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Further observations on the morphological characters of *Acipenser sturio* L., 1758 from the Iberian Peninsula: A comparison with North and Adriatic Sea populations

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ABSTRACT

Forty-two *Acipenser sturio* L., 1758 from Spain and Portugal were morphologically analysed. These Iberian sturgeons were collected in the Bay of Biscay, mouths of the Mondego and Tagus, and the Douro, Guadalquivir and Ebro Rivers. Specimens captured in the North and Adriatic Seas were compared with these Iberian specimens. In addition, morphological characters of various specimens of *Acipenser naccarii* Bonaparte, 1836 were included in this comparative analysis. Various morphological features, as well as 39 morphometric and 12 meristic characters, were determined and compared among specimens. Principal Component Analysis (PCA), using a correlation matrix, was used to assess meristic and shape variations. This technique revealed morphological differences between *A. sturio* and *A. naccarii*, and grouped all *A. sturio* from the three geographical areas considered. Nonetheless, univariate analysis revealed significant differences among North Sea specimens, and both Iberian and Adriatic *A. sturio*. Intra-specific variation of morphological patterns in *A. sturio* warrants further comparative research, adding specimens from other European regions, particularly from the Gironde estuary and from the Black and Baltic Seas.

Key words: Biometrics, conservation, distribution, fish, morphometry.

RESUMEN

Datos complementarios sobre la morfología de* Acipenser sturio *L., 1758 de la península Ibérica: comparación con las poblaciones del Mar del Norte y del Adriático

Se ha estudiado la morfología de cuarenta y dos ejemplares de Acipenser sturio *L., 1758 conservados en colecciones de España y Portugal. Estos esturiones ibéricos proceden del mar Cantábrico, de las desembocaduras del Mondego y del Tajo, y de los ríos Duero, Guadalquivir y Ebro. Asimismo, ejemplares de* A. sturio *del Mar del Norte y del Adriático fueron comparados con los de la península Ibérica. Los caracteres morfológicos de algunos ejemplares de* Acipenser naccarii *Bonaparte, 1836 también fueron incluidos en el análisis. Se estudiaron algunos caracteres morfológicos cualitativos, así como 39 caracteres morfométricos y 12 merísticos. Para evaluar la variación merística y de la forma utilizamos el análisis de componentes principales (ACP), a partir de una matriz de correlación. Este análisis multivariado mostró diferencias morfológicas entre los ejemplares de* A. sturio *y los de* A. naccarii, *pero no marcó diferencias apreciables entre grupos para los ejemplares de* A. sturio *de las tres áreas investigadas. Sin embargo, cuando aplicamos un análisis univariado, encontramos algunas diferencias significativas de los ejemplares de* A. sturio *del Mar del Norte frente a los ibéricos y adriáticos. Estas variaciones intraespecíficas del patrón morfológico deben ser contrastadas incluyendo muestras adicionales de otras regiones europeas, principalmente del estuario del Gironda y de los mares Báltico y Negro.*

Palabras clave: *Biometría, conservación, distribución, peces, morfometría.*

INTRODUCTION

Acipenser sturio L., 1758 is the only sturgeon native to the Iberian Peninsula (Doadrio, Elvira and Bernat, 1991; Elvira, Almodóvar and Lobón-Cerviá, 1991a, b; Elvira and Almodóvar, 1993; Pereira, 1995; Almaça and Elvira, 2000). In contrast to this generalised opinion, Garrido-Ramos *et al.* (1997) considered that the Adriatic sturgeon *Acipenser naccarii* Bonaparte, 1836 is also native to Iberian waters. Though this hypothesis has recently been refuted, based on morphological (Elvira and Almodóvar, 1999; Rincón, 2000a, b) and molecular (Doukakis *et al.*, 2000; Almodóvar, Machordom and Suárez, 2000) approaches, Hernando *et al.* (1999) extended this issue, stating that *A. naccarii* and the beluga *Huso huso* (L., 1758) are also native to Iberian waters. Therefore, this study attempts to elucidate the occurrence of *A. naccarii* and *H. huso* in Spain and Portugal. For this purpose we examined preserved Iberian sturgeons available in collections, including the specimens previously studied by Garrido-Ramos *et al.* (1997) and Hernando *et al.* (1999).

