PRELIMINARY GROWTH RATE AND BODY LENGTHS OF THE BOTTLENOSE DOLPHINS *TURSIOPS TRUNCATUS* (MONTAGU, 1821) FROM THE ADRIATIC SEA

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The age of a sample of 20 bottlenose dolphins (*Tursiops truncatus*) (12 females, 7 males and one of unknown sex) was determined by counting the growth layer groups (GLGs) formed in the dentine. Preliminary growth rates for the bottlenose dolphins in the Adriatic Sea were established using the Gompertz equation and the Fishery Science Application Program. The growth curve derived was found to be similar to that of other *Tursiops* populations. Growth parameters, age of physical maturity and body length of a newborn specimen were also calculated. The preliminary data collected represent the first information on stranded dolphins found in the Croatian part of the Adriatic.

Key words: bottlenose dolphin, *Tursiops truncatus*, age determination, growth layer groups, growth rate, Adriatic Sea

Pribanić, S., Mioković, D. & Kovačić, D.: Preliminarna krivulja rasta i dužina tijela dobrih dupina *Tursiops truncatus* (Montagu, 1821) iz Jadranskog mora. Nat. Croat., Vol. 9, No. 3., 179–188, 2000, Zagreb.

Starost 20 dobrih dupina (*Tursiops truncatus*) (12 ženki, 7 mužjaka i jedan neodređenog spola) određena je prebrojavanjem zona prirasta (GLG – engl. »growth layer group«) formiranih u sloju dentina. Koristeći Gompertzovu jednadžbu i Fishery Science Application Program, izračunata je preliminarna krivulja rasta u vrste dobri dupin za Jadransko more. Krivulja rasta podudara se s

krivuljama rasta iste vrste dupina u svijetu. Također su izračunati približna starost jedinki u kojoj se postiže fizička zrelost i približna duljina tijela mladunčadi. Podaci prikupljeni ovim radom preliminarni su i predstavljaju prvu informaciju o pronađenim uginulim dupinima u hrvatskom dijelu Jadranskog mora.

Ključne riječi: dobri dupin, *Tursiops truncatus*, određivanje starosti, zone prirasta, krivulja rasta, Jadransko more

INTRODUCTION

Bottlenose dolphins *Tursiops truncatus* (MONTAGU, 1821) are thought to be the only marine mammal species regularly to inhabit the Adriatic Sea (NOTARBARTOLO DI SCIARA & BEARZI, 1992; NOTARBARTOLO DI SCIARA *et al.*, 1993; BEARZI & NOTARBARTOLO DI SCIARA, 1995; GOMERČIĆ *et al.*, 1998). This situation reflects the decline in Cetacean diversity in Croatian waters and raises questions on how effective conservation of the species can be achieved. Estimating the growth rate is an essential parameter for the assessment of the general health, reproductive history, effects of stress and possible environmental impacts on odontocetes in general (LOCKYER, 1995) as well as on the bottlenose dolphins in Adriatic Sea in particular.

The age was determined by counting the growth layer groups – GLGs – which are known to be layered annually for this species (SERGEANT, 1959). The method used was scanning electron microscopy (SEM) analysis, as described by HOHN (1980).

This study provides the first estimation of the growth rate and growth parameters for *Tursiops truncatus* in the Adriatic Sea. It also gives the first such information on this species for the Mediterranean Sea.

MATERIALS AND METHODS

Twenty stranded or by-caught dolphins from the Adriatic Sea were inspected during an eight year period (1990–1997). Data on gender, body length and weight were recorded whenever possible (KUIKEN & HARTMAN, 1991), and two teeth taken from each animal and stored in 70% ethanol. In one case (dolphin coded 2) (Fig. 1a) only one tooth was available and in another (dolphin coded 17), the teeth had not yet erupted.

