OBSERVATIONS ON THE OVARY OF THE SOUTHERN MINKE WHALE

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ABSTRACT

Ovaries of minke whales appear similar in shape, form and structure to those of related balaenopterid whales. However, the size and weight of the ovaries and their internal structures are smaller. In particular, the mean sizes of the active corpus luteum (CL) and regressed corpora albicantia (CA) are smaller. A high number of corpora appear to be present in the ovaries relative to age, consistent with a more frequent ovulation rate and/or shorter reproductive interval than observed in other balaenopterids. The types of corpora observed in the minke whale are similar to those reported for other whales, although the CA in minke are characteristically very yellow in colour. The CA appear to persist in the ovary despite considerable shrinkage and degeneration, thus forming a complete record of the individual's ovulation history. The cyclical changes in the ovary in relation to reproductive condition appear similar to those observed in other balaenopterids.

INTRODUCTION AND BACKGROUND

The minke whale, *Balaenoptera acutorostrata,* the smallest of the balaenopterid cetaceans, attaining a maximum size in the southern hemisphere of 10.7 m (Lockyer, 1984) and weight of about 13.87 t (Lockyer, 1976; Ohsumi, 1979), is found in all latitudes of the world's' oceans. Although the life history, longevity, pattern of feeding, growth and reproduction have many similarities with other balaenopterids, the duration of the reproductive cycle appears to differ, and in minke whales is closer to one year rather than two years as in the majority of this genus (Best, 1982; Christensen, 1974; Ivashin and Mikhalev, 1978; Jonsgård, 1951; Larsen and Kapel, 1983; Lockyer, 1981, 1984; Masaki, 1979; Mitchell and Kozicki, 1975; Williamson, 1975).

The most reliable estimate of reproductive cycle length is 14 months (IWC, 1979), comprising 10 months' gestation and 4 months' suckling of a single calf. The female appears to commence a subsequent pregnancy either during lactation or at weaning of the calf. The evidence for this is derived from ovulation rates calculated by plotting ovarian corpora numbers versus age, from foetal growth records and timing of parturition, and from propor-

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tions of pregnant, lactating and anoestrous females in the mature portion of the commercial catches.

Studies of minke whale populations have been made in both hemispheres, and include polar waters of the Antarctic, off Norway and Greenland, and more temperate seas off South Africa, Canada, Japan and Korea, as well as equatorial waters off Brazil. The biology of the different populations has generally been comparable.

The subject of the present study is the Antarctic minke whale. The mature female usually conceives in August-September, and gives birth in May-June of the following year to a 2.8 m neonate (Ivashin and Mikhalev, 1978; Lockyer, 1984). The mean age at first ovulation and possibly conception, ranges between 6–14 years (Masaki, 1979; Kato, 1983, 1985) at an average body length of 8.0 m and weight of 6.05 t. In this study, a detailed account is presented of the macroscopic structure of the ovaries of the minke whale, and analyses of cyclical activity in relation to reproductive age and status.

MATERIAL AND METHODS

The study material comprised 67 pairs of ovaries, collected during the Japanese Antarctic minke whaling expedition December 1980–March 1981. The ovaries were removed intact from freshly killed carcases on board factory ships, were maintained frozen between −15°C and −20°C, and shipped back to Japan where, after initial palpation and examination at the Far Seas Fisheries Research Laboratory, Shimizu, they were fixed and preserved whole in neutral buffered 10% formalin (4% formaldehyde) and freighted to Cambridge. On arrival, the ovaries were in excellent anatomical and histological condition. Data on sexual status and condition, age, date of capture, body length, geographical position of capture and foetal length (if present), were provided. The classification of the reproductive status, e.g. pregnant, anoestrous, lactating, was determined on site when the whale was first dismembered after capture and the ovaries collected. This was done by careful macroscopic investigation of the uterus and mammary glands. Ages of individuals were determined by Dr H. Kato (Whales Research Institute, Tokyo).

After soaking/rinsing in running water for 24-hours, the individual ovaries were trimmed of adhering fallopean tube and connective tissue, weighed and examined for gross general appearance and presence of corpora lutea. These latter, if found, were detached, weighed, and cut vertically from the ovulatory scar along two planes at right angles to each other and to a third transverse plane of cut. The maximum diameters through these three planes were measured to give an average diameter of the corpus luteum (CL).

