COMPARISON OF MATURITY AND ACCUMULATION RATE OF CORPORA ALBICANTIA BETWEEN THE LEFT AND RIGHT OVARIES IN CETACEA

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INTRODUCTION

On the activity of ovaries in animals, there are some species of which one side of ovary is not functional, and there are other species of which both ovaries are functional. And the latter species are separated into two kinds, one is a animal of which both ovaries are active equally, the other one is a animal of which one ovary is more active than the other. Limitting to mammals, *Orinithorhynchus paradoxus* of Monotremata is functional in the left ovary only and the embryos are always found in the left uterus (Flynn & Hill, 1938) In some vespertilionid bats, only one ovary, usually the right, is functional ; in others, both appear to be functional, but pregnancies are found only in the right horn of uterus (Asdell, 1946). In domestic cattle (*Bos taurus*), the right ovary tends to produce more ovulations than the left. A corpus luteum count showed 60.2% in the right ovary (Reece & Turner, 1938). According to Henning (1939), the right ovary-functions act more frequently than the left, since ovulations have been found in that ovary in $58.58 \pm 1.85\%$ of cases. The other hand, in domestic pig (*Sus scrofa*), the left ovary appears to be slightly more active than the right. Warwick (1926) reported that 55.3% of ovulation were shed from the left ovary. The left ovary of horse (*Eqnus caballus*) functions more frequently than the right. In a series of 185 ovulations 61% were from the left (Andrews & McKenzie, 1941). But in many animal, there is practically little or no difference in the relative activity of the two ovaries (Guinea pig, *Gavia porcellus;* domestic rabit, *Oryctologus cuniculus;* Woodchuck, *Marmota monax;* rat, *Rattus rattus;* Bengal rhesus monkey, *Macaca mulatta* etc.), according to a book by Asdell (1946).

Concerning the difference of ovulation or pregnancy between the left and right ovaries in **CETACEA**, Sleptsov (1940) reported that in only 17% of 635 pregnant dolphin and beluga embryos were found in he right horn of uterus. And Slijper (1958) described that 'In all ***ODONTOCETES*** so far investigated, the fertilized ovum was almost invariably attached to the distended left horn of the uterus, while the smaller right horn was found to contain a part of the allantois. In ***MYSTICETES,*** on the other hand, the foetus may develope in eigher horn.' In **CETACEA**, a ovum ovulated from one side of ovary, usually attached to the same side of horn of uterus (Slijper, 1949), therefore we can estimate by the horn in which foetus is, from which ovary ovulation occured. And fortunately in **CETACEA,** all ovulations are recorded permanently in the ovaries as corpora albicantia. So, we can determine the number of ovulation by the time of investigation by counting corpora lutea and albicantia in each ovary. Laws (1961) reported that combining both corpora albicantia and corpora lutea, of 724 fin whale (*Balaenoptera physalus*) corpora, 52.4±3.72% were in right ovary and of 454 blue whale (*Balaenoptera musculus*) corpora, 52.4±4.68% were in right ovary, and he estimated possibility that there is a slight prevalence of right side in both species. Sergeant (1962) described that from the distribution of corpora lutea and albicantia in 42 ovary pairs of the pilot whale (*Globicephala melaena*) it was found that 70% of ovulations on average took place from the left ovary with wide individual variation in incidence of scars between two ovaries.

Reviewing the above reports, they seems to investigate the comparison of ovulation between the left and right ovaries including all age groups, and it seems that there is no report on the variation of accumulation rate of corpora in one side of ovary according to the increment of age. I studied the number of corpora lutea and albicantia between the left and right ovaries in 23 species of **CETACEA**, for the purpose of coparison of maturity and variation of corpora accumulation rate between the left and right ovaries. And then taxonomic consideration was given on the typing of relative corpora accumulation and interrelationship of the types.

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MATERIAL

Species, locality, number of samples, and investigater used in this study are shown in Table 1. To my regret, I collected the data on only 23 species, and they are not contained in all Genera of **CETACEA.**

Ovaries are convinced of the left and right, and number of corpora lutea and albicantia in each ovary are counted as accurate as possible. Mature ovary is defined as that in which more than one corpus luteum or albicans is accumulated, and I did not use an individual of which both ovaries are immature as the material for this paper.

As mentioned in above chapter, in **CETACEA**, corpus albicans is considered to be not absorbed. Therefore, the ovulations are recorded permanently as corpus albicans. Although there are individual variation in the ovulation rate,number of corpora albicantia is related to age in average. Then, the comparison of maturity and accumulation rate of corpora between the left and right ovaries are able to be examined by the comparison of number of corpora in the left or right ovary to the total number of corpora in both ovaries.

Frequencies of number of corpora in the left ovary in each class of number of corpora in both ovaries are tablated for eight species as shown in Appendix-Tables. Frequency of number of corpora in the right ovary is calculated easily from the table. From an Appendix-Table, a figure which shows a process of relative accumulation of corpora in the left and right ovaries is drawn for each species. On the species of which samples are small, indicidual data are plotted in the figure, and estimated mean curves of accumulation or corpora are drawn in the left and right ovary. Other species of which samples are collected more than 40, I calculated average number of corpora in the left or right ovary in adequate class of total number of corpora, and connected each average values by straight line.