Taxonomical and regional variability of *A. sturio* within the distribution area have recently been revised by Birstein, Betts and DeSalle (1998); Ludwig and Kirschbaum (1998); Artyukhin and Vecsei (1999); Debus (1999), and Holčík (2000). These studies reported marked morphological and molecular variability in contrasting stocks throughout the European seas. Therefore, our study is also a contribution to broaden the knowledge of the morphological variability of Atlantic sturgeon.

A. sturio is on the verge of extinction, and has been catalogued as "Critically Endangered (CR A2d)" by the IUCN (Anon., 2000) (Birstein, 1997, 1999; Birstein, Bemis and Waldman, 1997; Williot *et al.*, 1997; Elvira (ed.), 1999, 2000). Understanding local variations and their taxonomic implications is especially relevant for the implementation of recovery programmes (Birstein, Betts and DeSalle, 1998; Doukakis *et al.*, 2000, Holčík, 2000), specially if stocking becomes mandatory.

MATERIALS AND METHODS

Details on the material examined are included in appendix I. This includes information on specimens from 21 Spanish and Portuguese collections, and from Senckenbergische Museum, Frankfurt (Germany), and the Trieste Museum of Natural History (Italy). Institutional abbreviations used follow Leviton *et al.* (1985), and Leviton and Gibbs (1988), unless otherwise stated. Morphometric analysis included 42 preserved specimens (27 stuffed and 15 preserved in alcohol) from the Iberian Peninsula. Twenty-five specimens were of known locality, whereas other specimens were only presumably collected in Spanish or Portuguese waters. Comparative material included 21 preserved *A. sturio* specimens, 11 specimens from the North Sea, and 10 specimens from the Adriatic Sea. Moreover, 16 specimens of *A. naccarii* were analysed for comparative purposes.

Thirty-nine morphometric and 12 meristic characters were determined, according to Holčík, Banarescu and Evans (1989) (Elvira and Almodóvar, 2000). Measurements and meristic characters are listed in table I. Multivariate data analyses included principal component analysis (PCA) of all metric and meristic characters. Before computation, all these characters were standardised (Sokal, 1961) to pool information from different characters into a comparable scale. Morphometric characters were divided by total length, and meristic characters were log transformed. The morphological measurements were tested for allometry using the *log*-transformed relation $log\ M = log\ (a + b) \cdot log\ Tl$, where M is the character measurement and Tl, the total length. To explore differences in body shape among specimens, the metric measurements were adjusted for differences in body length according to: $M_C = M \cdot (Tl/Tl_M)^b$, where M_C is the adjusted measurement, M, the original measurement, Tl, total length, Tl_M, grand mean total length, and b, the regression coefficient of the $log\ M - log\ Tl$ relationship. A PCA for the allometrically adjusted measurements, factoring the correlation matrix, was also performed. This approach was preferred by Reist (1985, 1986) to other methods of size correction, and was used by Rincón (2000a, b).

Differences between *A. sturio* populations for metric and meristic characters were studied using univariate analysis. Owing to the controversy on the use of ratios to adjust size variations (Mayden and Kuhajda, 1996), an ANCOVA for total length as covariate was conducted to test for significant differences among those metric characters. Group means were then compared by a Tukey test (Zar, 1999). Differences between populations for meristic characters were identified using the non-parametric Kruskal-Wallis test. Multiple comparisons were carried out using Dunn's procedure (Zar, 1999).

For multivariate and univariate analyses, we employed STATISTICA (Anon., 1996) and NTSYSpc (Rohlf, 1998) packages. Unless otherwise indicated, statistical significance is $p < 0.01$.

Table I. Synopsis of the metric and meristic characters of 55 *A. sturio* specimens from the Iberian Peninsula, Adriatic Sea and North Sea