The ovaries were then sectioned at intervals of 2-3 mm, using a commercial meat slicing machine. During this procedure, slices were accumulated serially and examined for the presence of corpora albicantia (CA), follicles and various other ovarian structures, all of which were recorded and measured for mean maximum diameter in at least two planes. Unusual items, such as corpora atretica, were excised and put aside in 10% formalin for subsequent histological examination for confirmation of their identity.

The classification of ovarian bodies was made by reference to work of Laws(1961) and the International Whaling Commission report (IWC, 1984). The categorization of the CA into young, medium and old in terms of state of regression and resorption has been based on the terminology of Laws(1961).

RESULTS AND DISCUSSION

The ovarian structure is typically mammalian (Mossman and Duke, 1973), and generally conforms to the findings of Harrison (1969), Laws (1961) and Slijper (1966) for other cetaceans. In the following analyses, the ovaries were sorted by reproductive category of the female, as defined below:

Immature – where ovaries contain follicles but no evidence of ovulation;
Mature – where ovaries, of which at least one half of the pair, contain evidence of ovulation; there are sub-categories of maturity status:
a. Pregnant – where ovaries contain an active corpus luteum, and there is evidence of foetal development in the uterus;
b. Ovulating – where ovaries contain a large active corpus luteum, but there is no evidence of a foetus in the uterus; note however, that fertilisation may have occurred but not implantation;
c. Regressing CL – where ovaries contain a no longer active corpus luteum which is undergoing shrinkage and histological changes commensurate with becoming a corpus albicans (Marsh, 1985; Marsh and Kasuya, 1984);
d. Anoestrous – where ovaries contain no corpora lutea, active or regressing;
e. Lactating – where milk is present in the mammary glands, but the ovaries may contain a regressing CL, an active CL or no CL; ovulation and pregnancy may occur during lactation.

Gross appearance of the ovaries

1) Size

The elongate, slightly flattened ovaries are lobulate in mature and maturing females and smooth in juveniles. The overall external colour is a mixture of pink, white and grey. The hilus is long, similar to that in the fin whale, *B. physalus* (Laws, 1961). Corpora (both CL and CA) generally protrude from the surface, and are connected at the base by a thick "neck" to the main body of the ovary. The ovary surface is frequently criss-crossed by "tags" and adhesions such as observed for sei whales, *B. borealis* (Gambell, 1968 and

TABLE 1. OVARY WEIGHTS IN MINKE WHALES

Reproductive class and category		No individual ovaries	Mean ovary weight(g)±s.d. Ovary without CL	Ovary with CL
Immature		22	50.4±37.92	
Mature				
Anoestrous	<10CA	10	77.75±31.72	
	11-24CA	12	167.50±45.40	
	>25CA	8	218.12±97.24	
	All groups	30	150.11±81.13	
Pregnant	All groups	36	161.14±68.62	339.17±113.16
Ovulating	(CL+19CA)*)	2	200	480
Regressing	CL (2-11CA)**)	6	78.17±5.01	131.67±16.07

*) corpora count of ovary pair,

**) range of corpora counts in the 3 ovary pairs.

personal observation); 18% of juveniles and 12.5% of mature females showing this feature. Sometimes mushroom-like appendages dangle from the main body of the ovary, but have no unusual internal structure. These have also been observed in fin whales (Laws, 1961).

The paired ovaries are usually of similar size and weight, except where a CL is present, when the CL-bearing ovary greatly exceeds the weight of the other.

2) Weight

The average weight of ovaries for different reproductive classes are shown in Table 1. The minke ovaries, by reproductive class, are almost one tenth the weight of those reported for the much larger fin (Laws, 1961) and sei whales (Gambell, 1968). As expected, the immature ovaries are lightest. In the mature ovary, weight increases significantly with the accumulation of CA, although the overall mean weight of the anoestrous ovary is similar to that of the non-CL-bearing ovary of the pregnant female. The combined effects of corpora number and stage of pregnancy have not been investigated, as sample size is inadequate. The CL-bearing ovary in both the fully pregnant and post-lactational phase (with regressing CL), is significantly heavier than its partner. This, as will be shown later, is almost certainly due to the additional weight of the CL. The single ovulating female in the sample, also demonstrates a weight assymetry with greater weight in the recently ovulated ovary.

