

Gonadal activity in some Bottlenose dolphins (*Tursiops truncatus*)

R. J. HARRISON

Anatomy School, Downing Street, University of Cambridge

AND

S. H. RIDGWAY

Naval Undersea Research and Development Centre, San Diego, California

(Accepted 13 April 1971)

(With 2 plates and 3 figures in the text)

Details are given of the characteristics of the ovaries and testes of young and adult dolphins, *Tursiops truncatus*, all of which had been caught off Florida or Mississippi. Most had been in captivity for periods varying from a few days to ten years. Birth takes place most commonly during February to May and September to November. Length of neonates is between 98 and 126 cm. The state of activity of the gonads suggests that sexual maturity is reached in females at a length of over 220 cm and probably in their fifth year. Males do not become sexually active until about 260 cm in length and at an estimated age of at least ten years. Plasma testosterone levels are highest in a captive fertile male during April and May and October and November. The corpus luteum persists throughout the 12-month gestation period and also appears to persist as a corpus albicans for the dolphin's life span. The left ovary is usually larger than the right and twice as many corpora are found in the left as in the right ovary. No evidence of regular, cyclic ovulation is detected and it is concluded that ovulation is induced in *Tursiops*.

Contents

	Page
Introduction	355
Materials and methods	356
Time of birth and length of neonate	356
Females	357
Males	359
Discussion	362
Summary	365
References	366

Introduction

Despite the popularity of Bottlenose dolphins (*Tursiops truncatus*) as exhibits in marine-lands little is known for certain about reproductive events in this species (Asdell, 1964; Harrison, 1969) and virtually nothing is known about histological changes in the gonads. McBride & Kritzler (1951) have stated that females reach sexual maturity at four years of age and become pregnant for the first time in their fifth year. The height of sexual activity

in captivity in Florida was in April and May. Births in captivity in Marineland of Florida occurred in February, April and May. The gestation period was considered to be 12 or possibly 13 months. Tavalga & Essapian (1957) suggest that birth occurs every other year and that the lactation period can last for up to 20 months. Essapian (1963) has stated that in Miami, Florida births have occurred in September as well as in March and April. Layne (1965) has recorded recently born young stranded on Florida coasts in December and January. Harrison, Boice & Brownell (1969) record the length at birth in *Tursiops truncatus* to be 98 to 126 cm. Corpora albicantia up to six in number were found in females from 228 to 254 cm in length in either one or in both ovaries. No evidence of active spermatogenesis was found in males up to 234 cm in length.

Materials and methods

The animals had been captured in waters off Florida or Mississippi and had all been in captivity for varying periods at Marineland of Florida, at Point Mugu or Marineland of the Pacific, California and at Flamingo Park Zoo, Yorkshire. The cause of death could only be ascertained for a few dolphins. Where possible a post-mortem was performed but in several instances the gonads only were available.

The ovaries of 22 female *Tursiops truncatus* and the testes of 11 males have been examined. Where possible, the gonads were weighed. The ovaries were sliced by hand into thin sections to count corpora and follicles. The epididymis were cut and squeezed to see if sperm was obviously present. Histological sections were prepared from appropriate regions, staining being by routine procedures. When conditions allowed care was taken to assess the reproductive state of each dolphin and what was available of its history was noted.

For plasma testosterone analysis, animals at Point Mugu were bled about once each month. The samples were usually taken when the pools were drained for cleaning. Sampling dates varied from the 5th to the 25th of each month. The blood samples were drawn from the central vessels on the ventral aspect of the tail fluke (Ridgway, 1965). 25 ml of blood was collected in a heparinized disposable plastic syringe. The blood was transferred to a plastic test tube and centrifuged at 1500 r.p.m. to separate the plasma. 10 ml were pipetted into a plastic container and placed in a freezer at about 0°C to await analysis.

The testosterone analysis was performed at Bio-Science Laboratories, Van Nuys, California by a sensitive competitive protein-binding technique recently developed in that laboratory by Demetriou & Austin (1970).

Time of birth and length of neonate

Pregnant females of *T. truncatus* transported by air from Florida to Flamingo Park Zoo, Yorkshire gave birth to single young on 24 September 1965 (116 cm, female), 24 September 1965 (98 cm, male), 28 October 1965 (details not known), 17 November 1965 (109 cm, male), 21 November 1965 (105 cm, female), December 1961 (details not known), 23 May 1967 (details not known).

Caldwell & Caldwell (in press) have recently summarized 50 live births of *T. truncatus* at six different oceanaria in the United States. As the dolphins described above become pregnant in Florida waters, they are included, together with a November birth (Plate I) at Point Mugu, in Fig. 1 which gives the numbers born each month of the year. It indicates that birth takes place most commonly during two periods in those animals impregnated in United States waters, namely February to May, and September to November.

Females

The ovaries from two newborn females 105 and 116 cm in length weighed 0.5 (L) and 0.5 g, and 0.65 (L) and 0.66 g.

An immature female 215 cm in length had ovaries weighing 1.5 (L) and 1.4 g in December and another 218 cm length died in August with ovaries weighing 1.3 (L) and 1.4 g. Healthy and atretic follicles up to 2.0 mm in diameter were present in the ovaries (3.9 (L) and 5.1 g) of a female 223 cm in length in September. Another female of the same length had been in captivity eight years: it died in May. The ovaries weighed 3.5 (L) and 2.5 g and in the larger there was a follicle 5 mm in diameter: both ovaries exhibited several orange-coloured atretic follicles up to 2.0 mm in diameter.

