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Craniometry of bottlenose dolphins (*Tursiops truncatus*) from the Croatian Adriatic coast

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Introduction

Typical bottlenose dolphin skull is elongated antorbitally and compressed postorbitally. Many skull bones show variation in size and shape between individuals, they are therefore used for differentiation of subspecies and populations. In this study term the skull refers to the entire head skeleton.

The aim of this study was to investigate the bottlenose dolphin population from Croatian part of the Adriatic Sea by craniometric data.

Materials and Methods

In order to account for potential ontogenetic variation, juvenile and adult individuals were separated based on degree of fusion of maxillary and premaxillary bones. Fifty-nine cranial measurements (Figure 1.) were taken from 96 adult specimens of bottlenose dolphin collected in Croatia from October 1990 to May 2011. Measurements were conducted with 0.5 – 0.01 cm precision using a caliper.

Croatian results were compared with the same cranial measuremants of bottlenose dolphin from other seas. (Figure 2.)

Results

Only one morphotype was recognized in Croatian waters; however males and females significantly differed in 19 measurements, male skulls were more robust (Table 1.).

Skulls from the eastern Mediterranean Sea (Israeli coast) and from the Black Sea were significantly smaller. The western Mediterranean data did not differ from the Croatian. On a broader scale, populations from the eastern Atlantic Ocean, the North Sea, the north-western African coast, the South African coast and the Australian coast had significantly larger skulls compared to the Adriatic bottlenose dolphins. Populations from the Chinese waters and the eastern Florida coast had significantly smaller skulls than the Adriatic dolphins. (Table 2.)

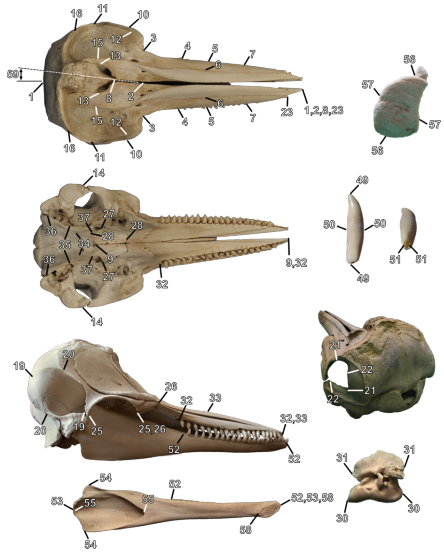

Figure 1. List of significantly different Measurements: ***1.*** Condylobasal length, ***2.*** Length of rostrum, ***3.*** Width of rostrum at base, ***4.*** Width of rostrum 60 mm of the base, ***5.*** Rostrum width at half length, ***6.*** Width of premaxillaries at half length, ***7.*** Rostrum width at ¾ length, ***10.*** Greatest preorbital width, ***11.*** Greatest postorbital width, ***12.*** Least supraorbital width, ***14.*** Greatest width across zygomatic process of squamosal, ***15.*** Greatest width of premaxillaries, ***16.*** Greatest parietal width, ***17.*** Vertical external height of braincase from midline of basospheniod to summit of supraoccipital, without supraoccipital crest, ***18.*** Internal length of braincase from hindmost part of occipital condyles to foremost part of cranial cavity, ***22.*** Minor diameter of left temporal fossa, ***23.*** Projection of premaxillaries beyond maxillaries, ***24.*** Distance from foremost end of nasals to hindmost part of margin of supraoccipital crest, ***26.*** Length of antorbital process of left lacrimal, ***28.*** Greatest length of left pterygoid, ***32.*** Length of upper left tooth row, ***38.*** Alveolar tooth width measured at middle of the rostrum, ***44.*** Number of teeth-upper left = number of teeth alveoli, ***49.*** Biggest tooth height, ***57.*** Greatest width of mandibular condyle

Table 1. Results of Croatian *T. truncatus* skull measurements (cm).
M=Measurement, Diff=Difference, Mean±s.d., N=Sample, Range.