Internal structure of the ovary

Internally, the encapsulating tunica albuginea in mature ovaries is between 0.83-2.99 mm in thickness with a modal range 1.25-1.50 mm. This is comparable to the 0.95-1.60 mm observed in fin whales (Laws, 1961). The

TABLE 2. MEAN DIAMETER OF THE LARGEST FOLLICLES IN MINKE WHALES

Reproductive class and category	No females	Mean diameter of the largest follicles (mm) ±s.d.
Immature	11	6.41±3.35
(age 2–7 years; length 6.2–8.6 m)		
Mature		
Anoestrous	17	9.29±4.90
Pregnant		
(foetus <30 cm)	8	9.87±5.92
(foetus 30–130 cm)	26	13.74±3.81
(foetus >130 cm)	2	13.00±0.07
Ovulating	1	14.00
Regressing CL (2–11CA)*)	3	3.50±2.18

*) range of corpora counts in the 3 females.

body of the ovary, particularly the medulla, is well supplied with blood vessels, and the cortex contains varying numbers of follicles of differing sizes with developing oocytes, the stage dependent on reproductive condition of the female, and products of ovulation, the CL and CA. In addition, various other bodies are found near the cortical surface, including different types of corpora atretica, cysts and cystic follicles. These ovarian bodies are described below.

1) Follicles

The dimensions and abundance of gel-filled Graafian follicles, found throughout the cortex of the ovary, vary in size with stage of maturity, and with stage of the reproductive cycle (Table 2). The immature ovaries of juveniles and animals approaching puberty have smaller follicles than those in most mature ovaries. In very young females, the follicles are not macroscopically visible.

Ovulating and mid- and late-term pregnant females have the largest follicles, whilst follicles in ovaries of anoestrous and early-term pregnant females are smaller. The smallest follicles, indicating little follicular activity, are seen in the ovaries of females with a regressing CL.

Follicular activity in terms of size, throughout the reproductive cycle in minke, is broadly similar to that of fin whales (Laws, 1961).

No mature ovaries were observed to lack follicles as has been reported by Marsh and Kasuya (1984) for older "post-reproductive" or senescent pilot whales (*Globicephala macrorhynchus*).

2) Corpus luteum

The active CL is similar in appearance to those described for fin (Laws,

TABLE 3. SIZE OF THE CORPUS LUTEUM IN MINKE WHALES

Reproductive class and category	Mean size of CL±s.d. (n=sample size) Diameter (mm)		Weight (g)	
Pregnant				
(foetus <30 cm)	62.68±8.78	(8)	137.25±45.27	(8)
(foetus 30–130 cm)	66.40±6.79	(26)	156.73±48.39	(26)
(foetus >130 cm)	70.58±12.94	(2)	202.50±137.89	(2)
Ovulating	75.70	(1)	180.00	(1)
Regressing CL	41.37±3.60	(3)	48.00±11.31	(3)

1961), sei (Gambell, 1968) and blue whales, *B. musculus* (Mackintosh and Wheeler, 1929); its form and structure is as described in the IWC report (IWC, 1984).

The CL of the ovulating female (determined as such from the absence of a foetus) was similar in appearance to those of the pregnant females, confirming the view (IWC, 1984; Marsh, 1985) that the CL of ovulation and pregnancy are not readily distinguishable, if at all. Of course, during the pre-implantation phase when the blastocyst is unattached, the reproductive status of the female is impossible to differentiate from that of the condition with a recent unfertilised ovum.

The stigma, site of the follicular rupture at ovulation, was usually clearly visible at the apex of the protruding CL, and was often surrounded by a slightly raised rim or corona. The colour of the CL was pinkish-grey to yellow. One unusual form of CL was found where a surrounding fold of tunica albuginea from the ovary had formed around the body, enfolding it like a cup around an acorn. Central vesicles within the CL were observed in 25% of early-pregnant (n=8; foetus length<30 cm) and 33.3% of mid-pregnant females (n=26; foetus length 30-130 cm), but none were observed in late-pregnant females (n=2; foetus>130 cm). There was no significant association with stage of pregnancy. Larsen (1984) reported an incidence of 13% of vesicular CL in pregnant minke whales, but no breakdown by stage of pregnancy was presented.