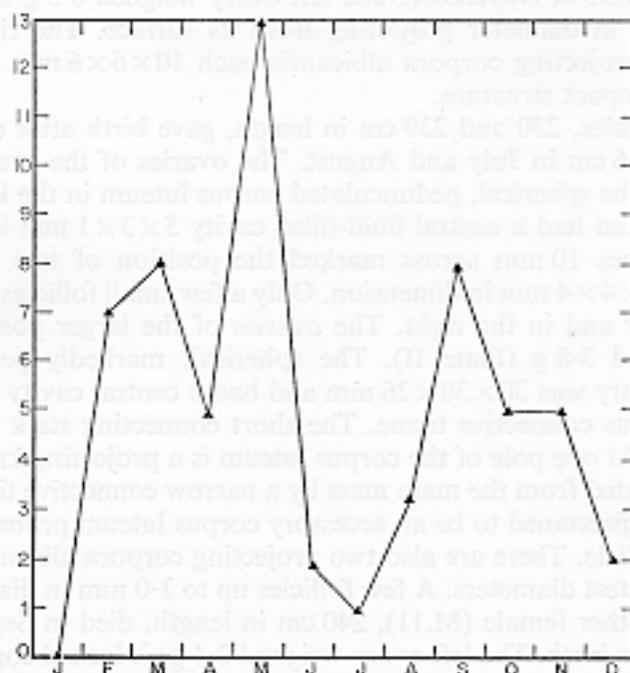


FIG. 1. Diagram to show incidence of births in captivity by month of the year in *Tursiops truncatus* caught off Florida and impregnated in the wild or in captivity in the United States. Data from Caldwell & Caldwell (in press) are included.

A female 230 cm in length was in captivity only three weeks before it died of septicaemia in May. The ovaries weighed 2.5 (L) and 2.6 g: corpora were lacking and there were no follicles over 0.5 mm in diameter. Another, captured in late February, died in late July when it was 244 cm in length. It was kept with several females and one or sometimes two young males: no mating behaviour was noted. The left ovary weighed 12.7 g and the right 6.2 g. Each ovary contained about twenty follicles between 1.0 and 4.0 mm in diameter and numerous smaller ones. No corpora were present.

Three females, all 228 cm in length, had ovaries containing corpora and some details of their reproductive history are available. M-38 had been in captivity for some months before giving birth in May 1967: it died one year later. The right ovary (3.8 g) was devoid

of corpora and had many small follicles up to 2.0 mm in diameter. The left ovary (7.2 g) had two protuberant corpora albicantia ($11 \times 7 \times 6$ and $10 \times 5 \times 5$ mm) and superficial scars marking the sites of three small corpora albicantia $9 \times 5 \times 5$, $6 \times 4 \times 4$ and $5 \times 4 \times 4$ mm in diameter. Three follicles 5.0 mm in diameter were also present (Plate II). The second female of 228 cm, M-WV, died in August after giving birth to a male stillborn calf 124 cm in length which was conceived in the wild. The left ovary was 22.4 g in weight, the right, 7.1 g. A well-developed spherical, pedunculated corpus luteum, 26 mm in diameter was present in the left ovary. Four superficial scars two to three millimetres across marked the sites of yellow-brown pigmented structures 2.0–5.0 mm across which on section appear to be atretic lutealized follicles. The right ovary lacked corpora and possessed numerous follicles up to 2.0 mm in diameter. The third female, M-18, had been in captivity about two years before it died in November. The left ovary weighed 6.5 g and had one corpus albicans 13×11 mm in diameter projecting from its surface. The right ovary weighed 4.3 g and had two projecting corpora albicantia each $10 \times 6 \times 6$ mm in diameter with a similar but more compact structure.

Two pregnant females, 230 and 239 cm in length, gave birth after capture to stillborn calves of 118 and 116 cm in July and August. The ovaries of the smaller adult weighed 20.0 (L) and 5.1 g. The spherical, pedunculated corpus luteum in the left ovary measured 25 mm in diameter and had a central fluid-filled cavity $5 \times 3 \times 1$ mm in dimensions. Two circular raised plaques 10 mm across marked the position of two corpora albicantia $10 \times 5 \times 5$ mm and $5 \times 4 \times 4$ mm in dimension. Only a few small follicles up to 2.0 mm were present in this ovary and in the right. The ovaries of the larger post-parturient female weighed 18.6 (L) and 3.8 g (Plate II). The spherical, markedly pedunculated corpus luteum in the left ovary was $30 \times 30 \times 26$ mm and had a central cavity 10 mm in diameter with fluid and mucous connective tissue. The short connecting stalk was 12×10 mm in length and breadth. At one pole of the corpus luteum is a projecting knob of luteal tissue, $10 \times 8 \times 8$ mm, separated from the main mass by a narrow connective tissue septum: it has a small cavity and is presumed to be an accessory corpus luteum probably derived from a small unruptured follicle. There are also two projecting corpora albicantia, $10 \times 8 \times 4$ and $10 \times 9 \times 4$ mm in greatest diameters. A few follicles up to 1.0 mm in diameter were present in both ovaries. Another female (M.11), 240 cm in length, died in September about five days after it had given birth. The left ovary weighed 2.4 g; it lacked corpora and had only few small follicles 0.5 mm in diameter. The right ovary (8.3 g) possessed a large pedunculated corpus luteum $24 \times 16 \times 16$ mm in greatest dimension: it lacked a central core. The large luteal cells were heavily vacuolated.