Character	n	Minimum	Maximum	Mean	sd
Tl	55	80.0	2 020.0	737.1	554.34
Fl	55	71.5	1 880.0	674.0	511.34
Sl	55	66.5	1 840.0	645.4	494.64
lc	55	24.0	370.0	152.4	102.49
prO	55	12.9	165.0	66.9	40.75
Oh	55	2.6	48.0	15.7	10.78
poO	55	8.5	187.0	69.7	53.77
pD	55	52.0	1 405.0	511.9	394.76
pP	55	25.4	420.0	165.6	115.31
pV	55	47.3	1 165.0	435.6	331.37
pA	55	53.5	1 485.0	541.9	418.34
lpcd	55	7.7	225.0	79.7	59.02
lpc	55	5.2	220.0	72.4	54.73
P-V	55	20.5	747.0	246.7	198.32
P-A	55	26.7	1 060.0	354.0	285.96
V-A	55	5.5	260.0	82.8	70.35
lD	55	5.3	168.8	59.4	46.20
hD	55	7.4	136.9	53.3	38.29
lPbs	55	3.4	101.5	27.3	21.52
lP	55	11.0	195.0	78.1	53.30
lVbs	55	2.3	75.0	27.1	20.70
lV	55	7.0	115.0	44.7	33.44
lA	55	5.2	108.5	33.7	26.52
hA	55	5.0	153.2	54.9	42.54
H	55	7.9	265.0	86.7	65.96
h	55	2.4	68.5	24.1	18.16
hco	55	5.1	118.0	44.9	33.53
hc	55	8.2	200.0	73.0	57.43
lam	54	4.5	110.5	34.7	25.71
laim	54	4.1	84.5	26.7	19.14
lac	55	10.0	200.0	74.9	56.69
io	55	6.2	130.0	50.3	36.79
lasa	54	8.0	166.0	62.4	45.46
lab	54	6.8	102.0	35.0	23.34
lb	53	3.6	45.0	18.3	10.16
s-m	53	14.2	190.0	81.2	50.98
s-mc	53	14.0	185.0	76.7	46.59
s-b	54	4.1	110.0	40.5	23.74
b-mc	53	5.5	93.5	35.4	24.06
Du	54	35	51	40.7	3.90
Pu	54	23	46	36.8	4.18
Vu	54	21	32	27.1	2.61
Au	54	22	38	27.2	2.94
Cu	43	69	110	85.9	9.25
Fu	45	18	31	25.2	3.21
Sp.br.	28	14	32	18.3	3.62
SD	55	9	14	11.7	1.20
SL-left	55	25	41	33.1	3.16
SL-right	55	24	40	33.2	3.26
SV-left	55	7	14	10.9	1.26
SV-right	55	6	14	10.9	1.41

RESULTS

A PCA was carried out factoring the correlation matrix of the metric and meristic data, whose fac-

Table II. Factor loadings for the first three principal components for *A. sturio* and *A. naccarii* specimens

	PC1	PC2	PC3
Fl	–0.622	0.267	0.571
Sl	–0.771	0.138	0.461
lc	0.678	0.621	0.211
Oh	0.468	0.096	–0.072
poO	0.185	0.084	0.608
pD	–0.644	0.599	0.341
pP	0.628	0.652	0.195
pV	–0.518	0.686	0.377
pA	–0.767	0.308	0.435
lpcd	–0.177	–0.446	–0.027
lpc	0.034	–0.738	–0.087
P–V	–0.929	0.043	0.141
P–A	–0.928	–0.154	0.223
V–A	–0.615	–0.422	0.253
lD	–0.092	–0.618	0.277
hD	0.736	–0.051	–0.210
lPbs	0.330	–0.236	0.464
lP	0.752	0.267	–0.037
lVbs	–0.184	–0.265	0.254
lV	0.746	0.117	0.015
lA	0.117	–0.028	0.497
hA	0.494	–0.109	–0.137
H	–0.153	0.157	0.333
h	–0.132	–0.070	0.605
hco	0.547	0.097	0.366
hc	–0.185	0.057	0.672
lam	0.569	–0.578	0.443
laim	0.617	–0.593	0.376
lac	0.320	–0.099	0.386
io	0.556	–0.110	0.551
lasa	0.476	–0.408	0.519
lab	0.660	–0.482	0.243
lb	0.791	0.114	0.010
s–m	0.712	0.628	0.110
s–mc	0.712	0.620	0.106
b–mc	0.605	0.594	0.204
Du	–0.028	–0.107	0.099
Pu	0.413	–0.075	–0.046
Vu	–0.081	–0.069	0.003
Au	0.108	0.130	–0.087
Cu	–0.123	–0.036	–0.334
Fu	0.268	–0.342	–0.063
Sp.br.	0.019	–0.584	–0.129
SD	0.211	0.534	0.096
SL–left	0.206	–0.613	0.246
SL–right	0.301	–0.604	0.219
SV–left	–0.293	0.124	–0.011
SV–right	–0.268	0.017	–0.094
Explained variance (%)	12.33	7.23	4.78