Variation in size of the CL throughout the reproductive cycle is shown in Table 3. Volume and weight appear to increase with advance of pregnancy. However, the differences in size are not significant with these small samples. The regressing CL, determined as such from shrinkage of the secretory lobules and commencement of fibrous replacement of the luteal tissue, appears very small in relation to the size at ovulation, and approaches the mean largest size of the youngest CA.

The additional weight of the CL explains the assymetry in the weight of ovaries from pregnant females (Table 1).

The size range of the minke CL (Table 3) is similar to that observed by Best (1982) for minke whales off South Africa, and by Larsen and Kapel

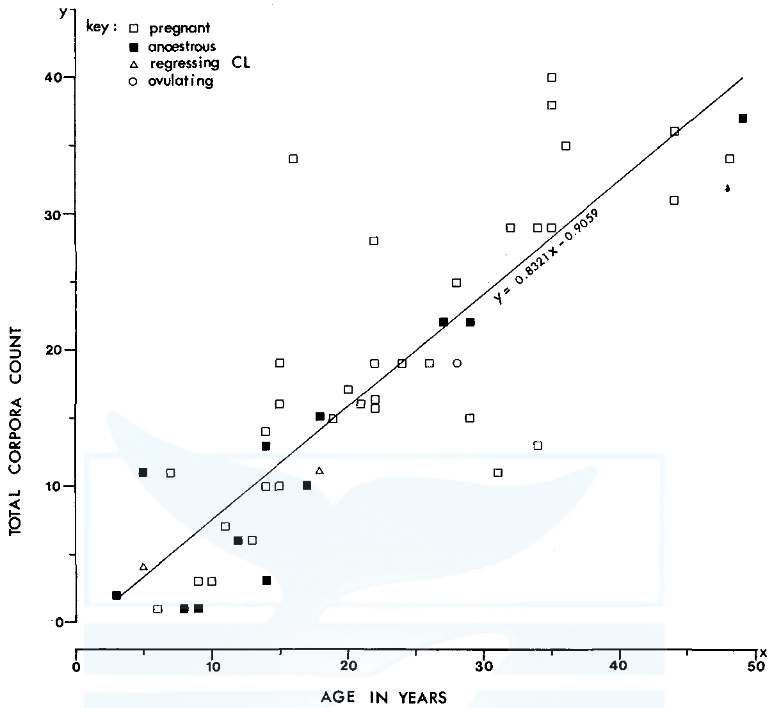

Fig. 1. Observed relation of ovarian corpora number with age from ear plug growth layers in minke whales.

(1983) for the minke whale off Greenland. Larsen (1984) gave a mean size of CL of pregnancy as 56.6±5.8(s.d.)mm for Greenland minke whales, rather smaller than the values for the southern hemisphere. He considered that the smaller size of the CL of the northern hemisphere animals might be due to their smaller body size. The size of the CL of ovulation observed here seems large by comparison with the data summarised by Lockyer (1984), approaching nearly twice the diameter given by Larsen (1984). However, no significance can be ascribed to this solitary observation. The mean sizes of the minke CL are smaller than those of all other baleen whales quoted by Lockyer (1984) for pregnant females, including:

blue, 136.5 mm (Mackintosh and Wheeler, 1929),
fin, 114.4 mm (Laws, 1961),
sei, 76-84mm (Gambell, 1968),
humpback, *Megaptera novaeangliae*, 106-123 mm (Matthews, 1937; Chittleborough, 1954),
Bryde's, *B. edeni*, 72-78 mm (Best, 1977), and gray, *Eschrichtius robustus*, 82-87 mm (Rice and Wolman, 1971).

In all these baleen species, the mean size of the CL of ovulation is smaller than that of pregnancy.

No examples of accessory CL, as described by Laws (1961) and IWC

(1984), were found. However, there is a possibility of their existence, particularly with reference to c. atretica described later, whose function and fate are unclear.