TABLE 1. LIST OF SPECIES AND NUMBER OF INDIVIDUALS EXAMINED IN THIS PAPER

Species	Locality	No. of specimen	Investigator
Balaenoptera musculus	N. Pacific	57	S. Ohsumi
——*physalus*	N. Pacific	297	S. Ohsumi
——*edeni*	Japan	54	S. Ohsumi
——*borealis*	Antarctic	80	S. Ohsumi
——*acutorostrata*	Japan	2	T. Ichihara
Megaptera novaeangliae	N. P. and Ant.	100	S. Ohsumi
Eubalaena glacialis	N. P. and Ant.	3	T. Nemoto and Matthews (1938)
Physeter catodon	Japan	298	S. Ohsumi
Kogia sp.	Japan	1	S. Ohsumi
Berardius bairdii	Japan	13	S. Ohsumi
Ziphius cavirostris	Japan and N.P.	3	S. Ohsumi and Kenyon (1961)
Delphinapterus leucus	Hudson Bay	16	D. E. Sergeant
Phocaenoides dalli	Japan	5	S. Ohsumi
Grampus griseus	Japan	2	M. Nakajima
Globiceplala melaena	Newfoundland	173	D. E. Sergeant
——*scammoni*	Japan	7	S. Ohsumi
Orcinus orca	Japan	1	S. Ohsumi
Feresa attenuata	Japan	4	M. Nishiwaki and S. Ohsumi
Lagenorhynchus obliquidens	Japan	1	M. Nakajima
*Tursiops truncatus**	Japan	26	M. Nishiwaki, M. Nakajima and S. Ohsumi
Delphinus delphis	Japan	6	M. Nishiwaki, and M. Nakajima
Stenella attenuata	Japan	3	M. Nakajima
——*caeruleoalba*	Japan	333	M. Nishiwaki and S. Ohsumi

* More taxonomic studies are needed on this species.

RESULTS

Balaenoptera musculus

Slijper (1949) reported 59% of pregnancies came from the left ovary in the blue whale, and Laws (1961) described that of 454 corpora, 52.4±4.86% were in right ovary. According to my material, total corpora in the left ovaries are 47.4% of total number of corpora in both ovaries.

As shown in Appendix-Table 1, each ovary attains to maturity by the time of two ovulations in each other side of ovary. And as shown in Fig. 1, accumulation rates of corpora are almost piled up each other in both sides of ovaries.

Considering above phenomenon, I conclude that in *Balaenoptera musculus* the left and right ovaries attain at maturity in the same time and ovulation occures alternately from the left and right ovary in average.

Balaenoptera physalus

Many materials are obtained for this examination from the northern part of the North Pacific. In total individuals, 51.9% of corpora accumulated in the left ovary. Slijper (1949) reported the percentage of existence of corpus luteum of pregnancy on 17, fin whales and the result was 65% of fin whales the corpus luteum was in the right ovary. However, Laws (1961) describes that combining the corpora lutea and albicantia, of 724 fin whale corpora, $52.4 \pm 3.72\%$ were in the right ovary, and he states it seems possible that there is a slight prevalence of the right side in the fin and blue whale. My result is that the left side is silghtly more, but it is included into the standard deviation by Laws (1961).

Appendix-Table 4 shows the distribution of number of corpora in the left ovary in each class of number of corpora in both ovaries. There is individual variation, for instance, in the 8 corpora class in both ovaries, the number of corpora in the left ovary distribute from 2 to 7, but the average is 4.6. That is to say, the average of corpora in the right ovary is 3.4. The left ovary attaines to maturity by the time when the other side of ovary accumulated 4 corpora, on the other hand, right ovary attaines to maturity by the time when 6 corpora accumulate in the left ovary.

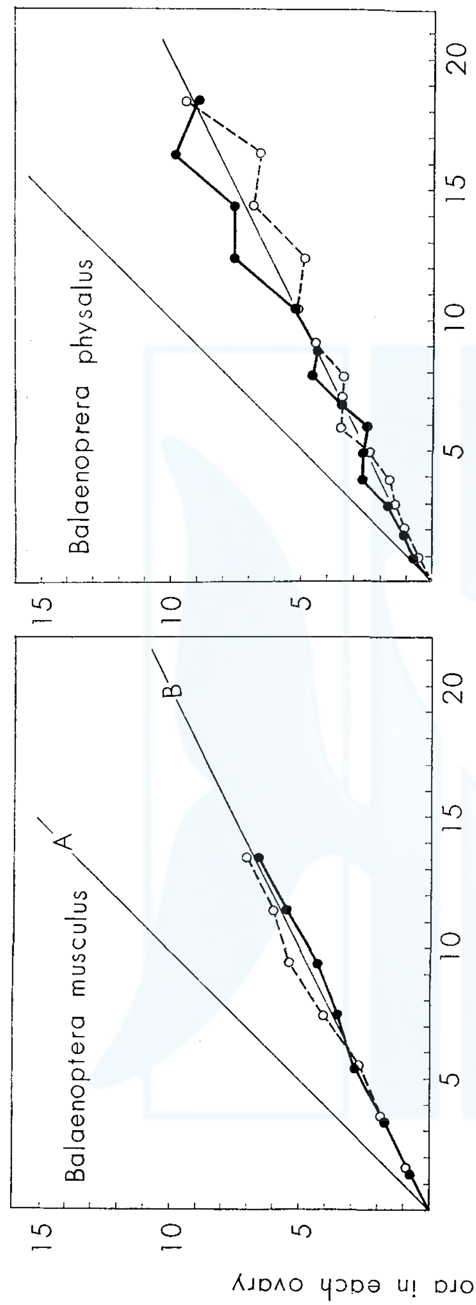
As shown in Fig. 1, the maturity and the relative accumulation rate of corpora are almost the same between the left and right ovary in average.

Balaenoptera edeni

Materials were collected from Japanese coast. In total of 54 whales, 48.7% of corpora accumulate in the left ovary. Each ovary attaines to maturity by 3 corpora accumulate in each other side of ovary. And as shown in Fig. 1, the maturity and relative accumulation rate of corpora are seemed in average to be the same between the left and right ovary, although there is some individual variation.

Balaenoptea borealis

Materials were obtained from the Antarctic Areas IV, V, and VI. 49.7% of corpora accumulate in the left ovary. The individual variation is seemed not to be so wide as *Balaenoptera physalus*. The left ovary attaines to maturity by 5 corpora accumulate in the right ovary, on the other hand, the right ovary attaines to maturiy by 4 corpora accumulate in the left ovary. The average accumulation of corpora in each ovary is shown in Fig. 2, and maturity and corpora accumuation is almost the same each other between the left and right ovary.



