Preliminary Report on Age Determination of South Pacific Albacore Using Caudal Vertebrae

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Abstract

A preliminary analysis of caudal vertebrae from 417 South Pacific albacore caught by trolling and longline indicates that rapid determination of age is possible in fish up to at least 10 years old. The predominance of troll caught fish (77.9%) appears to result biased estimates of asymptotic length, the Brody growth coefficient, and t_0. Further study of other hard parts and a more equitable distribution of large fish from the longline tuna catches may compensate for the initial poor estimates of the von Bertalanffy growth curve.

Introduction

In 1986, participants at the first South Pacific Albacore Research Workshop (SPAR) set research priorities for the rational development of albacore surface fisheries in the region (South Pacific Commission 1986). One of the priorities identified at this meeting was the validation of growth increments on albacore otoliths (sagittae) for South Pacific albacore using the methods of Laurs, et al. (1985). Due to the time required to read each otolith rapid alternatives to this technique based on other hard parts were identified as highly desirable.

We have initially chosen to examine the banding sequences in caudal vertebrae because of the ease of collection in both troll and longline fisheries and the encouraging results reported by Farber and Lee (1981) and Lee, et al. (1983). We propose to validate the banding sequences in caudal vertebrae with hard parts from whole tagged fish injected with oxytetracycline returned through the SPAR tagging programme. Our work is part of a joint study with scientists at the U.S. National Marine Fisheries Service Southwest Fisheries Center in Hawaii and La Jolla.

Materials and Methods

Vertebrae Collection

Caudal vertebrae were collected from troll caught albacore in 1987 and 1988 in the Tasman Sea and western South Pacific within the New Zealand EEZ and eastwards along the Subtropical Convergence Zone (STCZ) to at least 150°W. Vertebrae were also collected aboard Japanese tuna longliners in June - July 1987 and 1988 off the east coast of the North Island of New Zealand.

Upon landing fork length to the nearest lower cm was recorded and the caudal peduncle forward of the caudal keel removed, fins trimmed, and frozen. Vertebrae number 35 and 36 were chosen for examination because they were consistently undamaged. A summary of fishing areas, methods, sample details is given in Table 1.

Table 1. Summary of fishing areas, methods, sample size, and fork lengths of albacore sampled for caudal vertebrae.

Fishing Area	Period	Method	No. Fish	Fork Length (cm) Average	Std. Dev.	Range
New Zealand						
Chatham Rise	Feb 1986	troll	107	63.1	10.1	46-95
Tasman Sea	Mar 1986	troll	73	52.7	7.6	46-78
Tasman Sea	Nov 1986	troll	55	62.3	10.7	44-79
East Cape, N.I.	June 1987	longline	52	88.6	9.5	61-110
East Cape, N.I.	June 1988	longline	40	91.2	5.8	76-105
Central South Pacific						
STCZ	Feb 1986	troll	34	71.4	5.5	62-88
STCZ	Jan 1987	troll	56	68.7	12.1	47-93
			417	68.5	15.6	44-110

Preparation

The methodology and terms used in this and subsequent sections are based on Berry, et al. (1977), Berry (1978), and Lee, et al. (1983).

Samples of 50-100 peduncles per day were thawed and the flesh trimmed from around the vertebrae. Vertebrae 35 and 36 were then carefully separated using a knife and fine toothed hand saw. At this point two measurements were taken using vernier calipers to 0.1 mm;

vertebral length: measured from the anterior to the posterior face, and

vertebral diameter: measured as the internal diameter of the anterior face measured on the frontal plane between the bony keels.

Each vertebra was then clamped in a vice and sawn in half along the sagittal (dorso-ventral) plane. Remnants of cone jelly were removed with a soft bristled brush and the anterior cone lightly scrubbed. The left lateral cut was usually used for staining unless it had been damaged in cutting.

Staining

Immediately after preparation, the half vertebrae were submerged in Alizarin red-S stain using Berry's (1978) "school tuna" solution. Vertebrae were left to soak for 5 - 20 minutes depending on size and rinsed in fresh water. Vertebrae that stained too darkly were de-stained for 2-5 minutes in 5% hydrogen peroxide.