3) Corpora albicantia

All CA were classified into young, medium and old categories (Laws, 1961), and mean diameters measured. The first impression gained in examining the ovaries, was the high numbers of CA accumulated even in young females, so that it was not unusual to observe many females of age 15 years and over with as many corpora as years (Fig. 1). This suggests two points: 1) females probably ovulate at least annually, and may be poly-ovulating; 2) complete resorption even of old CA is unlikely, so that CA are permanent features of the ovary, even when greatly regressed in size.

The young CA, are in fact most usually highly pigmented and yellow-tan in colour, whereas fin or sei ovaries are usually pale greyish-brown (personal observation). In the minke whales, the medium and old CA generally become brown and greyish, but some CA are still well pigmented. The difference between a highly pigmented CA and a corpus aberrans (Laws, 1961) equivalent to a corpus atreticum type a (IWC, 1984) (see Plate la) is not immediately obvious, since the latter is often regularly shaped and bright yellow or orange-yellow in hue.

Fig. 2 shows the course of regression of the CA with time in different reproductive classes.

4) Young CA

The mean maximum diameter range of the young CA is 28.14-16.50mm, with pregnant and ovulating females tending to bear slightly larger and, in the former, more numerous young corpora than females in anoestrus and with regressing CL, despite similar total counts of all ages of corpora. This might suggest that hormones of pregnancy may temporarily allay degenerative processes and shrinkage of the CA. Such explanations have been proposed for fin whales where similar observations were made (Laws, 1961). Marsh and Kasuya (1984) found slower rate of shrinkage of CA in pregnant pilot whales. Larsen (1984) gave a mean diameter of young CA of 21.4±3.5(s.d.)mm for Greenland minke whales, within the range presented here.

Initially the CL shrinks rapidly to 40% of its original diameter (Larsen, 1984, gave a figure of 37.8%), and then continues to about 25% of original CL diameter (Fig. 2a).

5) Medium CA

The range of mean diameters of the medium CA is 19.17−10.00 mm, the smallest being about 15% of original CL diameter, and 40% of initial diameter of the youngest CA. The shrinkage of the CA in this medium phase is

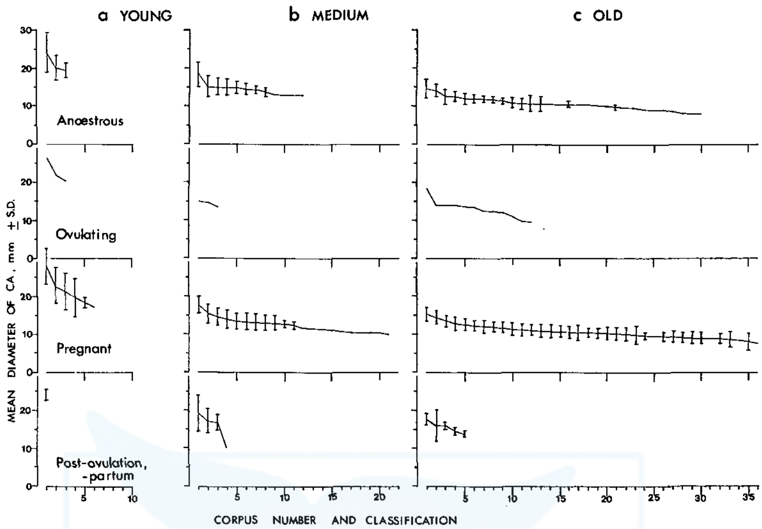

Fig. 2. Regression of accumulated corpora albicantia, measured by mean diameter, in decreasing order of c.albicans size, by different reproductive classes:
a. Young c.albicantia;
b. Medium c.albicantia;
c. Old c.albicantia.

slower (Fig. 2b), and there is considerable size overlap with the old CA category below (Fig. 2c). Larsen (1984) observed a shrinkage in diameter of medium CA in Greenland minke to 15.8±2.4(s.d.)mm, similar to results here, and 27.9% of original CL diameter.