Female 6-68 was captured in January 1957; it gave birth in September 1958 having mated in captivity. The calf died after 24 hours. The female was intermittently in contact with males until February 1968 when it aborted a 48 cm foetus, and it died two days later when 240 cm in length. The left ovary weighed 5.0 g and contained a single corpus albicans, $10 \times 7 \times 7$ mm in size, which formed a distinct protuberance with a crinkled surface (Plate II). The right ovary weighed 12.3 g and the right uterine horn was considerably enlarged. There was a pedunculated spherical corpus luteum $25 \times 22 \times 22$ mm in greatest dimensions. It lacked a central core; the glandular tissue is arranged in distinct folds with peripheral connective tissue septa carrying large blood vessels.

Females M-17, M-7, M-7-62, M-8-62 and M-19 were 241 to 248 cm in length. M-17 was in captivity about two years: its ovaries were small (1.45 (L) and 2.25 g) and one

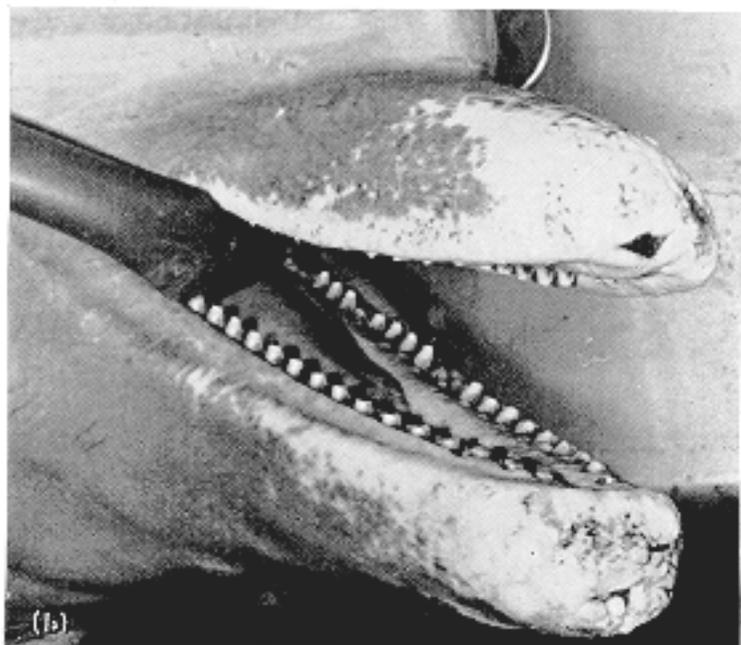


PLATE I. (a) Newborn calf of *Tursiops truncatus*, born 3 or 4 November 1970 at Point Mugu, California.
(b) Male *Tursiops truncatus*, 260 cm in length, with worn anterior teeth and scarring of the snout, alleged to indicate advanced age.