Interpretation and Reading

Stained vertebrae under high intensity visible light display distinct stained bands as couplets on the anterior cone. Within each couplet the bands are uniformly spaced around the cone and separated by a thin translucent zone. Each couplet is separated from adjacent couplets by a wide opaque zone, although this opaque zone is somewhat compressed towards the centrum. Each couplet of twin bands is interpreted as a distinct growth mark or "annulus". This term is used as it is by Lee et al. (1983), to refer to a rythmic growth increment that possibly but not implicitly coincides with an annual event.

Twenty vertebrae were initially stained and read by two experienced otolith readers to reach agreement on counting procedures. The workload was shared by the two readers, one reading 20 vertebrae while the other recorded and then changing tasks. Consistency between readers was maintained by reading at least 25% of the same vertebrae each day independently and cross checking readings.

During reading the following measurements were taken with vernier calipers to 0.1 mm;

vertebral cone radius: measured as the distance from the focus to the outside edge of the cone, and

annulus size: measured as the distance from the focus to the distal edge of each couplet.

Using this procedure, 70-100 vertebrae could be prepared, stained, and read each day.

Vertebrae 35 was selected for further analysis after a comparison of a sample of 200 vertebrae 35 and 36 were shown to give equivalent ages. Vertebrae 35 was chosen because its larger size made reading and measurment easier.

After reading all vertebrae were stored individually in a solution of 25% isopropanol (90% by volume) and glycerol (10% by volume). Berry (1978) reports that vertebrae stored in this solution are suitable for rereading up to a year later if required.

Results

Albacore caught by trolling and longline in the western South Pacific Ocean and Tasman Sea ranged in size from 44 to 110 cm fork length. Ages determined from reading the 35th caudal vertebrae of 412 fish ranged from one to 10 annuli. The 35th and 36th vertebrae were found to yield equivalent ages for a sample of 200 fish. This differs from the findings for Atlantic bluefin tuna. The inferred ages are highly correlated with fork length but to a lesser extent with vertebral morphometrics. The correlation matrix is presented in Table 2. Also from this table it is apparent that the vertebral measurements chosen are all highly correlated with albacore size and appear to grow isometricly.

Table 2. Correlation matrix of albacore length, age, and vertebral morphometrics for 412 albacore caught by trolling and longline in the South Pacific in 1986-1988.

	fork length	vertebral diameter	vertebral height	vertebral cone radius
vertebral diameter	0.952			
vertebral height	0.964	0.954		
vertebral cone radius	0.965	0.953	0.964	
age	0.910	0.879	0.889	0.885

The relationship between body parts is also evident in the extremely good fit shown in figure 1 between fork length and vertebral cone radius. Over all sizes of fish sampled this relationship explains over 92% of the variance in fork length. There is, however, a tendency in the fish larger than about 85 cm for increasing scatter about the line and in samples dominated by large longline caught fish may require fitting separate curves. This procedure which adopted by Lee, et al. (1983) for Atlantic bluefin tuna is not justified by the present data.

Evidence of compression of annuli can be seen in figure 2 for fish with more than eight vertebral annuli. Fish younger than this show no evidence of compression. Even in the oldest fish, however, there was no difficulty in reading vertebrae and it is likely that this method will be applicable to fish older than those sampled to date.

An initial scatterplot of fork length and annuli suggest that these data behave in a matter similar to von Bertalanffy growth curve and in a pattern common to many species. That is, the greatest variation in size at age was in intermediate age classes. This behaviour coupled with the preponderance of small troll caught fish (77.9%) biases parameter estimates for the von Bertalanffy growth curve.

An iterative nonlinear modelling algorithm was used to estimate parameters and standard errors of the von Bertalanffy curve. Parameter estimates are contrasted with published values for albacore in Table 3. As can be seen from this table the asymptotic length is overestimated. Since the remaining parameters of the curve are all highly negatively correlated then both k and t_0 are underestimated. The biased estimates probably result from the dominance of small troll caught fish in the present sample.

Table 3. Comparison of von Bertalanffy growth parameters for Pacific albacore (present study contrasted with values reported by .

Source	L_∞	(S.E.)	k	(S.E.)	t_0	(S.E.)
present study	192.0	46.8	0.06	0.02	- 3.3	0.6
western North Pacific[1]	104.8		0.431		1.504	
North Pacific[1]	114.4		0.308		0.818	
North Pacific[1]	145.3		0.159		- 0.056	
North Pacific[2]	125.0		0.184-0.199		n/a	
eastern North Pacific[1]	108.8		0.2247		-2.2728	
western North Pacific[1]	145.3		0.150		-0.396	
North Pacific[1]	118.8		0.250		1.999	

[1]Foreman (1980)

[2]Laurs and Wetherall (1981)

Figure 3 depicts the fit of the von Bertalanffy curve and the observed scatter around the curve.