6) Old CA

The range of mean diameters of the old CA is 18.5-7.5 mm. The shrinkage here is very slow (Fig. 2c), and not greatly different from that for medium CA. The similar size range with the medium CA, suggests not so much continued shrinkage, but a continued histological change in the structure. It seems unlikely that CA which have regressed to this third stage will regress or alter further; they become a permanent feature in the ovary. Examples of old CA are shown in Plates la and ld.

The general pattern of corpus regression in minke whales is similar to that in fin whales (Laws, 1961), but the sizes of minke CA in the different ovarian age categories are smaller. The ultimate regressed modal diameter (about 10 mm) of the old CA in minke being approximately half that for the fin whale (Laws, 1961). However, this body is still quite readily visible macroscopically. Larsen (1984) found a mean diameter of old CA of 10.0±2.4(s.d.)mm in Greenland minke, and shrinkage to about 17.7% of original CL diameter. The equivalent shrinkage here is 15.2% of CL size, close to the estimate of Best (1982) of 15.7%.

7) Corpora atretica, cystic follicles and cysts

Corpora atretica–type a: The corpus atreticum type a (IWC, 1984) identified here is equivalent to the corpus aberrans described by Laws (1961). These bodies exhibit follicular origins, there being evidence of apparent rupture or ovulation through presence of a stigma on the germinal epithelium overlying the body (Plate lb). However, they fail to luteinise fully and undergo instead a fatty degeneration over time (Plates 1c and 1d). These corpora often attain a moderate size, e.g. 23mm in diameter, and are very bright yellow in colour (Plate 1e). When recently formed they appear as lobules protruding from the mass of the ovary, and frequently a CA in form. The presence of older regressed or atrophied ones is often ascertained only after cutting into the ovary. A few maintain central vesicles (Plate 1f).

No c.atretica a were found in the ovaries of the eleven juveniles, none in the ovaries of the ovulating female, or of the three females with a regressing CL. The anoestrous females (n=14) showed an incidence of 78.6%. Half of the anoestrous females had only a single c.atreticum a, while 7% had two, 14.3% had 3, and 14.3% had four. The mean diameter of the c.atreticum a was 10.82±4.50(s.d.)mm. Among pregnant females, the incidence of c.atretica a was 62.5% for those with a foetus <30 cm (n=8), 37.5% having a single body and 25.0% having two. The mean diameter was 10.08±3.78(s.d.)mm. The incidence in the group of foetal size 30–130 cm (n=26), was lower, at 26.9%, with 15.4% having a single body, 7.7% having two and 3.8% having three. The mean diameter was 10.50±5.4(s.d.)mm. The two females in late pregnancy had no c.atretica a. Sample size is too small in several categories for a valid χ^2-test, but restricting the test to incidences in anoestrous and pregnant females, $\chi^2=10.6751$ with d.f.=2, and is significant at $p<0.01$. It is therefore suggested that these bodies are directly associated with certain phases of the reproductive cycle, and by implication, certain hormone levels. Laws (1961) observed a decrease in incidence of c.aberrantia (c.atretica a) with advance of pregnancy in fin whales. In odontocetes, Best (1967) reported the highest incidence of c.atretica a in recently ovulated females, 45.5%, with lower levels of 4.6% in pregnant, 7.7% in lactating and 13.6% in anoestrous sperm whales, *Physeter macrocephalus*. Marsh and Kasuya (1984) found an apparent association of incidence of c.atreticum a with states of oestrus, ovulation and early pregnancy in pilot whales. The bodies appeared to degenerate post-partum and in anoestrus.

The fact that percentage occurrence varies so much between reproductive classes in minke whales also suggests that most c.atretica a degenerate completely, perhaps within a year, the usual reproductive interval. Laws (1961) held a similar view on the fate of c.aberrantia (c.atretica a) in the fin whale.

Of females with ovaries having a vesicular CL (n=11), 54.5% had a c.atreticum a, compared with 24.0% of those females with ovaries having a non-vesicular CL (n=25). The difference, however, was insignificant with p>0.05 using a χ^2test.

Corpora atretica – type b: This category corresponds with the definition of c.atreticum used by Laws (1961) and with the c.atreticum type b (IWC, 1984). These bodies are usually smaller than the c.atreticum a, and, unlike the frequently regular internal shape of the latter, are usually stellate or amoeboid in shape and deep yellow-orange or tan in colour. They never protrude from the ovary surface, and none examined exhibited a stigma. Usually, these c.atretica b lay deeper in the cortex than the c.atretica a.