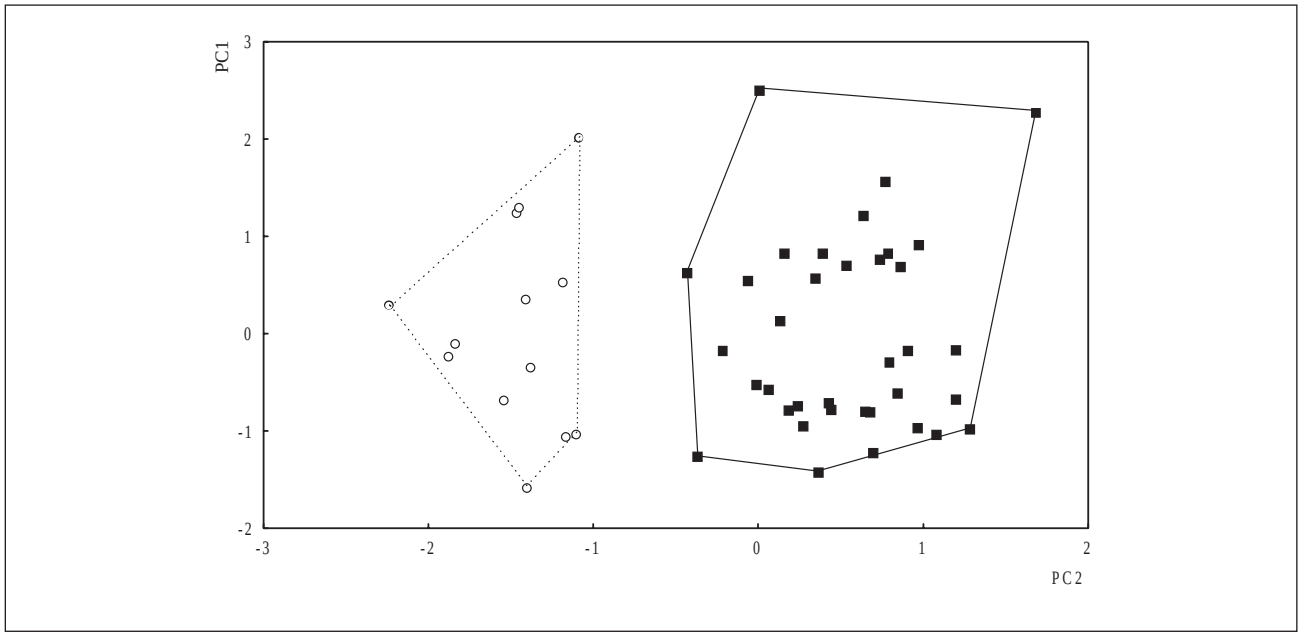

Figure 1. Plot of the factor scores for PC1 and PC2 of all metric and meristic characters for 36 *A. sturio* (■) and 13 *A. naccarii* (○).

tor loadings are shown in table II. The variance explained by the first two components was 19.6 %. The first factor was mainly defined by measurements of size (Sl), head shape (lc, lb, s-m, s-mc), and by the position (pA, P-V, P-A) and size of fins (hD, lP, lV). The second component was mainly correlated with meristic characters (Sp.br., SL), metric measurements related to fin position (pD, pP, pV), and length of caudal peduncle (lpc).

Visual inspection of the plots for the first and second components easily distinguished two major groups (figure 1). The first factor of the PCA did not separate species, but the second component resulted in an evident separation of the two species. Unlike *A. naccarii*, *A. sturio* is characterised by lower numbers of gill rakers and lateral scutes, and by shorter mean caudal peduncles, mean dorsal fin lengths and mean mouth widths. Moreover, larger