Summary

The ease and speed of the vertebral ageing method is attractive for fish up to at least 10 years old based on counts of stained vertebral bands. The bias observed in the parameter estimates is likely to be the result of the inequality in numbers of young to old fish in the present sample. The bias in the parameters estimated in this preliminary report are not acceptable.

The evaluation of this method for age determination must await further sampling of older fish or the collection of hard parts from fish of known age.

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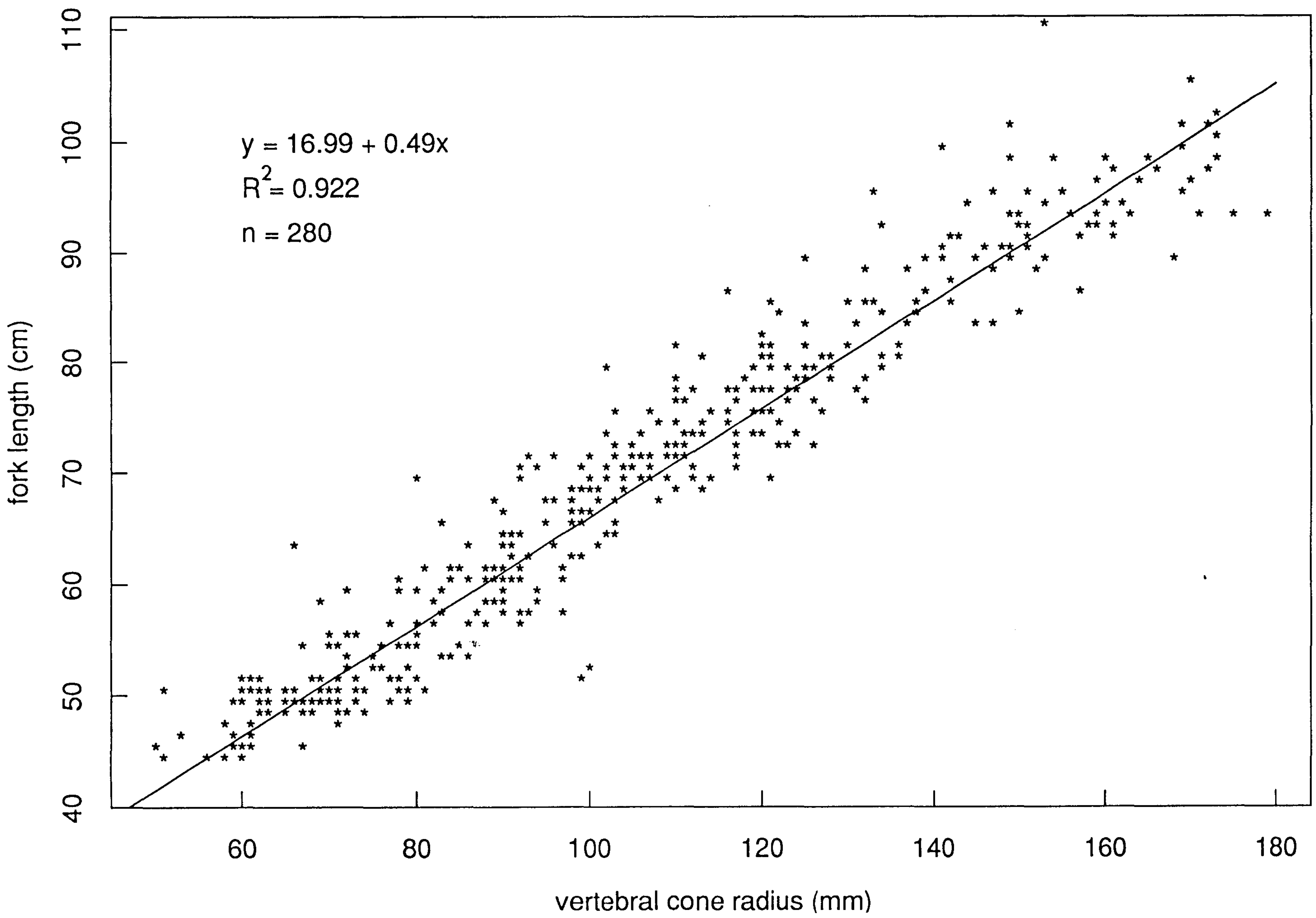
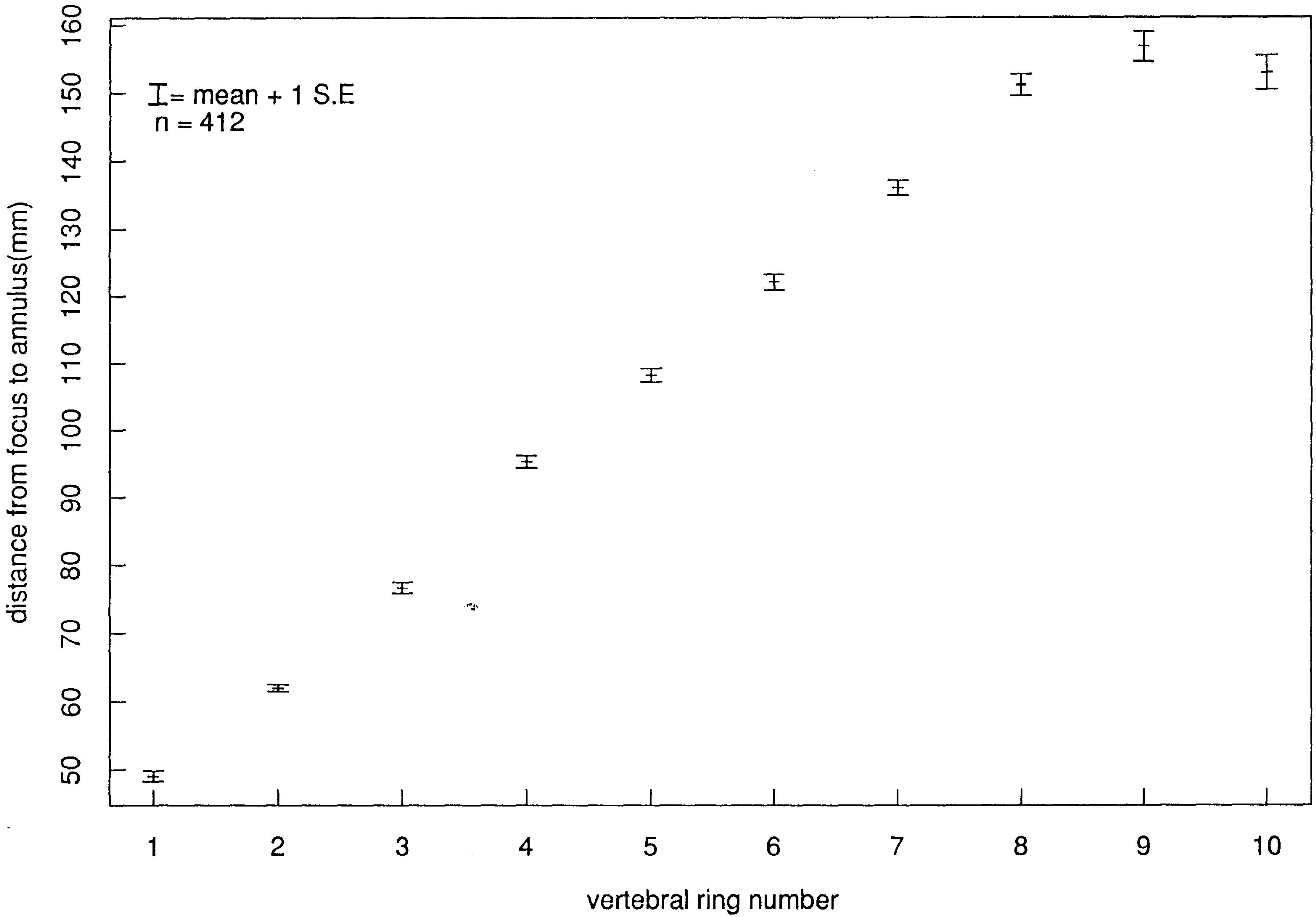
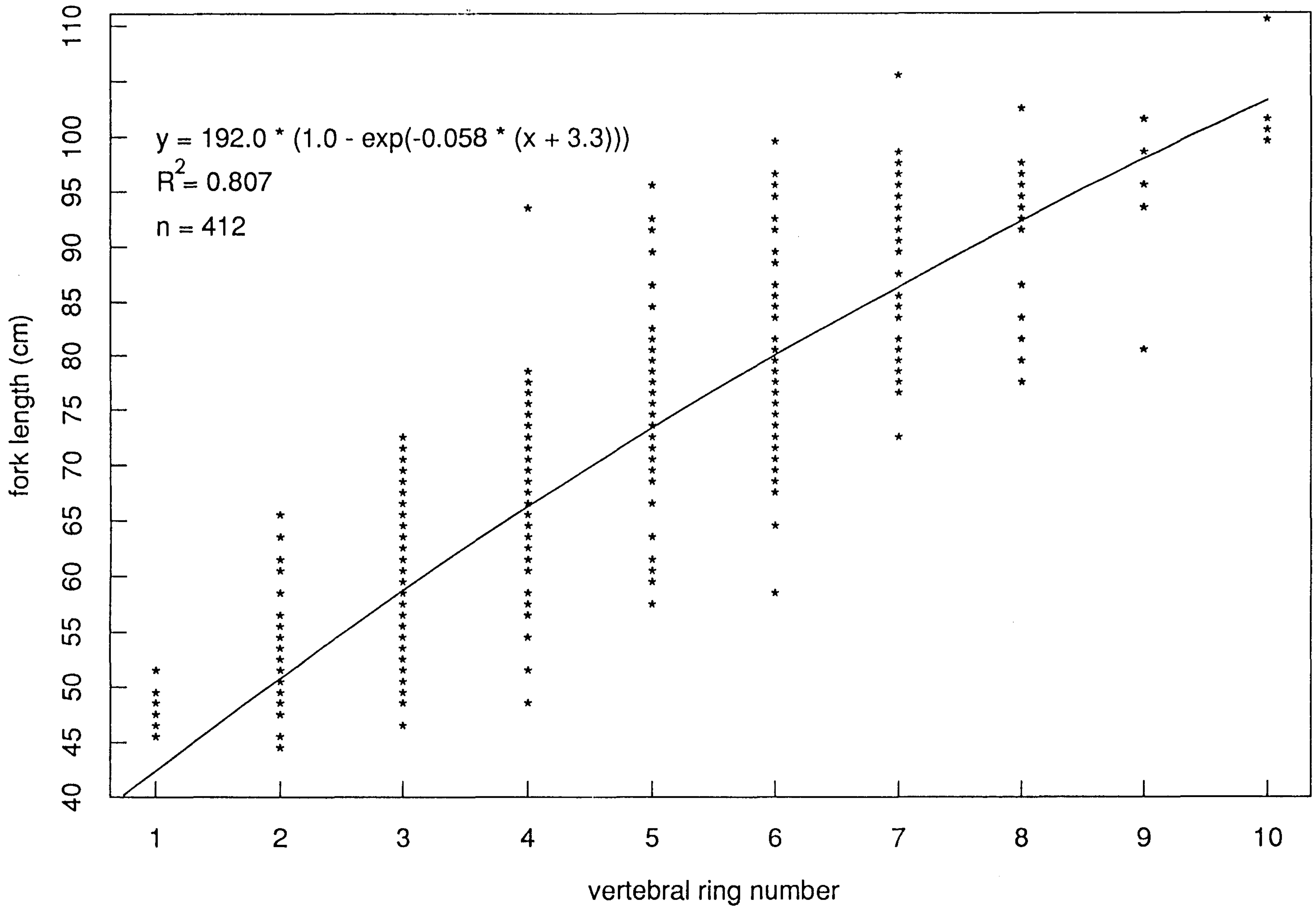

y = 16.99 + 0.49x
R^2 = 0.922
n = 280
fork length (cm)
vertebral cone radius (mm)
40
50
60
70
80
90
100
110
60
80
100
120
140
160
180



I= mean + 1 S.E
n = 412
distance from focus to annulus(mm)
50
60
70
80
90
100
110
120
130
140
150
160
1
2
3
4
5
6
7
8
9
10
vertebral ring number


y = 192.0 * (1.0 - exp(-0.058 * (x + 3.3)))
R2= 0.807
n = 412
fork length (cm)
40
45
50
55
60
65
70
75
80
85
90
95
100
110
1
2
3
4
5
6
7
8
9
10
vertebral ring number