Following the procedures described by HOHN (1980) and PERRIN & MYRICK (1980), thin (1–2 mm) mid, longitudinal and transversal sections of the teeth were made with a circular diamond saw, etched in 5% formic acid (PIERCE & KAJIMURA, 1980) and prepared for analysis. A Philips 515 SEM was used. Microphotographs of both transverse and longitudinal sections were taken with Polaroid 552 professional film. Tooth sections were plated with a thin layer of gold, which gave a good contrast between hyper and hypo–calcified layers in GLGs (Fig. 1d). The gold plated tooth sections were later used for checking numbers of GLGs with the magnifying glass.
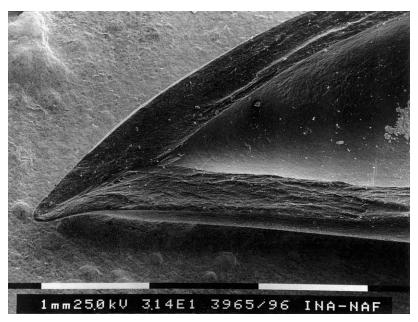
Fig. 1a. Microphotography of the longitudinal section of a tooth from a yearling (code 2).
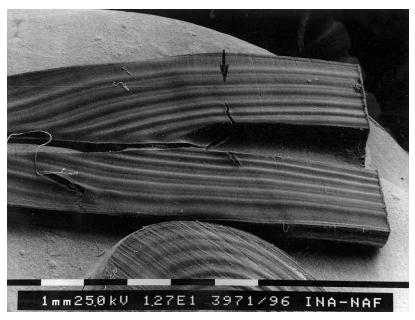

Fig. 1b. Microphotography of the longitudinal section of a tooth (code 3).
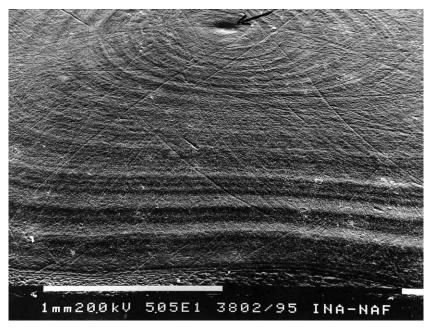Arrow shows a GLG.

Fig. 1c. Microphotography of the transversal section of the tooth of an old animal (code 9). Arrow shows occlusion of the pulp cavity.
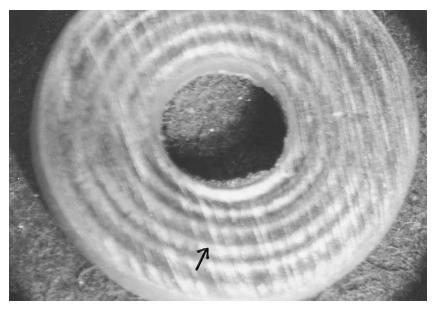

Fig. 1d. Photograph of the gold plated section of a tooth (code 1). Arrow shows a GLG.

Age was determined by counting the GLGs formed in the dentine (HOHN, 1980; HOHN, 1980a) (Fig. 1 b, c, d).

By using the Gompertz equation (ZWEIFEL & PERRIN, 1980; SAILA *et al.*, 1988; DI MEGLIO *et al.*, 1996) and a Fishery Science Application Program, the age/body-length curve was plotted and the body length of a newborn specimen calculated.

The Gompertz equation is as follows:

$$Y(t) = Yo \exp(G\ (1 - \exp(-g\ t)))$$

Where:
t = age in years (number of GLGs)
Y(t) = body length for the certain age
Yo = body length of a newborn (in cm)
G and g = primary and secondary growth coefficients.

As suggested by HERSH *et al.* (1990), dolphins were grouped in categories according to age (Fig. 3) and sexual maturity (Fig. 4). Age categories were: I – perinates, II – yearlings (less than 2 years or GLGs), III – 2 – 5 year-olds (2 – 5 GLGs), IV – 5 – 10 year-olds (5 – 10 GLGs), V – older than 10 (more than 10 GLGs). Categories concerning the sexual maturity were: 1 – perinates (which included age category I); 2 – yearlings (which included age category II); 3 – sub-adults (sexually immature; which included age category III); 4 – adults (sexually mature; which inclu- ded age categories IV and V).