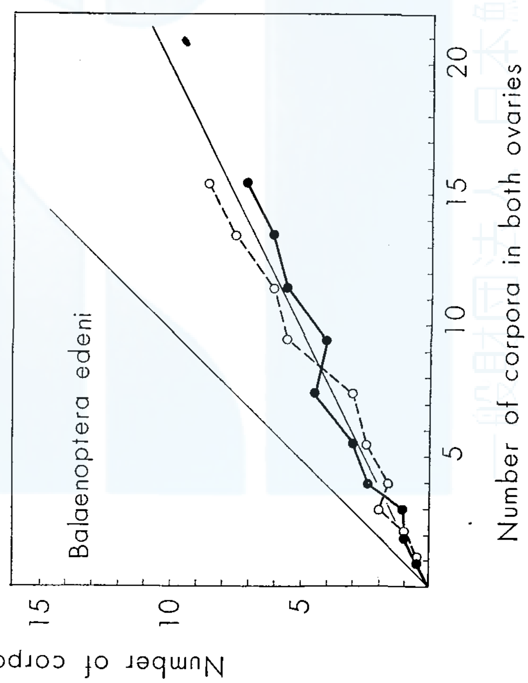


Fig. 1. Relative accumulation of corpora lutea and albicantia in the left and right ovaries on *Balaenoptera musculus*, *B. physalus*, and *B. edeni*. Open circles and broken line: Average values in the right ovary, Closed circles and broad straight line: Average values in the left ovary. Thin line A: Ovulation occures from one side only. Thin line B: Ovulation occures equally from each ovary. Circles and curves: Law values and estimated average accumulation of corpora. (Explanations are same as above in the following Figures)

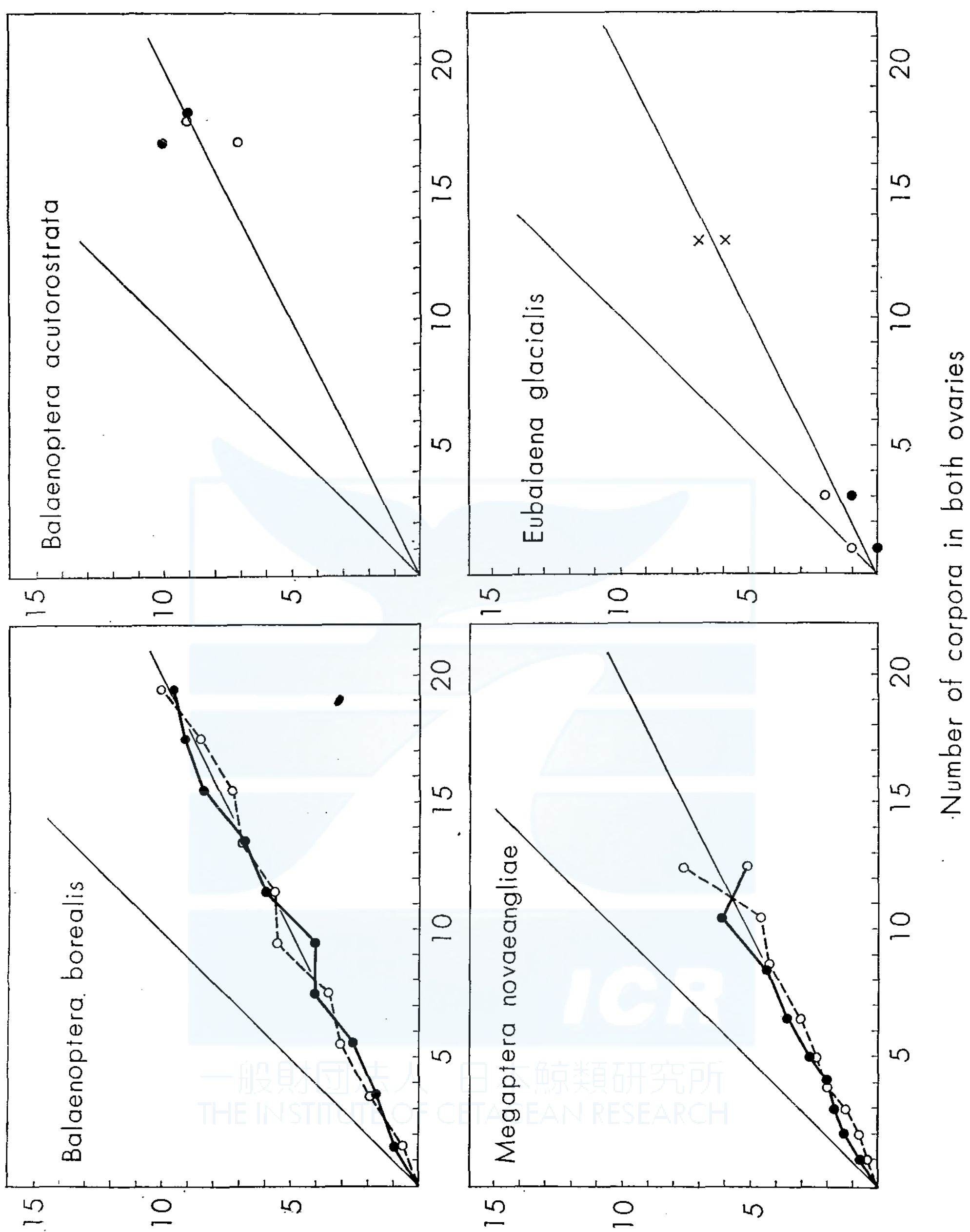


Fig. 2. Relative accumulation of corpora in the left and right ovaries on *Balaenoptera borealis*, *B. acutorostrata*, *Megaptera novaeangliae* and *Eubalaena glacialis*. Cross: Unknown which is the left or the right ovary.