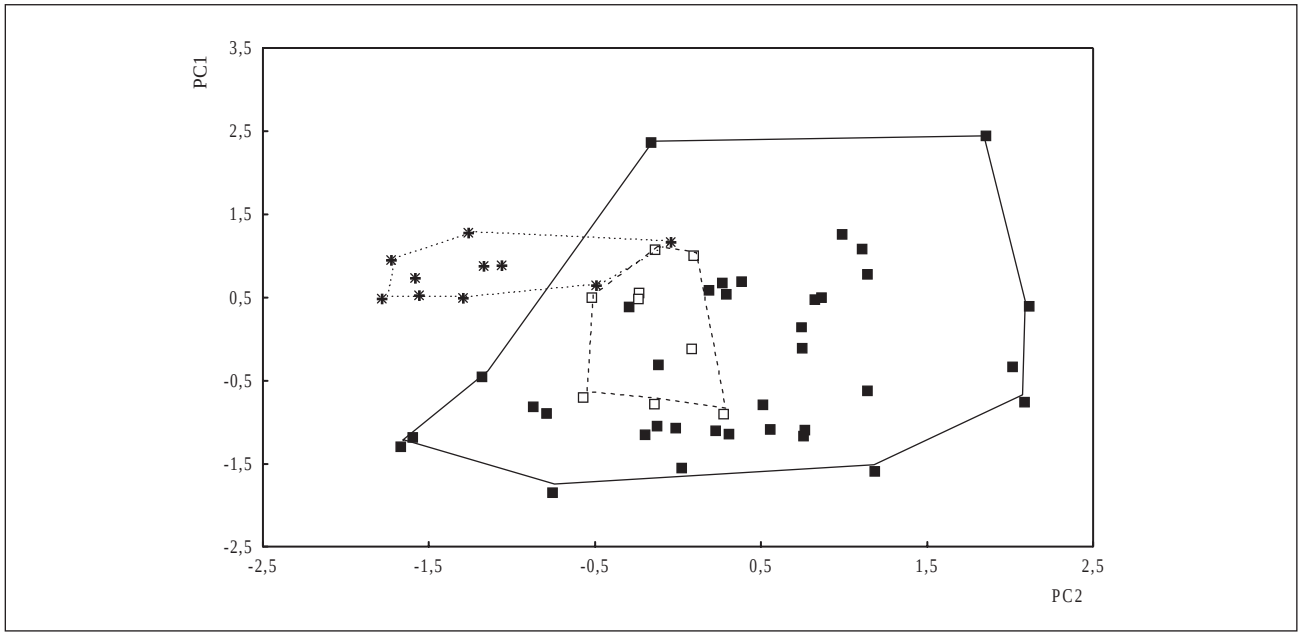

Figure 2. Plot of the factor scores for PC1 and PC2 of all metric and meristic characters for 55 specimens of *A. sturio*: Iberian Peninsula (n = 36) (■), Adriatic Sea (n = 9) (□) and North Sea (n = 10) (∗).

mean pre-dorsal, pre-pectoral and pre-ventral distances, larger mean head length, and longer snout identified *A. sturio* specimens. In addition, PCA's allometry adjusted metric measurements together with *log*-transformed meristic characters resulted in similar relationships between *A. naccarii* and *A. sturio*.

A second PCA for all of these characters was performed, including the dataset for *A. sturio* from the Iberian Peninsula, North Sea and Adriatic Sea (factor loadings in table III). Nevertheless, the plot of the factor scores for the first and second principal components showed no obvious separation among the three populations (figure 2). Further differentiation was not possible using the successive principal components.

Conversely, ANCOVAs for metric characters among *A. sturio* populations with total length as covariate revealed significant differences ($p < 0.01$) in nine out of 38 metric characters (table IV). Moreover, subsequent comparisons of means values revealed significant differences between the North Sea and both Adriatic and Iberian Peninsula sturgeons in eight out of the nine former characters (Tukey test, $p < 0.01$), while the length of ventral fin was significantly different (Tukey test, $p < 0.01$) among the three sturgeon populations. Adjusted means for the *log*-transformed metric characters indicated that sturgeons from the North Sea have longer caudal peduncles, shorter fins, narrower mouths and lower interorbital distances.

We also found significant differences (Kruskal-Wallis test, $p < 0.01$) in five out of 12 meristic characters among the three *A. sturio* populations (table V). A posterior comparison among mean values showed that these differences occurred between the North Sea and the other two populations (Dunn test, $p < 0.01$). Sturgeons from the North Sea had significantly higher numbers of unbranched rays in the pectoral and ventral fins, and lower numbers of fulcrae and lateral scutes.

Table III. Factor loadings for the first three principal components for Iberian Peninsula, Adriatic Sea and North Sea *A. sturio* specimens