[To face page 358

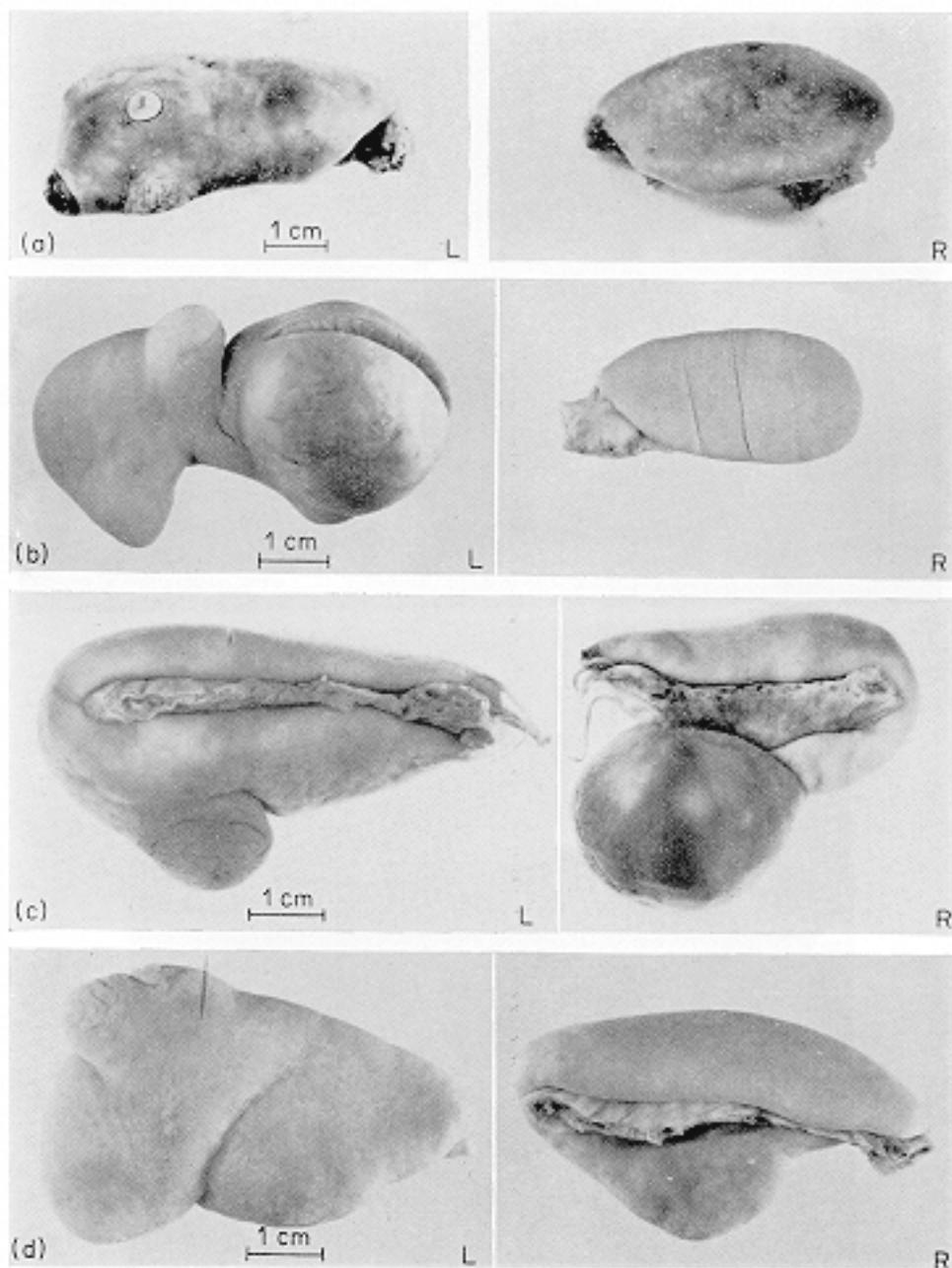


PLATE II. Photograph of the left and right ovaries of *Tarsiops truncatus*, (a) 228 cm in length, not pregnant, (b) 239 cm in length, recently pregnant with a 116 cm foetus, (c) 240 cm in length, aborted a 48 cm foetus two days before death, (d) 254 cm in length, five corpora albicantia in left ovary, two in the right.

corpus albicans, $13 \times 11 \times 10$ mm, was in the left ovary. M-7 was captured in May 1963, gave birth in December 1963 and died in June 1965. The left ovary (7.1 g) contained six corpora albicantia varying in dimensions from $10 \times 8 \times 8$ (2), $10 \times 6 \times 5$ (2), to $8 \times 5 \times 5$ mm (2). The right ovary (3.8 g) was inactive. M-7-62 was in captivity for an unknown period: the ovaries at death in July weighed 7.0 (L) and 5.5 g. The left contained two corpora albicantia, $10 \times 8 \times 8$ and $5 \times 5 \times 5$ mm, the right had four, $10 \times 7 \times 7$, $8 \times 5 \times 5$, $8 \times 4 \times 4$, $8 \times 4 \times 4$ mm. M-8-62 had one large corpus albicans, $14 \times 9 \times 9$ mm, in the right ovary and a smaller, $8 \times 5 \times 5$ mm, in the left: the animal's history is not known. M-19 had a stillborn young in October, some months after capture, and died five months later. One large corpus albicans, $12 \times 10 \times 10$ mm, and two smaller, each $10 \times 8 \times 8$ mm, were in the right ovary.

A female (No. 178) was taken into captivity in December and was with a mature male (No. 175) until the next February. The female died the following September when it had a length of 254 cm and weighed 172 kg. The left ovary weighed 11.2 g and contained five corpora albicantia. They projected slightly from the surface to form raised, puckered plaques: their greatest diameters were: $11 \times 10 \times 10$, $8 \times 8 \times 8$, $7 \times 6 \times 6$, $10 \times 4 \times 4$, $5 \times 4 \times 4$ mm. All had a similar appearance. The right ovary weighed 7.2 g and had two corpora albicantia similar to those in the left; they measured $12 \times 10 \times 10$ and $8 \times 5 \times 5$ mm (Plate II). A few follicles up to 1.0 mm in diameter were present in both ovaries.

Another female 254 cm in length (M5-68) gave birth after an unknown period in captivity and died in October about four years later. The left ovary (4.7 g) contained four corpora albicantia. The largest projected from the surface and measured $5 \times 4 \times 4$ mm: the three others formed crinkled protuberances near one pole of the ovary and were all 4×3 mm in greatest dimension. The small right ovary (2.0 g) lacked any follicles larger than 0.5 mm. across.

Female No. 73 was captured in 1963 when it measured 205 cm in length. It was exposed intermittently (the animals were in the same tank but often separated by a divider) to the same male (No. 75) throughout the seven years of its captivity and mating behaviour was observed and filmed in April 1968. No evidence of a pregnancy was noted up to its death in April 1970 when it was 259 cm in length with a weight of 136 kg: it had weighed 206 kg six months before death. The left ovary weighed 9.45 g: it had numbers of healthy and atretic follicles up to 2.0 mm in diameter. One corpus albicans, $10 \times 8 \times 8$ mm, formed a raised plaque on the surface. It has a folded, hyalinized peripheral region 2.0 to 3.0 mm thick with a yellow-brown pigmented central core. There were few obliterated blood vessels anywhere in the structure. The pigmented material was positive to Perl's reaction. The right ovary weighed 5.25 g and exhibited a few follicles up to 2.0 mm in diameter.

Males

The testes of two male newborn calves of 98 and 109 cm length weighed 2.45 and 2.5 g, 4.4 and 3.4 g respectively. In a male of 148 cm the testes weighed 7.5 cm and 7.5 g: in males of 200 and 228 cm testis weights were 24.5 and 22.0 g in May and 26.1 and 28.1 g in February respectively. The last two animals had been transferred to Flamingo Park Zoo where they were in captivity for about two years. The testes were 8-10 cm in length; the seminiferous tubules averaged $70 \mu\text{m}$ in diameter and lacked a lumen. No spermatozoa were in the epididymis.

Male No. 186 was caught in December 1968, and died November 1969 when it was 230 cm in length and 148 kg in weight. During 1969 plasma testosterone levels were as follows:

January	15 ng/100 ml
April	25
July	12
August	12
September	82

The left testis weighed 29.1 g, the right 31.1 g. The tubules averaged 100 μ m in diameter; the majority lacked a lumen. No spermatids or spermatozoa were present. Interstitial cells were small and palely stained.