No c.atretica b were observed in females with immature ovaries (n=11), and none were observed in the ovulating ovary or in the three pairs of ovaries with regressing CL. The incidence in anoestrous females (n=14) was 35.7%, with 14.3% having one, 7.1% having two, and 14.3% having seven c.atretica b. The maximum diameter of the c.atreticum b was 8.3mm, but many were much smaller. Among pregnant females, the early pregnant (n=8) group had an incidence of 12.5% with two c.atretica b, and very small diameter, <5 mm, while mid-pregnant females (n=26) had an incidence of 34.6%, with 19.2% having one and 15.4% having two c.atretica b. The maximum diameter observed was about 7 mm. Marsh and Kasuya (1984) observed no c.atretica b in immature pilot whales, but found 75% of all mature ovaries bore these bodies. Best (1967) found an average incidence of 50% in all reproductive classes of sperm whales.

Using similar criteria as above for the c.atreticum a data, a χ^2-test showed no significant differences between reproductive states, excluding juveniles. A similar finding was obtained in fin whales (Laws, 1961), and also in pilot whales (Marsh and Kasuya, 1984) and sperm whales (Best, 1967).

The persistence of these bodies is uncertain, particularly because of their small irregular form which may mean that some are inevitably overlooked in a macroscopic examination of the ovaries. Marsh and Kasuya (1984) suggest that these bodies do not persist. Total resorption is a possibility. Also, the overall incidence of c.atretica b are lower than for c.atretica a.

8) Cysts

Follicular, gel-filled cysts: In the present sample of ovaries, this type of cyst appears to occur exclusively in ovaries of pregnant females, with an incidence of 12.5% and a mean diameter of 31.7 mm in females in early pregnancy (n=8), and 3.8% and a mean diameter of 40 mm in females in mid pregnancy (n=26). No other examples of cystic follicles were observed. These cysts were often multichambered, resembling a thin-walled honeycomb filled with mucous gel. The ultimate fate of such cysts is not known, but presumably they regress, because they are not observed in other reproductive groups. Should some luteinisation or hyalisation occur, they may regress to a form of yellow body such as c.atreticum b, but this is speculative.

Cornified solid cysts: Only one example of a solid cyst was observed, and this was present in the cortex of a female in early pregnancy, in the form of a small whitish and homogeneous sphere, with a fibrous collagen-type of texture. The origin of this body was unknown.

Differential activity in the ovary pairs

The side of the whale from which the ovary was collected was not generally known or identifiable. The possibility of bi-lateral activity could thus not be evaluated as to preferential left or right activity. However, a simple analysis was performed to identify whether or not one ovary, regardless of side, might be more active than the other.

The pairs of ovaries with a total corpora count of 2 or more (52 pairs) were arranged in ascending order of corpora count. The individual ovary corpora counts of each pair were compared and the difference between them (d) was squared (d^2) and divided by the total corpora count (N). A plot of d^2/N on N revealed no pattern of increasing variability with corpora count, and insignificant correlation of $p>0.05$ with $r=-0.127$, d.f.=50. We may therefore conclude that there is no indication of differential activity between halves of ovary pairs.

Both Slijper (1949) and Laws (1961) found a tendency for the right ovary to be more active in fin and blue whales. Larsen (1984), examining left and right ovaries for a small sample of Greenland minke, found no significant bi-lateral ovarian activity.

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EXPLANATION OF PLATE

PLATE I

a. Old corpus albicans (on right) and corpus atreticum type a (on left) showing pigmentation.
b. External appearance of a recent corpus atreticum type a, showing the stigma (site of rupture).
c. Internal appearance of recently ruputured follicle above (Plate 1b) showing commencement of luteinisation.
d. Uneven luteinisation of corpus atreticum type a, with a fibrin-filled vesicle (on left), showing the stigma and adjacent old c. albicans (on right).
e. Corpus atreticum type a (centre) showing yellow pigmentation and the stigma (point of follicular rupture), and adjacent follicles.
f. Corpus atreticum type a with a central vesicle.