	PC1	PC2	PC3
Fl	–0.575	0.570	0.384
Sl	–0.726	0.413	0.380
lc	0.737	0.403	0.331
Oh	0.533	–0.095	0.099
poO	–0.010	0.628	0.189
pD	–0.730	0.450	0.343
pP	0.711	0.362	0.419
pV	–0.569	0.504	0.520
pA	–0.769	0.484	0.335
lpcd	0.119	–0.330	0.357
lpc	0.136	–0.456	0.153
P–V	–0.935	0.179	0.062
P–A	–0.939	0.244	0.043
V–A	–0.801	0.296	0.033
lD	–0.298	0.529	–0.551
hD	0.411	0.366	–0.050
lPbs	0.373	0.226	0.233
lP	0.636	0.302	–0.177
lVbs	–0.109	0.144	–0.013
lV	0.543	0.374	–0.358
lA	0.084	0.453	0.016
hA	0.344	0.114	–0.441
H	–0.124	0.332	0.096
h	–0.223	0.593	–0.128
hco	0.505	0.417	–0.016
hc	–0.394	0.621	0.177
lam	0.577	0.465	–0.073
laim	0.701	0.471	–0.138
lac	0.198	0.392	0.097
io	0.374	0.649	0.040
lasa	0.467	0.638	0.148
lab	0.798	0.231	–0.025
lb	0.850	0.026	0.007
s-m	0.827	0.192	0.326
s-mc	0.834	0.175	0.327
b-mc	0.613	0.390	0.264
Du	0.130	0.135	–0.322
Pu	0.534	–0.185	0.233
Vu	0.234	–0.421	0.280
Au	0.363	–0.333	–0.026
Cu	0.124	–0.510	0.044
Fu	–0.084	0.265	–0.585
Sp.br.	0.149	–0.173	–0.155
SD	0.011	0.455	–0.372
SL-left	–0.094	0.406	–0.616
SL-right	–0.110	0.457	–0.694
SV-left	–0.278	–0.040	–0.236
SV-right	–0.205	–0.217	–0.172
Explained variance (%)	12.79	7.36	4.08

DISCUSSION

Garrido-Ramos *et al.* (1997) reported four Iberian sturgeons preserved in Portuguese and Spanish collections as *A. naccarii*, namely specimens labelled EBD-8173, EBD-8174, UC-46b, and UC-uncat. In a later study, these same authors (Hernando *et al.*, 1999) accepted the taxonomical position determined for three specimens (EBD-8173, EBD-8174 and UC-uncat.) as *A. naccarii*. However, by applying skin patterns as diagnostic characters previously validated by Artyukhin and Vecsei (1999) and Debus (1999) to differentiate *A. sturio* from closely-related

Table IV. Results of the ANCOVA using total length as covariate (only for characters that became significantly different) for metric characters among *A. sturio* populations: Iberian Peninsula (IP), Adriatic Sea (AS), and North Sea (NS)

Character	$F_{(2,33)}$	p	Tukey test
Length of caudal peduncle from dorsal fin	7.60	0.0019	IP, AS < NS
Length of caudal peduncle from anal fin	9.20	0.0007	IP, AS < NS
Length of dorsal fin	15.42	< 0.0001	IP, AS > NS
Length of pectoral fin	8.37	0.0012	IP, AS > NS
Length of ventral fin	13.52	0.0001	IP > AS > NS
Depth of anal fin	5.81	0.0069	IP, AS > NS
Width of mouth	9.60	0.0005	IP, AS > NS
Internal width of mouth	8.38	0.0011	IP, AS > NS
Interorbital distance	6.54	0.0041	IP, AS > NS

taxa, specimens EBD-8173 and EBD-8174 (labelled in the Guadalquivir River) were assigned to *A. sturio* by Elvira and Almodóvar (1999, 2000). Portuguese specimens UC-uncat. (labelled in Lisbon) and UC-46b (labelled in Buarcos), included in our present study, resulted in clustering of these with other *A. sturio*. Likewise, the skin patterns of these two specimens are typical of the species. Therefore, we conclude that there is no reason to consider native sturgeon specimens from Iberian waters as members of *A. naccarii*.

Hernando *et al.* (1999) determined the specimen UP-1 as *H. huso*, whilst they considered the specimen UP-84 as a hybrid *H. huso* × *A. sturio*. Specimen UP-1 (unrecorded locality, no date; Portugal) is mounted, and its poor preservation conditions do not permit an appropriate morphological assessment: its mouth was re-constructed with plasticine by the taxidermist (but it is not crescent), and barbels are four pieces of cord (!). In fact, we were unable to detect unequivocal external diagnostic characters to assign this specimen as *H. huso*. In contrast, the specimen UP-84 (Douro River) is well preserved in alcohol, and showed only one uncommon meristic character for *A. sturio*: 32 gill rakers. However, we found no character attributable to *H. huso*: this specimen showed an isthmus, the mouth was not crescent, the gill rakers were not rod-shaped, the barbels were not laterally compressed, and did not bear foliate appendages. Consequently, we considered this specimen a young *A. sturio* with a peculiarly high number of gill rakers. In conclusion, by no means could native sturgeons collected in Iberian waters be considered *H. huso*.