Male No. 70 was brought to Point Mugu from Gulfport, Mississippi in September 1962. Length was 212 cm and age was estimated to be at least three years. During 1969 and early 1970 plasma testosterone levels were measured monthly. The highest level recorded was 167 ng/100 ml during October 1969 and the low was 7 ng/100 ml in July of the same year. The dolphin died in April 1970 from an acute clostridial myositis. At this time it was 242 cm in length and weighed 146 kg. On post mortem the left testis weighed 26 g. The right was equally small but was preserved with an adhesion as a pathological specimen could not be accurately weighed. Therefore during almost eight years this dolphin grew 30 cm in length but according to the plasma testosterone measures and the size of the testes at death, sexual maturity had not yet been reached although erection, masturbation, and even copulatory behaviour had been noticed on many occasions. As Caldwell & Caldwell (in press) point out, erection is seen even in baby dolphins. Masturbation and copulation are frequently observed in adolescent males.

Male No. 72 was captured off Florida in April 1963 at a length of 215 cm and a weight of 110 kg. In October 1964 it was catheterized for a urine specimen: this apparently caused some stimulation and an erection followed. As the catheter was being withdrawn the animal ejaculated 2 to 3 ml of fairly clear viscous fluid. Microscopic examination of wet and stained smears revealed no live sperm. There were spermatids but no mature sperm. The dolphin died after five years in captivity having reached a length of 259 cm and 156 kg in weight. Unfortunately the testes were not weighed accurately during the post mortem examination but were about 40 g each.

Male No. 113 was captured on 28 June 1967. It died in November 1969 at San Diego, at an approximate length of 260 cm. The following were the testosterone levels obtained for the period March to November 1969:

March 1969	392 ng/100 ml
April 1969	62
June 1969	80
September 1969	132
October 1969	27
November 1969	36

A section of the right testis, which weighed 40.6 g, showed the seminiferous tubules to average 80 μ m in diameter. The epithelium lining the tubules was single-layered and composed of cells with darkly stained nuclei: a few mitoses were present. Interstitial cells were present but were 6-8 μ m across and had only scanty cytoplasm.

Male No. 175 was taken into captivity in December 1968. The anterior teeth were worn smooth with the gum; extensive scarring around the snout suggested advanced age (Plate D). In January 1969, the plasma testosterone level was 491 ng. Death occurred suddenly in late February: the dolphin was 260 cm in length and weighed 199 kg. Post-mortem examination revealed a severe peritonitis that was apparently caused by a severe unilateral orchitis. The left testis weighed 532 g and the right 375 g. The larger testis was severely inflamed and microscopic examination revealed generalized bacterial infection of the tissue. The smaller right testis was not inflamed but no semen could be observed when the testicle and epididymis were bisected. In a section of the normal testicle seminiferous tubules averaged 120 μm in diameter, most had a lumen and the epithelium was two or more cells thick. Some spermatids were present and a few attached spermatozoa. No sperm were in the epididymis. Interstitial cells were 8–10 μm in diameter with a granular cytoplasm.

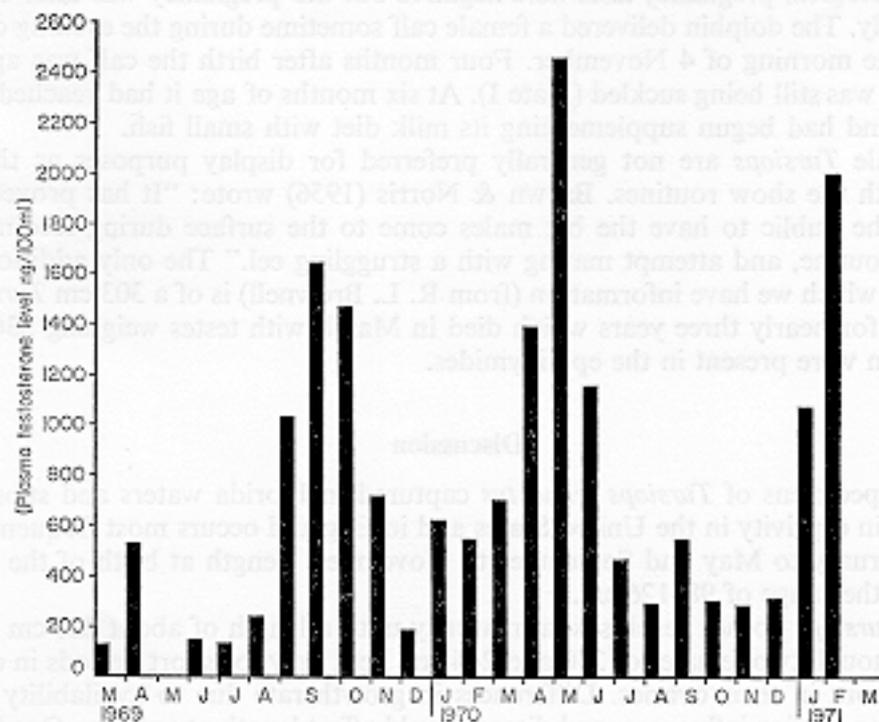


FIG. 2. Plasma testosterone (ng/100 ml) monthly levels in a fertile male *Tursiops truncatus* estimated by the method of Demetriou & Austin (1970). This male is the parent of the calf in Plate I. Values for adult human males vary from 400 to about 1200 ng/100 ml.