M	Combined	Male	Female	Diff (%)
	10,13±0,68	10,42±0,62	9,94±0,51	
4.	N=91	N=41	N=45	
	(8,0–11,7)	(8,6–11,7)	(8,2–10,8)	4,8
	8,62±0,62	8,84±0,58	8,45±0,57	
5.	N=84	N=40	N=41	
	(7,1-10,9)	(7,6–10,9)	(7,1–9,6)	4,5
	4,77±0,41	4,91±0,4	4,64±0,35	
6.	N=86	N=40	N=43	
	(3,9–5,6)	(3,9–5,6)	(4,0–5,5)	5,7
	6,75±0,56	6,94±0,47	6,58±0,6	
7.	N=83	N=40	N=41	
	(5,5–8,0)	(5,8–7,9)	(5,5–8,0)	5,3
	22,91±1,16	23,44±1,09	22,5±0,92	
10.	N=93	N=43	N=45	
	(19,0–25,4)	(20,4–25,4)	(19,0–25,0)	4,1
	25,75±1,24	26,27±1,14	25,37±1,02	
11.	N=92	N=43	N=44	
	(21,4–28,7)	(22,8–28,7)	(21,4–28,0)	3,5
	22,99±1,14	23,47±1,05	22,68±0,92	
12.	N=94	N=43	N=46	
	(19,2–25,5)	(20,3–25,5)	(19,3–25,0)	3,4
	25,57±1,42	26,07±1,35	25,25±1,15	
14.	N=89	N=43	N=41	
	(20,7–28,8)	(23,0–28,8)	(20,7–27,0)	3,2
	9,63±0,53	9,77±0,57	9,53±0,44	
15.	N=94	N=43	N=46	
	(8,6–11,0)	(8,6–11,0)	(8,6–10,6)	2,6
	15,04±0,71	15,25±0,72	14,87±0,62	
17.	N=91	N=43	N=43	
	(13,5–17,2)	(13,8–17,2)	(13,6–16,5)	2,6
	15,16±0,89	15,44±0,98	14,94±0,76	
18.	N=88	N=40	N=43	
	(13,5–17,1)	(13,9–17,1)	(13,5–16,5)	3,3
	5,23±0,56	5,4±0,48	5,11±0,54	
22.	N=92	N=42	N=45	
	(3,5–6,5)	(4,2–6,5)	(3,5–6,2)	5,7
	1,6±0,53	1,77±0,43	1,44±0,57	
23.	N=75	N=37	N=37	
	(0,2–2,8)	(0,9–2,8)	(0,2–2,6)	20,8
	4,98±0,84	5,22±0,81	4,69±0,83	
24.	N=92	N=43	N=44	
	(3,4–7,9)	(3,8–7,4)	(3,4–7,9)	10,7
	5,33±0,59	5,6±0,42	5,16±0,58	
26.	N=93	N=43	N=45	
	(3,2–6,3)	(4,5–6,3)	(3,7–6,2)	8,2
	7,6±0,6	7,75±0,65	7,46±0,45	
28.	N=78	N=41	N=32	
	(6,4–9,1)	(6,4–9,1)	(6,7–8,4)	3,8
	1,13±0,14	1,18±0,15	1,09±0,12	
38.	N=92	N=42	N=45	
	(0,8–1,7)	(0,9–1,7)	(0,8–1,4)	7,7
	3,35±0,33	3,43±0,28	3,28±0,35	
49.	N=83	N=38	N=44	
	(2,3–4,1)	(2,8–4,1)	(2,3–3,8)	4,5
	2,87±0,33	3,0±0,31	2,78±0,28	
57.	N=89	N=40	N=45	
	(2,0–3,7)	(2,5–3,7)	(2,2–3,4)	7,5

Table 2.: Results of *t*-test performed on skull measurements (cm) of *T. truncatus* from Croatian Adriatic coast and other world seas. * = Significantly different (p<0.05). Mean ± s.d., N = Sample, Range. (1) - Hersh et al. 1990, (2) - Viaud-Martineza et al. 2008, (3) - Sharir et al. 2011, (4) - Wang et al. 2000, (5) - Charlton - Robb et al. 2011 , (6) - Ross 1977, (7) - Robineau & Vely 1997