All native sturgeons studied from Spain and Portugal were assigned as *A. sturio*. The putative occurrence of *A. naccarii* and *H. huso* in these waters could not be confirmed. Our findings agree with those previously presented by us and other research groups (Elvira and Almodóvar 1999, 2000; Doukakis *et al.*, 2000; Almodóvar, Machordom and Suárez, 2000; Rincón 2000a, b), and further reinforce the idea that the only sturgeon species native to the Iberian Peninsula is *A. sturio*.

With regard to the three sturgeon populations analysed, we detected significant differences between sturgeon from the North Sea versus the Iberian Peninsula and Adriatic Sea. Even considering the small sample available for this study, differences detected are significant enough to infer that the currently accepted species *A. sturio* may consist of several different separate taxonomical units, i.e. species (?) (Almaça, 1988; Holčík *et al.*, 1989; Artyukhin and Vecsei, 1999; Debus, 1999; Almaça and Elvira, 2000; Holčík, 2000). In any case, we believe further analyses ought to be undertaken to unequivocally demonstrate the taxonomical value of these differences. Meanwhile, cautionary and reversibility principles must be considered by

Table V. Results of the Kruskal-Wallis test (only for characters that became significantly different) for meristic characters among *A. sturio* populations: Iberian Peninsula (IP), Adriatic Sea (AS), and North Sea (NS)

Character	H	p	Dunn test
Unbranched rays of pectoral fin	10.60	0.0050	IP, AS < NS
Unbranched rays of ventral fin	9.83	0.0073	IP, AS < NS
Fulcrae	12.83	0.0016	IP, AS > NS
Lateral scutes (left)	15.78	0.0004	IP, AS > NS
Lateral scutes (right)	22.90	< 0.0001	IP, AS > NS

decision-makers on transfers or translocations of specimens among these different areas.

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APPENDIX I

Sturgeon material examined. Specimens marked with (*) are preserved in poor condition and were not included in the multivariate analysis. Unless otherwise indicated, size is expressed as standard length

Acipenser sturio (63 specimens)

Atlantic sturgeons from the Iberian Peninsula (42 specimens)

MNCN uncat. (IFIE 7bis); Ebro River, Amposta, Tarragona; 9 December 1951; 66.5 mm; alcohol

MNCN 1579-1581 (3 ex.); Ebro R., Amposta, Tarragona; 226, 303 and 325 mm; alcohol

MNCN 1582; Guadalquivir R.; 208 mm; alcohol

MNCN 1583; Ebro R., Tortosa, Tarragona; 242 mm; alcohol

MNCN 44145; Mediterranean Sea, Spain; 755 mm; stuffed

VBCM uncat.; no data, Spain?; 455 mm; stuffed

Doñana Biological Station, Seville, EBD 8173 (*); Guadalquivir R., Alcalá del Río, Seville; 12 April 1974; Tl = 1 755 mm; alcohol

EBD 8174 (*); Guadalquivir R., Alcalá del Río, Seville; 11 May 1975; Tl = 1 520 mm; stuffed

EBD 8401; Guadalquivir R., Coria del Río, Seville; Winter 1981; 1 450 mm; alcohol

Aguilar y Eslava Institute, Cabra, Córdoba, IAEC uncat.; Guadalquivir R.; 1880; 1 150 mm; stuffed

J. M. Pascual Collection, Seville, CJMP uncat.; Guadalquivir R.; 1965-1967; 288 mm; alcohol

F. Ibarra Collection, Seville, CFI uncat.; Guadalquivir R.; 268 mm; stuffed

Department of Animal Biology, University of Badajoz, DABUBA uncat.; no data, Spain?; 195 mm; stuffed

Department of Animal Biology, University of Seville, DABUS uncat. (3 ex.) (*); Cádiz; 189, 277 and 300 mm; stuffed

Cantabrian Museum, Santander, Cantabria, MMCS 3/Vc/171; Bay of Biscay, Cantabria; 1914; 430 mm; alcohol

MMCS 3/Vc/1210; San Vicente de la Barquera, Cantabria; 10 June 1988; 1 205 mm; stuffed

Zoology Museum, Barcelona, MZB 82-5337; Ebro Delta, Tarragona; 1 285 mm; stuffed

MZB 82-5340; no data, Spain?; 460 mm; stuffed

MZB 82-5342; no data, Spain?; 730 mm; stuffed

MZB 95-0105; no data, Spain?; 835 mm; stuffed

Department of Animal Biology, University of Barcelona, DABUB uncat.; no data, Spain?; 680 mm; alcohol