RESULTS

Twelve females, 7 males and one of unknown sex (only skeletal material available) were recovered (Table 1). Results of age determination are listed in Table 1. Six animals (codes 4, 5, 9, 12, 16, 20) had the pulp cavity occluded (Fig. 1c) and
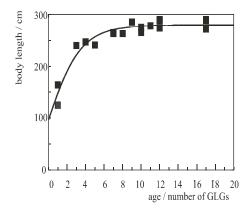

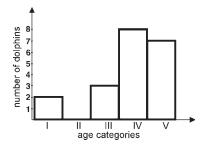**Fig. 2.** Gompertz growth curve for Adriatic bottlenose dolphins.

Fig. 3. Age category distribution of 20 stranded and by-caught bottlenose dolphins from Adriatic Sea from 1990–1997.
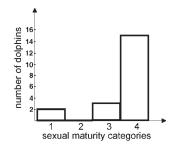
Fig. 4. Sexual maturity category distribution of 20 stranded or by-caught bottlenose dolphins from the Adriatic Sea from 1990–1997.

Tab. 1. Dataset of 20 stranded or by-caught bottlenose dolphins from the Adriatic Sea. m = males and f = females. Animals 1, 2, 3, 8, 11, 12, 17, 19 and 20 were from the collection of the Veterinary Faculty, University of Zagreb, Croatia, whilst animals 4, 5, 6, 7, 9, 10, 13, 14, 15, 16 and 18 were from the collection of the Faculty of Science, University of Zagreb, Croatia. * – closed pulp cavity, probably older.

dolphin code	sex	date	place	body length (cm)	age (number of GLG's)
1.	f	16. 10. 1990.	Istra	265	7
2.	f	1. 11. 1990.	Rovinj	164	<1
3.	m	18. 6. 1992.	Rovinj	263	7
4.	m	30. 7. 1992.	Cres	288	17*
5.	f	25. 8. 1992.	Veli Lošinj	290	17*
6.	m	22. 9. 1993.	Lošinj	241	5
7.	f	28. 1. 1994.	Mali Lošinj	263	8
8.	f	11. 6. 1994.	Medulin	265	10
9.	f	21. 6. 1995.	Mali Lošinj	272	17*
10.	m	21. 12. 1995.	Šibenik	278	11
11.	f	19. 4. 1996.	Pula	247	4
12.	m	2. 10 1996.	Pula	290	12*
13.	-	8. 1997.	Srakane	-	6
14.	f	27. 4. 1997.	Martinšćica	275	10
15.	f	25. 5. 1996.	Hvar	285	9
16.	f	30. 7. 1997.	Unije	274	12*
17.	m	2. 8. 1997.	Martinšćica	125	<1
18.	f	28. 8. 1997.	Unije	-	3
19.	m	16. 8. 1997.	Istra	240	3
20.	f	8. 10. 1997.	Šibenik	288	12*

Gompertz growth curve for our sample is presented in Figure 2. No statistical differences were found between genders regarding the age distribution of dolphins in our sample (t – test p0.05). The mean age for females was 9.2 years (SD = 5.0) with a mean body length of 262.5 cm (SD = 35.00), whilst for males it was 8 years (SD = 5.6) and 246.4 cm (SD = 57.32), respectively. The asymptotic value, which represents the age of physical maturity (number of GLGs at the inflection point), was estimated to be at the age of 12 (12 GLGs) and at a body length of approximately 280 cm. The average body length at birth was calculated to be 97 cm by using the Fishery Science Application Program. Results of the sexual maturity categories and the age category distribution showed that our sample consisted mostly of sexually mature (adult) animals (Fig. 3 & 4).

DISCUSSION

The sample we had was small and very unevenly distributed among the different age categories. The yearlings' class was completely excluded and only 5 animals represented the category of sub-adults, which was important to establish the rising part of the growth curve. Nevertheless, we can conclude that our results are comparable to growth rate analyses of other *Tursiops* populations.

The growth asymptote is higher compared to the age/length plot estimated for the Gulf of Mexico (230 cm), Southern Africa (240 cm) and the central Atlantic coast of the US (250 cm and 12 GLGs), and is approximate to the one made for bottlenose dolphins off Japan (280–290 cm) (MEAD & POTTER, 1980).

Although our sample included only two animals that were less than 1 year old, the average body length of newborn dolphins was calculated using Fishery Science application program. The length at birth is comparable to that for Hawaiian bottlenose dolphins (95–115 cm) and slightly less than for those of the central Atlantic coast of the US (107–132 cm) and Southern Africa (103 cm) (MEAD & POTTER, 1980; SCHROEDER, 1980; COCKROFT & ROSS, 1989).

