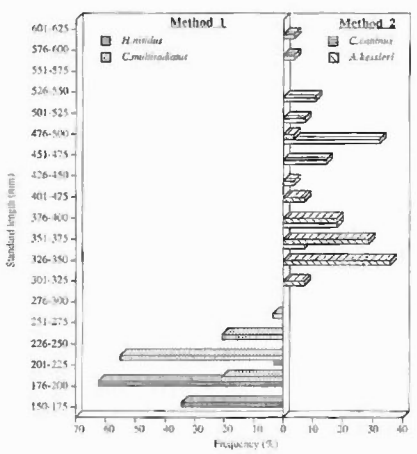


FIGURE 5

Standard length (SL) frequency distribution of four fish species used in this study butchered by two different techniques.

2) Loss of most branchial region elements is observed in both butchering methods (Figure 6). The observed distribution of bones grouped by anatomical region differ significantly from the expected distribution in an intact fish (c2 test; $p<0.001$). However, if the branchial elements are excluded, bone loss by anatomical region did not differ statistically between the two butchering methods.

3) Although fish processed by method 1 do not exhibit damage or loss of any neurocranial bones (Figure 7) other cranial bones, i.e., the cleithrum, coracoid and the basypterygia are often damaged (Table 3).

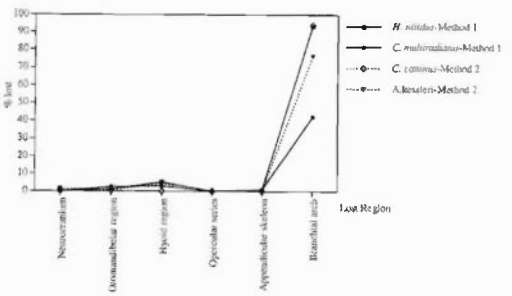


FIGURE 6

Percentage of fish skeletal elements lost due to butchering methods 1 and 2.

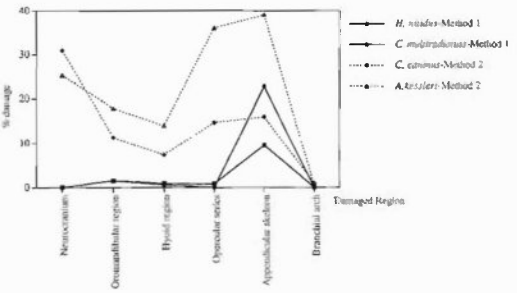


FIGURE 7

The percentage of fish skeletal elements damaged by butchering methods 1 and 2.

4) Fish processed by method 2 exhibit damage to neurocranial elements (Figure 8) and also to other, extra cranial bones (Tables 3 and 4). This pattern is significantly different from that observed in fish butchered by method 1 (Kruskal-Wallis; $p<0.01$). The most frequently damaged neurocranial bones of both the crevalle jack and sculpted catfish are: ethmoid, vomer, frontal, exoccipital, parasphenoid, and basioccipital (Table 4). The supraoccipital of the sculpted catfish is damaged when the first dorsal spine and its base are sliced off.

5) In butchering method 2 cranial bones are damaged and lost less frequently than neurocranial bones, but more frequently than when fish are butchered by method 1. Elements most often affected are: the cleithrum, coracoid, premaxilla, quadrate, metapterygoid, epihyal, preopercular, interopercular, and urohyal (Table 3). According to MDS analysis, morphologically distinct species butchered by the same method display a similar bone breakage pattern (Figure 9). The MDS two-dimensional representation explained 99% of the variance in the original data, giving a stress factor of 0.00088.