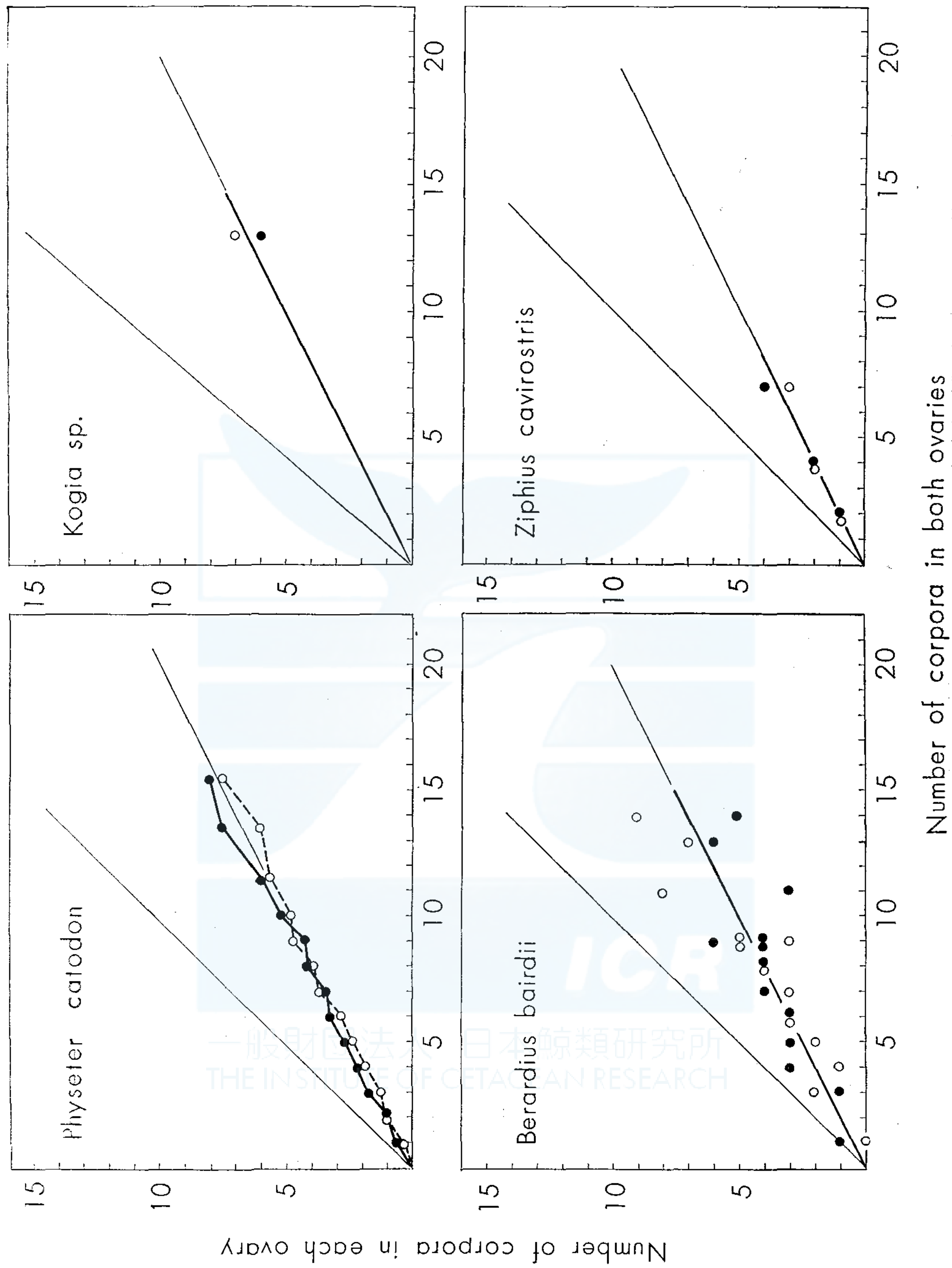


Fig. 3. Relative accumulation of corpora in the left and right ovaries on *Physeter catodon*, *Kogia sp.*, *Berardius bairdii* and *Ziphius cavirostris*.