Male No. 75 was captured off Gulfport, Mississippi in September 1963. The dolphin weighed 114 kg and was 218 cm in length. It was maintained in a tank with female No. 73 for most of the time until the summer of 1969 when it weighed 177 kg and was 273 cm in length. At this time the animal was moved to a larger pool containing several females. The trainer who had been working with this animal for about three years noted that it appeared to have grown considerably during 1968. Plasma testosterone levels were therefore taken monthly from March 1969. These values are presented in Fig. 2. In April 1970 the dolphin

was 290 cm in length and weighed 216 kg. It has remained in the same tank with no other adult male and with never less than three large females since the summer of 1969. Mating occurred on several occasions at irregular intervals throughout this period with at least two large females one of which was No. 81 and the other was a spayed female. It was observed that the male was always accompanied in a particular sleeping position in the tank by female No. 81 directly on the right side with the spayed female further away (1-2 m) on the left and with the other females asleep or circling 5-15 m towards the other side of the 17 m tank. The amount of sexual activity and erection displayed by this adult male was much less than that usually exhibited by young adolescent males. An attempt at electro-ejaculation of this male in August 1970 was unsuccessful; later it was found that the plasma testosterone was at a low level at that time, and it has remained low. In the summer of 1970 it was suspected that No. 81 a 224 kg, 256 cm female was pregnant. Standard rat and immunological pregnancy tests were negative but the pregnancy was later confirmed radiologically. The dolphin delivered a female calf sometime during the evening of 3 November or the morning of 4 November. Four months after birth the calf was apparently healthy and was still being suckled (Plate I). At six months of age it had reached a length of 168 cm and had begun supplementing its milk diet with small fish.

Adult male *Tursiops* are not generally preferred for display purposes as they often interfere with the show routines. Brown & Norris (1956) wrote: "It has proved embarrassing to the public to have the big males come to the surface during feeding shows, ignore the routine, and attempt mating with a struggling ccl." The only additional dead adult about which we have information (from R. L. Brownell) is of a 303 cm *Tursiops gilli* in captivity for nearly three years which died in March with testes weighing 536 (L) and 590 g. Sperm were present in the epididymides.

Discussion

Birth in specimens of *Tursiops truncatus* captured in Florida waters and subsequently maintained in captivity in the United States and in England occurs most frequently in the periods February to May and September to November. Length at birth of the neonates falls within the range of 98-126 cm.

Female *Tursiops* do not reach sexual maturity until a length of about 220 cm has been attained although two females of 230 and 244 cm, kept only for short periods in captivity, had no corpora in their ovaries. Differences in growth rate due to availability of food, genetic and endocrine influences, and disease could affect length at puberty. One female of 228 cm which had given birth a year before death had four corpora albicantia smaller than and additional to the one presumably associated with the last pregnancy. Another female 259 cm in length, on the other hand, had only one corpus albicans.

The increase in length for any year of a dolphin's life is not known with any accuracy. Records of strandings on British coasts (Harmer, 1927; Fraser, 1934-1953; and Fraser (pers. comm.)) suggest that young *T. truncatus* increase in length by 30 cm during the first year after birth. B. Clark (pers. comm.) has informed us that young *Tursiops* at Miami Seaquarium have reached a length of 180 cm by 18 months after birth in captivity. If such a growth rate were maintained, sexual maturity could be reached, assuming a birth length of 100 cm, in the fifth year of life. Growth of adolescents in captivity, however, appears to be at a much slower rate: 205 to 259 cm in 7 years (female), 215 to 259 in 5 years (male),

218 to 290 cm in 7 years (male), 212 to 242 cm in 8 years (male). Even allowing for effects of captivity, these growth rates of between about 3.75 cm and 7.5 cm per year suggest that *Tursiops* attains sexual maturity at an age older than that of six years, the estimate given by Slijper (1962). The final length reached by adult western Atlantic *Tursiops truncatus* is not known but females longer than 260 cm (True, 1891) have not been recorded. In the eastern Atlantic, Fraser (1934) has reported a stranded female of 250.5 cm and also (1953) a female of 294 cm with ovaries lacking follicles and corpora. The *Tursiops* population in the eastern Atlantic appears to comprise larger animals. As regards the population in Florida, if sexual maturity in females is reached at a length of about 220 cm and final length is about 260 cm, then the length at sexual maturity as a percent of total length is 84.6. Laws (1956) has derived similar figures for *Globicephala melaena* (80.0) and *Stenella caeruleo-albus* (c. 87.6).

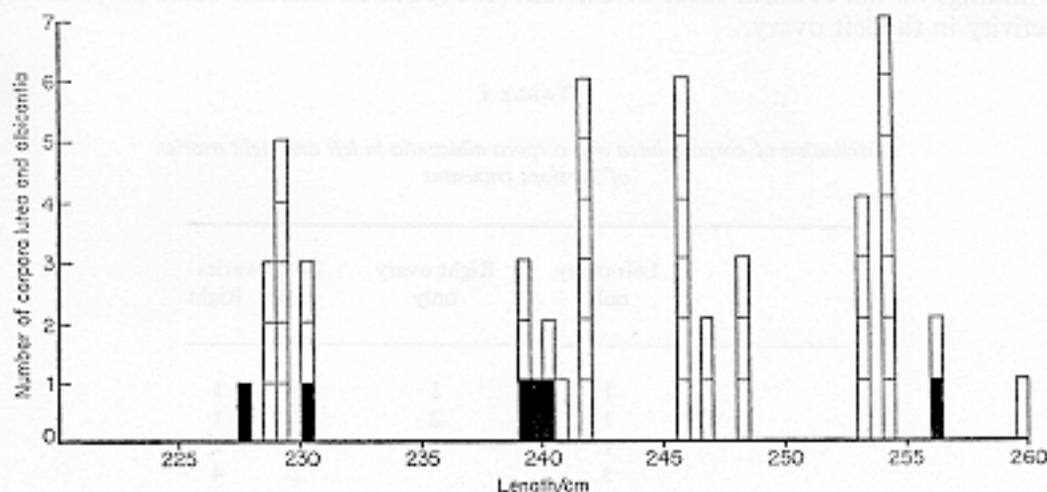


FIG. 3. Number of corpora lutea (black) and corpora albicantia (white) in female *Tursiops truncatus* of 226 to 259 cm in length.