Although FERNANDEZ & HOHN (1998), READ *et al*. (1993) and TOLLEY *et al*. (1995) have found sexual dimorphism expressed among bottlenose dolphins, our results failed to prove this, which is the consequence of the small sample size and of including all age classes in the analyses.

In determination of the age, the SEM technique was the easiest method available, although FERNANDEZ & HOHN (1998) and READ *et al*. (1993) have suggested using decalcified stained teeth sections. To obtain more reliable results in the future, both methods should be used and the results compared.

We are aware that the future analyses must concentrate on collecting samples from all age classes. The present analyses are preliminary and represent the only information available on stranding events in Adriatic Sea. Moreover, it makes an important contribution to the fragmentary biological understanding of the Adriatic bottlenose dolphin population. Although protected by law from 1995, Cetacean status and the techniques used for their conservation in Adriatic Sea are inade-

quate. Development of a concise and effective stranding network, like those already existing in Italy or the UK, is required. In that way a more reliable estimation of age distribution of stranded and by-caught dolphins in the Adriatic East coast would also be made possible.

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S A Ž E T A K

Preliminarna krivulja rasta i dužina tijela dobrih dupina *Tursiops truncatus* (Montagu, 1821) iz Jadranskog mora

S. Pribanić, D. Mioković & D. Kovačić

Dobri dupin, *Tursiops truncatus* (Montagu, 1821), jedina je vrsta morskih sisavaca za koju sa sigurnošću možemo tvrditi da živi u Jadranskom moru. U razdoblju od 1990–1997. godine u Jadranskom moru pronađeno je ukupno dvadeset uginulih dobrih dupina (*Tursiops truncatus*): 12 ženki, 7 mužjaka i jedna jedinka kojoj nije bilo moguće odrediti spol. Osnovna *post-mortem* analiza načinjena je kod svih životinja i od svake su uzeta po dva zuba. Starost je određena prebrojavanjem godišnjih zona prirasta (GLG – engl.«growth layer group«) formiranih u sloju dentina, koristeći skening elektronski mikroskop i pozlaćene presjeke zuba. Krivulja rasta i parametri

rasta izračunati su uz pomoć Gompertzove krivulje i Fishery Science Application programa.

Naš uzorak bio je malen i neujednačeno rapoređen po starosnim kategorijama. U starosnoj kategoriji jednogodišnjaka nije bilo primjeraka, dok ih je u kategoriji spolno nezrelih jedinki, koja je važna pri određivanju početnog uzlaznog dijela krivulje rasta, bilo samo 5.

Asimptotska vrijednost (broj GLG-a u točki infleksije krivulje), koja predstavlja starost u kojoj jedinka postiže fizičku zrelost, iznosi 12 godina (12 GLG-a) za duljinu tijela od 280 cm. Dobiveni rezultat sličan je rezultatima istraživanja iste vrste dupina u Japanu (280–290 cm), a nešto su veći od dupina uz Atlantsku obalu SAD-a (107–132 cm), u Meksičkom zaljevu (230 cm) i južnoj Africi (240 cm).

Iako su u uzorku bile samo dvije životinje mlađe od godinu dana, srednja vrijednost duljine tijela novorođenčadi izračunata je uz pomoć Fishery Science Application programa i iznosi 97 cm. Slične su i duljine tijela novorođenčadi dupina iste vrste na Havajima (95–115 cm), dok je novorođenčad dobrih dupina uz Atlantsku obalu SAD-a (107–132 cm) i južnoj Africi (103 cm) nešto veća.

Spolni dimorfizam u krivulji rasta ove vrste nismo primijetili, što je posljedica relativno malog uzorka i analiziranja svih starosnih skupina zajedno.

Unatoč svemu, daljnja istraživanja i veći broj jedinki u uzorku omogućit će preciznije rezulate.

Podaci o krivulji rasta i parametrima rasta prvi su za dobre dupine u Jadranu i Sredozemnom moru. Dobivena krivulja rasta odgovara krivuljama rasta roda *Tursiops* i karakteristična je za skupinu odontoceta.