Measurement		Condylobasal length	Length of rostrum	Width of rostrum at base	Greatest preorbital width	Greatest parietal width	Length of upper left tooth row	Number of teeth-upper left
Indian/Banana River on the east coast of Florida (1)	male	44.71±1.73 N=36*	24.51±1.16 N=36*	10.7±0.83 N=36*	19.68±1.19 N=36*	18.05±0.58 N=35*	21.33±1.05 N=36*	24.7±1.1 N=32*
	female	45.16±2.13 N=33*	24.75±1.34 N=33*	10.81±0.67 N=33*	19.69±1.1 N=33*	17.77±0.59 N=33*	21.54±1.21 N=33*	23.8±1.0 N=33*
Black Sea (2)		45.23 N=27*						
Israeli coast (3)		49.7±1.88 N=40 (46.8-54.0)*	27.62±1.2 N=29 (25.5.30.3)*	12.7±0.68 N=30 (11.38-14.5)*	21.54±1.03 N=29 (20.1-24.1)*	19.53±1.12 N=30 (18.0-22.83)*	23.64±1.06 N=28 (21.7.25.9)*	22.82±1.02 N=28 (21.0-25.0)
Chinese waters (4)		50.62±3.33 N=50 (39.4-56.1)*	28.38±2.34 N=49 (20.4-32.0)	13.45±1.12 N=49 (9.8-15.4)	23.18±1.86 N=49 (17.2-26.3)		24.36±2.05 N=49 (17.2-27.8)	23.9±1.4 N=54 (21.0-27.0)*
Western Italy (3)		51.98±1.42 N=13 (50.2-55.4)	29.05±0.81 N=13 (27.3-30.1)	13.34±073 N=13 (12.3-15.0)	22.56±1.14 N=12 (20.2-24.6)	20.44±0.65 N=13 (19.0-21.5)	24.68±0.82 N=12 (23.4-26.0)	21.92±0.9 N=12 (21.0-23.0)
Croatian Adriatic coast		**51.54±2.04 N=84 (45.3-56.0)**	**29.00±1.48 N=86 (24.1-31.8)**	**13.13±0.82 N=94 (10.5-15.2)**	**22.91±1.16 N=93 (19.0-25.4)**	**21.0±1.0 N=92 (18.8-25)**	**24.22±1.33 N=86 (20.1-27)**	**22.55±1.38 N=83 (17.0-26.0)**
Western Mediterranean (2.)		52.03 N=18*						
Eastern Italy (3)		52.23±1.6 N=21 (50.1-55.5)	29.31±1.27 N=21 (27.1-32.5)	13.83±0.65 N=21 (12.4-14.9)*	23.34±1.27 N=21 (21.8-25.9)	21.24±0.85 N=21 (19.9-22.8)	24.71±1.0 N=21 (22.9-27.0)	22.0±1.38 N=20 (20.0-25.0)
Spanish Mediterranean (3)		52.52±1.12 N=5 (51.0-54.0)	29.78±1.02 N=5 (28.2-30.9)	14.22±0.42 N=6 (13.5-14.8)*	23.45±0.73 N=6 (22.4-24.4)	21.6±0.75 N=6 (20.5-22.3)	25.08±0.85 N=5 (23.7-25.9)	21.2±1.3 N=5 (20.0-23.0)
South Australia (5)		52.79 N=13 (50.55-54.7)*	30.37 N=13 (29.15-32.6)*	14.31 N=13 (13.63-15.89)*	23.76 N=13 (22.4-25.1)*	19.02 N=13 (18.16-19.63)*	25.31 N=13 (24.0-26.7)*	23.36 N=11 (20.0-26.0)*
Eastern Atlantic (2.)		53.74 N=18*						
British shores (6)		54.15±1.94 N=17 (50.0-57.5)*						
South Africa (4)		54.58±2.62 N=9 (50.4-57.8)*	30.91±1.8 N=9 (28.32-33.46)*	14.28±1.08 N=9 (12.7-15.78)*	25.34±1.56 N=9 (22.98-27.69)*		24,24±4,58 N=6 (15.4-27.69)	24.2±0.67 N=9 (23.0-25.0)*
North Sea (7)		55.4±1.0 N=34 (54.0-57.3)*	30.9±0.8 N=34 (29.7-32.4)*	15.5±0.6 N=34 (14.0-16.5)*		22.0±0.8 N=34 (20.4-23.7)*		24.0±1.6 N=50 (19.0-28.0)*
North-west African (7)		56.9±1.7 N=53 (54.0-61.0)*	33.2±1.2 N=53 (30.8-36.2)*	13.7±0.7 N=52 (12.4-15.4)*		19.0±0.8 N=52 (17.3-20.8)*		23.0±1.2 N=52 (20.0-27.0)

Figure 2. Comparison of skull measurements of European populations with Croatian *T. truncatus* population. Blue - larger, Red - equal size to Croatian population, Yellow - smaller

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