All the ovaries of the sexually mature females exhibit at least one corpus luteum and up to seven corpora albicantia. The number of corpora albicantia does not increase in relation to the length of the dolphin (Fig. 3). There is some evidence that the corpus albicans of odontocetes persists throughout the life of the animal, as it does in mysticetes (Harrison, 1949; Sergeant, 1962; Slijper, 1966; Harrison, 1969). The corpus luteum of *Tursiops* persists throughout pregnancy and in the present specimens appear to shrink rapidly during the three post-parturient years. A graded series of corpora albicantia, some almost certainly related to known pregnancies, can be established on histological appearances for as long as ten years. If all the corpora albicantia were those of previous pregnancies, then ovulation would seem to be induced, as in some other odontocetes (Slijper, 1966). There is little evidence of regular cyclic ovulations, if their corpora albicantia were also to persist, but pseudopregnancy is not impossible. The growth rate in captivity certainly suggests that a female could have up to seven pregnancies while increasing in length from 220 cm to 260 cm: and there is no reason to assume a steady rate of growth. The findings tend to support Slijper's (1962) estimate that the number of young per cow in *Tursiops truncatus* is

about eight in a lifetime. They also indicate that in some animals at least inhibition of ovarian activity may occur during captivity.

In several odontocetes, the left ovary is often larger than the right and contains either all or the majority of the corpora albicantia (Slijper, 1949; Harrison, Boice & Brownell, 1969). Ohsumi (1964) placed *Tursiops truncatus* in his Type III of "accumulation curves" in cetacean ovaries. "For relatively long time, ovulation occurs only from the left ovary, but after attainment of maturity of the right ovary, corpora accumulation of the right becomes more frequently than the left." In our series of 18 females over 215 cm in length, where weights are available, 12 had heavier left ovaries and six had heavier right ovaries. Out of 16 adult females, eight animals had corpora in only the left ovary, three had them in the right ovary only and five had them in both ovaries. There were altogether 34 corpora in left ovaries and 16 in right ovaries distributed in numbers as shown in Table I. Our findings do not confirm those of Ohsumi (1964) but do indicate some preponderance of activity in the left ovary.

TABLE I

Distribution of corpora lutea and corpora albicantia in left and right ovaries of Tursiops truncatus

	Left ovary only	Right ovary only	Both ovaries	
			Left	Right
	1	1	1	1
	1	2	1	1
	1	3	1	2
	3		2	4
	3		5	2
	4			
	5			
	6			
Number of dolphins	8	3	5	

Evidence of production of spermatozoa is lacking in captive *Tursiops truncatus* of lengths of 230, 242, 259 and 260 cm. The testes in these dolphins weigh 25-40 g, they are histologically inactive and the plasma testosterone level is low in three animals throughout the periods it was estimated. One of these dolphins, with a length of 242 cm, had been in captivity for nearly eight years and its age at capture had been estimated to be at least three years. Harrison, Boice & Brownell (1969) found no evidence of spermatogenesis in the testes of males of *T. truncatus*, *T. catalania* and *T. gilli* with lengths of up to 234 cm. Sergeant (1962) has found that male *Globicephala melaena* do not reach sexual maturity until about 11 years old.

A male of 260 cm length had much heavier testes (532 and 375 g in February) than those of the shorter dolphins: its tooth wear suggested that it was an older animal. Histo-

logically, one testis appeared to be virtually inactive with no spermatozoa in the epididymis; the other testis was diseased. Plasma testosterone was not markedly raised (491 ng/100 ml), although much higher than values of adolescent animals. Another male was sexually active at a length of 290 cm when it is known to have impregnated a female which gave birth in early November 1970. Plasma testosterone levels were highest (1400–2400 ng/100 ml) in September and October 1969 and in April and May 1970. The gestation period in *Tursiops truncatus* has been given as about 12 months (Essapian, 1963; Harrison, 1969) and possibly as long as 13 months (McBride & Kritzler, 1951).

It is not known whether or not male delphinids are sexually active throughout the year. The testes of some dolphins are remarkably large when known to be active. Ridgway & Green (1967) observed that adult male *Lagenorhynchus obliquidens* and *Delphinus delphis* caught during the Californian summer had active testes weighing as much as 1.0 kg each. They suggested that male *Delphinus* exhibit an annual rhythm with breeding activity in mid to late summer. Harrison, Boice & Brownell (1969) have reported that the testes of adult *Delphinus* can together weigh as much as 3.2 kg and are active during most of the year but are heaviest in the Californian winter and spring. They also describe *Tursiops gilli* as 303 and 333 cm which had active testes together weighing more than 1.1 kg in March and October. The present findings suggest that male *Tursiops truncatus* in captivity for varying periods do not reach sexual maturity until about 260 cm in length and at least ten years of age. Plasma testosterone level appears to be greatest during September and October and in April to May in animals kept in California. This correlates well with the periods when the largest number of young have been born in captivity.

Summary

The characteristics of the ovaries and testes are described in 22 female and 11 male Bottlenose dolphins, *Tursiops truncatus*, all originally caught off Florida or Mississippi. All the dolphins had been in captivity in the United States or England for periods varying from a few days to about ten years.