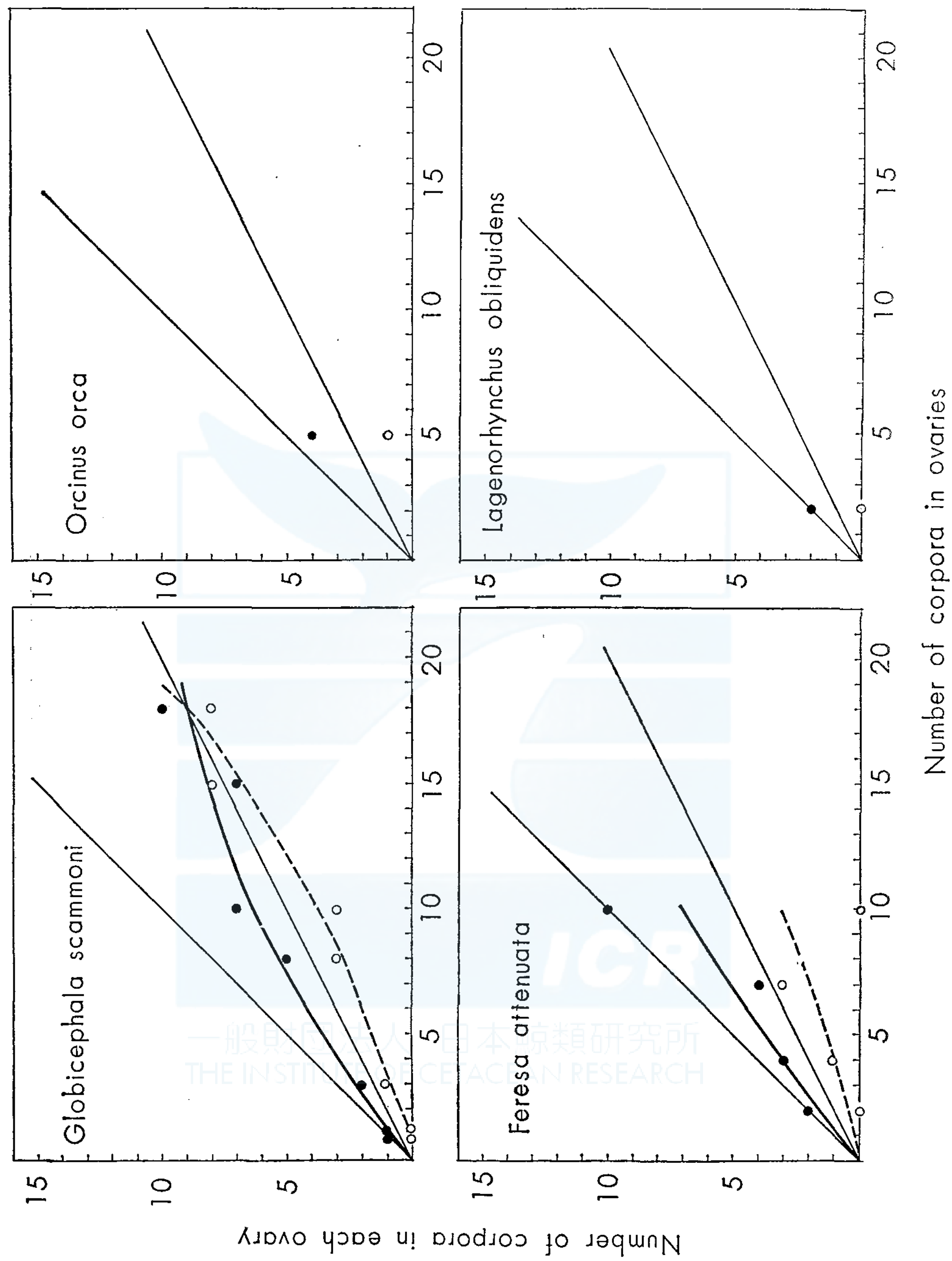


Fig. 4. Relative accumulation of corpora in the left and right ovaries on *Delphinapterus leucus*, *Phocaenoides dalli*, *Grampus griseus* and *Globicephala melaena*.

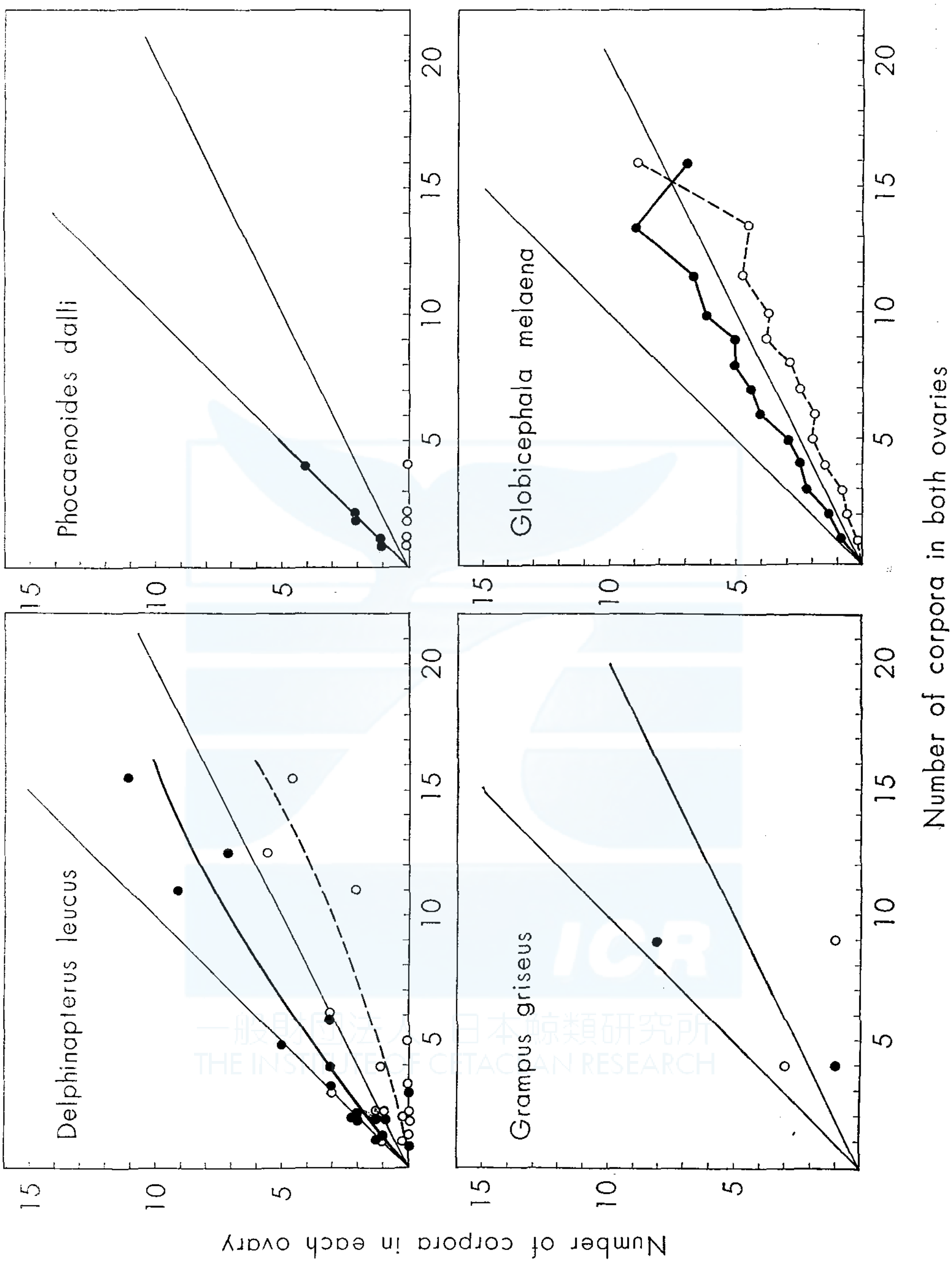


Fig. 5. Relative accumulation of corpora in the left and right ovaries on *Globicephala scammoni*, *Orcinus orca*, *Feresa attenuata* and *Lagenorhynchus obliquidens*.