Department of Animal Biology, University of Granada, DABUG uncat. (*); no data, Spain?; Tl = 1 600 mm aprox.; stuffed

DABUG; no data, Spain?; 675 mm; stuffed

Capuchins Ethnographic-Missions Museum, Barcelona, MEMCCB uncat.; no data, Spain?; 970 mm; stuffed

Sagrada Familia Institute, Puerto de Santa María, Cadiz, ISFPSM uncat.; no data, Spain?; 1 640 mm; stuffed

Cardenal Cisneros Institute, Madrid, ICCM uncat.; no data, Spain?; 1 640 mm; stuffed

Luis Iglesias Museum, Santiago de Compostela, A Coruña, MLISC uncat.; no data, Spain?; 1865-1870; 1 430 mm; stuffed

P. P. Paúles Museum, Villafranca del Bierzo, León, MPVB uncat.; no data, Spain?; 1 460 mm; stuffed

Department of Zoology and Ecology, University of Navarre, Pamplona, DZEUN uncat.; Bay of Biscay, San Sebastián, Guipúzcoa; 21 May 1975; 945 mm; alcohol

University of Porto, UP 1; Portugal?; 1 340 mm; stuffed

UP 2; Portugal; 447 mm; stuffed

UP 3; Douro R.; May 1916; 920 mm; stuffed

UP 84; Douro R., Barca d'Alva; June 189(?); 183.5 mm; alcohol

UP 85; no data, Portugal?; 360 mm; alcohol

Rodrigues de Freitas Institute, Porto, LRFP 88; no data, Portugal?; 915 mm; stuffed

LRFP uncat.; no data, Portugal?; 245 mm; alcohol

University of Coimbra, UC 46b; Buarcos; 11 July 1897; 1 310 mm; stuffed

UC uncat.; Lisbon; 1890; 1 840 mm; stuffed

Atlantic sturgeons from the Adriatic Sea
(10 specimens)

Trieste Museum of Natural History, MCSNT 97; Adriatic Sea; 265 mm; alcohol

MCSNT 300; Adriatic Sea; 335 mm; alcohol

MCSNT 302; Adriatic Sea; 430 mm; alcohol

MCSNT uncat.; Adriatic Sea; 1 320 mm; stuffed

MCSNT uncat.; Adriatic Sea; 1 415 mm; stuffed

MCSNT uncat.; Adriatic Sea; 505 mm; stuffed

Senckerbergische Museum, Frankfurt, SMF 794; Adriatic Sea; 1831; 258 mm; alcohol

SMF 2397; Adriatic Sea, Trieste; 1902; 395 mm; alcohol

SMF 2448; Adriatic Sea, Trieste; 1902; 393 mm; alcohol

SMF 7647 (*); Adriatic Sea, Neapel (?); 1827; 470 mm; stuffed

Atlantic sturgeons from the North Sea
(11 specimens)

SMF 158; North Sea; 1830; 333 mm; alcohol

SMF 792 (2 ex.); North Sea; 1830; 169 and 155 mm; alcohol

SMF 1341; Lower Elbe, Kraütsand; 1907; 142 mm; alcohol

SMF 4640; North Sea, Deutsche Bucht; 20 October 1958; 203 mm; alcohol

SMF 7636; Elbe R., Hamburg; 1913, 225 mm; alcohol

SMF 7637-7640 (4 ex.); Eider R., Nübbel; April 1913; 313, 208, 366 and 190 mm; alcohol

SMF 7651 (*); North Sea, south of Helgoland; 1960; 525 mm; alcohol

Acipenser naccarii (16 specimens)

MCSNT uncat.; Adriatic Sea; 860 mm; stuffed

MCSNT uncat.; Adriatic Sea; 830 mm; stuffed

MCSNT uncat.; Adriatic Sea; 875 mm; stuffed

SMF 7634; Neapel (?); 21 July 1924; 485 mm; alcohol

SMF uncat.; Saxenstör 94; 6 June 1995; 156 mm; alcohol

VBCM uncat. (3 ex.) (*); fish farm; 75, 75 and 100 mm; alcohol

EEAUS uncat. (2 ex.); fish farm; 177 and 190 mm; alcohol

EEAUS uncat. (2 ex.); fish farm; 650 and 690 mm; frozen

EBD uncat. (4 ex.); fish farm; 405, 1 120, 1 120 and 1 190 mm; frozen