Birth has been recorded during every month of the year but occurs most frequently during the periods February to May and September to November. Length of neonates is between 98 and 126 cm. Some evidence suggests that there is an increase in length of about 30 cm in the first year of life and in captivity a length of 180 cm can be reached after 18 months. Thereafter the growth rate in captivity appears to slow; one female took seven years to increase from 205 to 259 cm and annual increments in males varied from 3.5 to 8.0 cm. Sexual maturity, as judged by ovarian activity, develops after females are about 220 cm in length but may be delayed until they are 244 cm. It is estimated that females can become sexually active in their fifth year, but there may well be some variation. Males exhibit testicular activity when some 260 cm in length. In captive males the available evidence suggests that sexual maturity is not reached until they are at least ten years old. Plasma testosterone levels in a captive male of proved fertility are highest in the periods April to May and September to October.

The left ovary exhibits a preponderance in weight in 66% of adult females and 34 corpora are in the left as opposed to 16 in the right ovary. The corpus luteum of pregnancy persists in a histologically active state until term when it is 25–30 mm in diameter. It shrinks rapidly to a corpus albicans of between 5 and 9 mm diameter over about two years

and remains that size or shrinks further to about 4 mm across, possibly depending on subsequent reproductive events. No evidence is found of a corpus luteum of an infertile cycle; all corpora lutea present are related to pregnancies.

Grateful thanks are expressed to Marineland of the Pacific, Marineland of Florida, Miami Seaquarium, Flamingo Park Zoo and to R. C. Boice, R. L. Brownell, D. A. McBrearty, F. C. Fraser, W. G. Gilmartin, J. G. Simpson and W. Walker who have helped us with specimens and information.

REFERENCES

- Asdell, S. A. (1964). *Patterns of mammalian reproduction*, 2nd ed. London: Constable.
- Brown, D. H. & Norris, K. S. (1956). Observations of captive and wild cetaceans. *J. Mammal.* **37**: 311-326.
- Caldwell, M. C. & Caldwell, D. K. (In press). Behavior of marine mammals. In *Mammals of the sea: Biology and medicine*. Ridgway, S. H. (Ed.). Springfield: Charles C. Thomas.
- Demetriou, J. A. & Austin, F. G. (1970). Quantitation of plasma testosterone by improved competitive protein-binding technique. *Clin. Chem.* **16**: 111-117.
- Essapian, F. S. (1963). Observations on abnormalities of parturition in captive bottle-nosed dolphins, *Tursiops truncatus*, and concurrent behavior of other porpoises. *J. Mammal.* **44**: 405-414.
- Fraser, F. C. (1934). Report on Cetacea stranded on the British coasts from 1927 to 1932. *Rep. Br. Mus. nat. Hist.* No. 11: 1-41.
- Fraser, F. C. (1946). Report on Cetacea stranded on the British coasts from 1933 to 1937. *Rep. Br. Mus. nat. Hist.* No. 12: 1-56.
- Fraser, F. C. (1953). Report on Cetacea stranded on the British coasts from 1938 to 1947. *Rep. Br. Mus. nat. Hist.* No. 13: 1-48.
- Harmer, S. F. (1927). Report on Cetacea stranded on the British coasts from 1913 to 1926. *Rep. Br. Mus. nat. Hist.* No. 10: 1-91.
- Harrison, R. J. (1949). Observations on the female reproductive organs of the Ca'ating Whale *Globicephala melaena* Traill. *J. Anat.* **83**: 238-253.
- Harrison, R. J. (1969). Reproduction and reproductive organs. In *The biology of marine mammals* Chapter 8: 253-348. Andersen, H. T. (Ed.). New York and London: Academic Press.
- Harrison, R. J., Boice, R. C. & Brownell, R. L. Jr. (1969). Reproduction in wild and captive dolphins. *Nature, Lond.* **222**: 1143-1147.
- Laws, R. M. (1956). Growth and sexual maturity in aquatic mammals. *Nature, Lond.* **178**: 193-194.
- Layne, J. N. (1965). Observations on marine mammals in Florida waters. *Bull. Fla. St. Mus. Biol. Sci.* **9**: 131-181.
- McBride, A. F. & Kritzler, H. (1951). Observations on pregnancy, parturition and postnatal behaviour in the bottlenose dolphin. *J. Mammal.* **32**: 251-266.
- Ohsumi, S. (1964). Comparison of maturity and accumulation rate of corpora albicantia between the left and right ovaries in cetacea. *Scient. Rep. Whales Res. Inst., Tokyo* **18**: 123-148.
- Ridgway, S. H. (1965). Medical care of marine mammals. *J. Am. vet. med. Ass.* **147**: 1077-1085.
- Ridgway, S. H. & Green, R. F. (1967). Evidence for a sexual rhythm in male porpoises, *Lagenorhynchus obliquidens* and *Delphinus delphis bairdi*. *Norsk Hvalfangsttid.* **56**: 1-8.
- Sergeant, D. E. (1962). The biology of the pilot or pothead whale *Globicephala melaena* (Traill) in Newfoundland waters. *Bull. Fish. Res. Bd Can.* **132**: 1-84.
- Slijper, E. J. (1949). On some phenomena concerning pregnancy and parturition of the cetacea. *Bijd. Dierk.* **28**: 416-448.
- Slijper, E. J. (1962). *Whales*. London: Hutchinson.
- Slijper, E. J. (1966). Functional morphology of the reproductive system in cetacea. In *Whales, dolphins and porpoises*, Chapter 15: 277-319. Norris, K. S. (Ed.). Berkeley and Los Angeles: University of California Press.
- Tavolga, M. C. & Essapian, F. S. (1957). The behavior of the bottle-nosed dolphin (*Tursiops truncatus*): mating, pregnancy, parturition and mother-care behavior. *Zoologica, N.Y.* **42**: 11-31.
- True, F. W. (1891). Observations on the life history of the bottlenose porpoise. *Proc. U.S. natn. Mus.* **13**: 197-203.