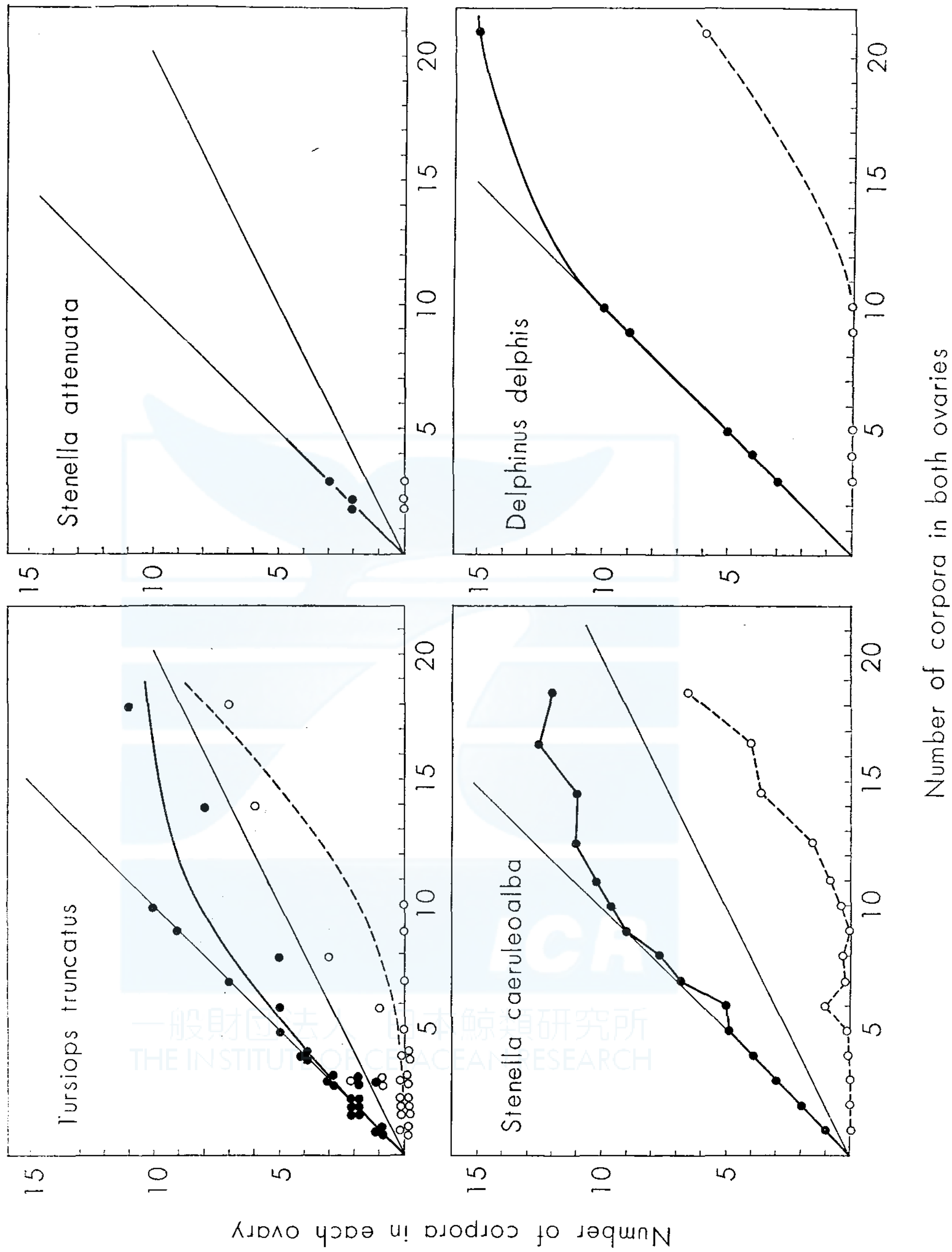


Fig. 6. Relative accumulation of corpora in the left and rgiht ovaries on *Tursiops truncatus*, *Stenella attenuata*, *S. caeruleoalba* and *Delphinus delphis*.

Balaenoptera acutorostrata

I have only two materials. But as shown in Fig. 2, the maturity and corpora accumulation is seemed to show the same type as the above species.

Megaptera novaeangliae

I used the ovaries materials from the Antarctic and the North Pacific. In the total of 100 individuals, 53.4% of corpora accumulate in the left ovary. The left ovary attaines to maturity by 5 corpora in the right ovary, and the right ovary attaines to maturity by 4 corpora in the left ovary. But in average, as shown in Fig. 2, the left and right ovaries are almost the same in the maturity and relative accumulation of corpora.

Eubalaena glacialis

By 1963, 11 right whales were killed by Japan in the North Pacific on the special permission of scientific research. Among them female whales are 4. The ovaries of one of the females were entirely immature and no follicle was seen on their surface (Omura, 1958). The ovaries of the second female are seemed to be prepuberal, because one follicle of which diametre is 3.8 cm is seen in the left ovary but there is not difference in the size between the both ovaries (Left: 30.0 × 12.0 cm, Right: 31.0 × 11.5 cm), and they are considered to be almost the same stage from the observation by naked eye. Other two females are both pregnant. One individual has only one corpus luteum in the right ovary and there is no corpus albicans in both ovaries. The other individual has one corpus luteum in the left ovary and two corpora albicantia in the right ovary.