		Method-1				Method-2			
	Species	*C. multiradiatus* (n=29)		*H. nitidus* (n=32)		*C. caninus* (n=28)		*A. kessleri* (n=28)	
Region	Cranial bones	No*	%	No*	%	No*	%	No*	%
Appendicular region	Cleithrum	22	37.9%	33	51.6%	30	53.6%	54	98.4%
	Coracoid	24	41.4%	0	0	20	35.7%	35	62.5%
	Basypterygia	7	12.1%	12	18.7%	3	5.35%	0	0
Oromandibular Region	Premaxilla	0	0	1	1.56%	17	30.3%	12	21.4%
	Dentary	0	0	0	0	6	10.7%	18	32.14%
	Quadrate	0	0	1	1.56%	8	14.28%	30	53.6%
	Metapterygoid	1	1.73%	1	1.56%	13	23.2%	17	30.3%
Opercular Series	Preopercular	0	0	2	3.12%	13	23.2%	32	57.1%
	Interopercular	0	0	0	0	15	26.8%	18	28.6%
	Opercular	0	0	0	0	2	3.45%	8	14.5%
Hyoid region	Epihyal	0	0	0	0	18	32.1%	11	19.6%
	Urohyal	1	3.4%	1	3.1%	4	14.3%	16	57.1%

* The values are calculated for both sides (left and right).

TABLE 3

The most frequent cranial bones damaged due to butchering by method 1 and 2.

Species	*C. caninus* (n=28)		*A. kessleri* (n=28)	
Neurocranial bones	No*	%	No*	%
Prefrontal	17	30.3%	–	–
Frontal	35	62.5%	21	37.5%
Epiotic	28	50%	2	3.57%
Exoccipital	48	86%	26	46.4%
Prootic	36	64.3%	27	48.2%
Ethmoid	26	92.9%	28	100%
Vomer	22	78.6%	28	100%
Tripus	–	–	18	32.1%
Supraoccipital	27	96.4%	28	100%
Parasphenoid	26	92.9%	28	100%
Basioccipital	22	78.6%	28	100%

* The values are calculated for both sides (left and right).

TABLE 4

The most frequent neurocranial bones damaged due to butchering by method 2.

DISCUSSION AND CONCLUSIONS

Our data from Parita Bay, Panama, represent the developmental stage of an empirical model appropriate for identifying certain butchering methods practiced at archaeological sites. We cannot demonstrate cultural continuity between our informants' butchering methods and those of pre-Hispanic fisherpeople in this region. Our fieldwork was restricted to two sites. Despite these limitations, however, the world-wide occurrence of similar salting and drying methods, and the ample distribution of the fish genera and families we studied, promise to enhance the universality of our, as yet, preliminary observations.

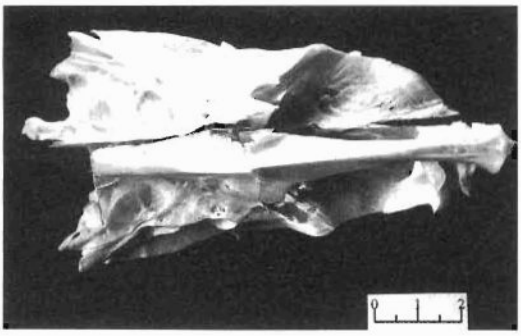
The two butchering methods employed by our informants for preparing fish for salting and drying show that bones from fishes that weigh less than 400 g, and measure less than 325 mm SL, suffer less damage than bones of larger fish.

Since all fish are gutted, both butchering methods lead to considerable loss of branchial arch bones. In large fish, several neurocranial and some other cranial elements are damaged. In small fish, the bones of the neurocranium are not damaged, but some appendicular bones are considerably damaged.

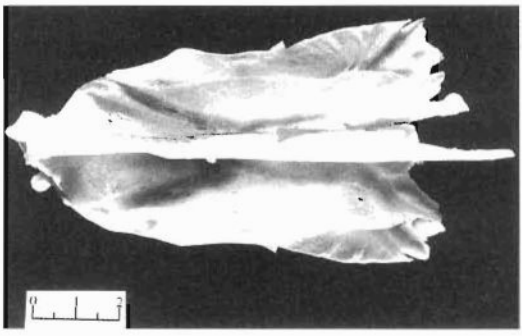
These data infer that bone and body part distributions should be very different at processing and consuming sites. Assuming that similar butchering methods were employed, and providing no animals were around to devour discarded pieces of fish, bone surviving at processing sites would consist predominantly of branchial arch elements, and in the case of marine catfish, whole and damaged predorsal plates, dorsal spines and supraoccipitals. At consuming sites there would be minimal quantities of branchial arch bones. Neurocranial, cranial and postcranial bones of large fish would show relatively increased physical damage compa-