Matthews (1938) reported that No. 1019 right whale in the southern hemisphere had one corpus luteum and 6 corpora albicantia in one side of ovary, and has 6 corpora albicantia in the other side of ovary.

Although I have small data on this species, and it is difficult to conclude, I estimate that maurity and relative corpora accumulation are the same in average between the both ovaries like the above 6 species.

Physeter catodon

Materials were obtained in the coast of Japan. In the total 298 whales, 51.6% of corpora accumulate in the left ovaries. From this point, we can estimate that ovulation occures equally from the both sides of ovaries. Appendix-Table 6 shows the distribution of corpora in the left ovary. Each ovary attaines to maturity by 5 coprora accumulate in the other side of ovaries. Deviation of corpora is not so wide even if in the old stages. As shown in Fig. 3, the maturity and relative accumulation rate of corpora is seemed to be equall in the both side of ovaries like as ***MYSTACOCETI.***

Kogia sp.

A *Kogia* was caught in a coast of Japan. Dr. M. Nakajima investigated and collected many materials on the species, but it is not yet identified. This individual has 6 corpora albicantia in the left ovary and 7 corpora albicantia in the right ovary.

I have only one material, but I estimate that this species will be the same tendency as *Physeter catodon.*

Berardius bairdii

13 individuals were examined the corpoa counts separating the left and right ovaries. 47 corpora (47.5%) accumulated in the left ovary. Although the materials are not so many, we can estimate the maturity and relative accumulation will be the same between the both ovaries.

Ziphius cavirostris

I have only two materials from the coast of Japan. And Kenyon (1961) describes that one corpus albicans accumulated in each ovary of a female. Consideraing the above data and Fig. 3, I estimate that the tendency of maturity and corpora accumulation will be the same as *Physeter.*

Delphinapterus leucus

In the total corpora, 68.9–70.8% of corpora accumulate in the left ovary, and apparently the ovulations from the left ovary exceed those from the right side.

As shown in Fig. 4, there is an individual of which right ovary is still immature when 5 corpora accumulate in the left ovary. On the contrary, there is an individual of which left ovary is still immature when 3 corpora accumulate in the right ovary. The right ovary in average attaines to maturity later than the left ovary, but the deviation is not so much. Relative accumulation rate in the right ovary is somewhat lower than that in the left ovary in younger stage, but the deviation of corpora accumulation between the both ovaries seems to become shorter gradually.

Phocaenoides dalli

There are 5 paires of ovaries taken in the coast of Japan.

Unfortunately they are all relatively young stage (the oldest individual has only 4 corpora in the both ovaries), and data are given from only 5 individuals. Therefore, conclusion will be not introduced, but all corpora accumulate from the left ovary. Right ovary is still immature, when 4 corpora accumulate in the left ovary. And the size of ovary is smaller in the right ovary than in the left ovary.

Grampus griseus

One individual has one corpus albicans in the left ovary and one corp. luteum and two corp. albicantia in the right ovary, whereas the other individual has one corp. luteum and 7 corp. albicantia in the left ovary and one corp. albicans in the right ovary. Then, 69.2% of corpora accumulate in the left ovary.

Globicephala melaena

In total corpora, 65.5% of corpora accumulate in the left ovary, therefore ovulation occures more frequently from the left ovary than from the right ovary.

Left ovary attaines to maturity by the time when 9 corpora accumulate in the right ovary, on the contrary, there is an individual of which right ovary is immature when 9 corpora accumulate in the left overy. As shown in Appendix-Table 7. there are many individuals of which left ovary is mature but the right ovary is still immature.

Fig. 5 shows the average corpora in the left and right ovaries in each total corpora class. From this figure relative corpora accumulation in the left ovary exceeds that in the right ovary.

Globicephala scammoni

I have only 7 data on the corpora count on this species. Considering Fig. 5, the relative accumulation curve is similar with that of *Globicephala melaena.* 58.9% of corpora accumulate in the left ovary.

Orcinus orca

I have only one corpora count on this species. One corpus luteum and 3 corpora albicantia accumulate in the left ovary and one corp. albicans exists in the right ovary. Assuming from only this specimen, this species is included into the similar type as *Globicephala.*

Feresa attenuata

There is an individual of which right ovary is still immature when 10 corpora accumulate in the left ovary. However, in total corpora, 82.6% of corpora accumulate in the left ovary. Although there are scanty of data, the relative corpora accumulation will be similar with that of *Globicephala.*

Lagenorhynchus obliquidens

I have only one material. This individual has two corpora albicantia in the left ovary, but the right ovary is still immature.

Tursiops truncatus

Zoological name of this species caught in the coast of Japan must be studied further, but I used it as *T. truncatus* according to Ogawa (1938).

82.8% of corpora accumulate in the left ovary, and all left ovaries are mature in the materials, but mature right ovary appears from the time when 3 corpora accumulate in the left ovary. And there is an individual of which right ovary is immature when 10 corpora accumulate in the left ovary. From Fig. 5, it will be assumed that the left ovary attaines at maturity first, and in younger stage ovulation occures in average from only the left ovary. Then, after attainment of later maturity of the right ovary, relative corpora accumulation rate of the right ovary will be larger than the left ovary.

Delphinus delphis

Of total individual, 88.5% corpora accumulate in the left ovary. In 5 individuals of total 11 corpora only the left ovaries are mature. The other individual has 15 corpora albicantia in the left ovary and 6 corpora albicantia in the right ovary. From Fig. 6, it will be considered that the right ovary attaines to maturity by the time when about 10 corpora accumulate in the left ovary, after then relative accumulation rate will be more in the right ovary than in the left ovary.

Stenella attenuata

I have 3 corpora counts taken and kept in Japan. The data are scant and got from young animals, but all corpora accumulate in only the left ovary.