Caranx caninus

Ventral view

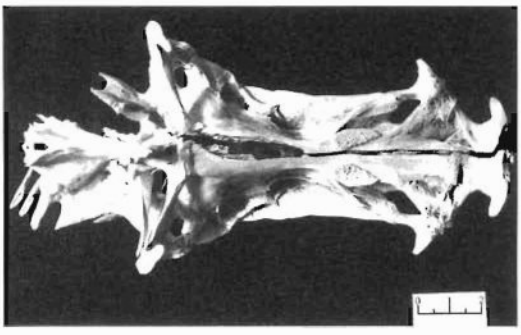


Dorsal view



Arius kessleri

Ventral view



Dorsal view

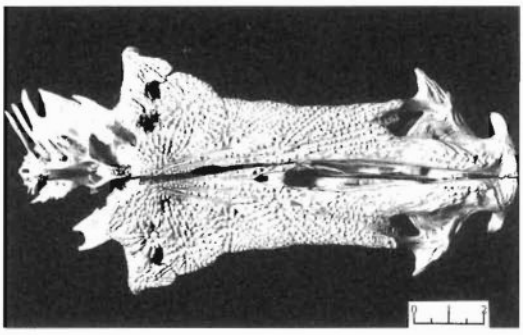


FIGURE 8

Caranx caninus and *Arius kessleri* skulls after butchering by method 2 (notice the breakage along the skull mid-line).

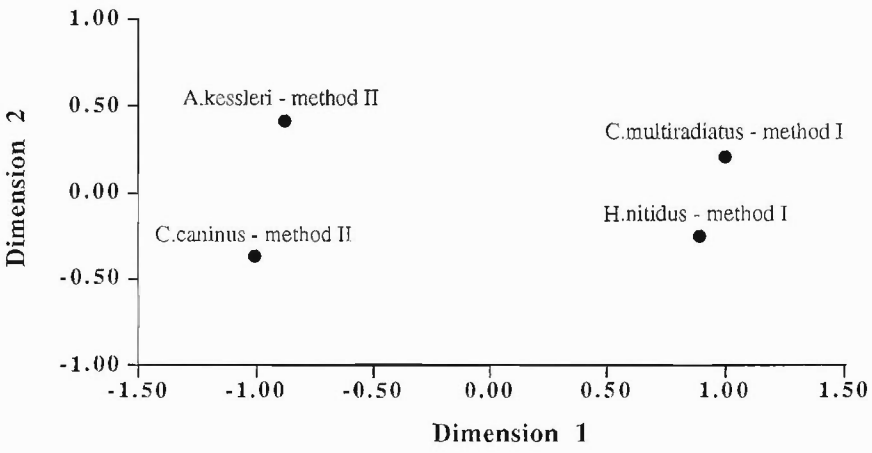


FIGURE 9

Interspecific Euclidean distanees based on pattern of bone loss and breakage were used for this Multidimentional Scaling (MDS) plot of four fish species. Patterns of butchering are indicated.

red to those of small fish. This suggest that survival rate of head bones of small fish in archaeological deposits is greater than some specialist expect (Butler, 1993; Lubinski, 1996).

Lastly, MDS analysis has demonstrated our ability to distinguish between fish butchering methods based on patterns of bone loss and breakage. It may be possible to use a similar approach in order to identify processing methods practiced by past populations.

In future communications, we plan to include data from other fish species, describe a typology of damage observed on individual bones and body parts, and compare the results of this experimental research with specific archaeofaunal assemblages.

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