Stenella caeruleoalba

As many as 333 materials are obtained from the coast of Japan as shown in Appendix-Table 8.

There is no individual of which only left ovary is immature. On the other hand, there are many individuals of which right ovary is still immature by the time when 14 corpora accumulate in the left ovary. 93.4% of corpora accumulate in the left ovary in total corpora.

In average, ovarian maturity occures from the left ovary first, and until the time when about 9 corpora accumulate in the left ovary, the right ovary is still immature. But the right ovary is not immature for life. After the maturity of the right ovary, relative corpora-accumulation rate becomes more in the right ovary than in the left ovary.

TYPES OF CORPORA ACCUMULATION IN BOTH SIDES OF OVARIES

Considering the relative corpora-accumulation curves, we can classify them into three kinds of types for 23 kinds of Cetacean species.

Type I: Left and right ovaries attaines to maturity almost the same time in average, and there is no difference in the relative accumulation rate of cropora between the left and right ovary. Following 10 species are considered to be included into this kind of type: *Balaenoptera musculus*, *B. physalus*, *B. edeni*, *B. borealis*, *B. acutorostrata*, *Magaptera novaeangliae*, *Eubalaena glacialis*, *Physeter catodon*, *Berardius bairdii*, and *Ziphius cavirostris*. I have only one *Kogia sp.* of which ovaries are examined. So, it is dangerous to conclude, but I consider that this species is also included in Type I.

Type II: Maturity of right ovary is attained somewhat later than the left. Relative accumulation rate of corpora in the left ovary is more than that in the right during young stage, but the difference between the left and right ovaries is not so much. In older stage, relative accumulation rate of corpora in right ovary exceeds that of the left ovary. Following 4 species are considered to be included into Type II: *Delphinapterus leucus*, *Globicephala melaena*, *G. scammoni* and *Feresa attenuata*.

Owing to the deficiency of samples, I could not determine the type of cropora accumulation for *Grampus griseus* and *Orcinus orca*. But I presumably consider they are also included into this kind of type.

Type III: Remarkable difference of corpora-accumulation rate occures between the left and right ovaries. Left ovary attaines to maturity earlier than the right. And for relatively long time, ovulation occures from only left ovary. But after attainment of maturity of right ovary, the ovulation from right ovary becomes more frequently than the left. Following 5 species are considered to be included into this type: *Phocaenoides dalli*, *Tursiops truncatus*, *Delphinus delphis*, *Stenella attenuata* and *S. caeruleoalba*.

On *Lagenorhuchs obliquidens*, I have only one material, so I hesitate to conclude that this species is included in Type III, but I think it is possible.

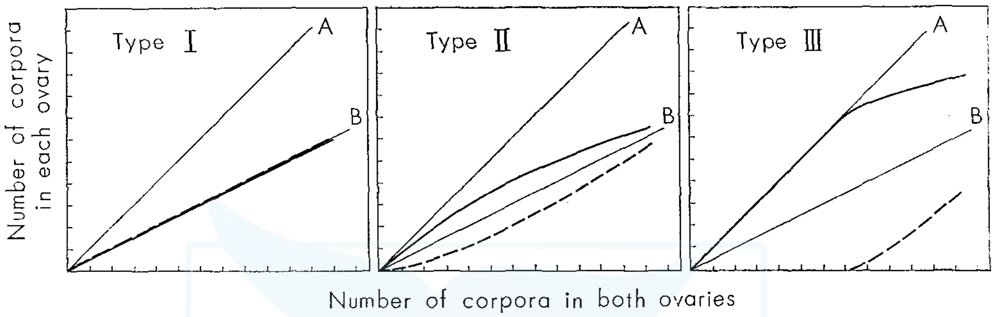


Fig. 7. Schematic figures of the three kinds of types of relative corpora accumulation in the left and right ovaries of cetacea.
Broad solid line: Left ovary, Broad broken line: Right ovary, A-line: Ovulation occures from only one side of ovaries, B-line: Both ovaries attains to sexual maturity in the same time and ovulation occures equally from both sides of ovaries.

Table 2 shows the accumulation type and the per cent of number of ovulations (number of corpora lutea and albicantia) from the left ovaries to total ovulations from both ovaries for 23 species of **CETACEA** examined. As shown in the previous figures, such percents must be variable according to the variation of age distribution, especially in Types II and III. For instance, in *Stenella caeruleoalba*, if we collect only young animals, the percentage of ovulation in the left ovary is near 100%. On the contrary, if we collect only older animals, the percentage decrines remarkably. Therefore, I want to emphasize on this phenomenon. Previous workers reported percentage of the existance of fetuses in left or right uterine cornu (Sleptsov, 1940; Slijper, 1949 etc.) or percentage of number of corpora in left or right (Laws, 1961; Sergeant, 1962). But I think they did not consider the above phenomenon.

Nevertheless, as shown in Table 2, the percentages of total ovulation from left ovary to that from both ovaries are seemed to have relation with the types of corpora accumulation. That is to say, it is as a matter of course, the percentages of ovulation from left ovary are distributed between 45 and 55% in 11 species of Type I. They are 52.0% in average. In Type II, percentages of ovulation from the left ovary are distributed between 58 and 83% for 6 species. They are apparently separate from the values of Type I. And in average 65.9% of ovulations occures from the left ovaries on the 6 species.

Type-III species have much percentage of ovulation from the left ovaries. The range of the ratios is between 82 and 100% and the average is calculated as 92.7% for the 6 species.

I consider that if we have only material on the distribution of corpora in left and right ovary or the percentage of foetal existence in the left or right uterine cornu on one species, we can estimate briefly in what kind of corpora-accumulation type the animal is classified.

TABLE 2. TYPES OF CORPORA ACCUMULATION AND TOTAL NUMBER OF CORPORA

Species	No. of specimens	No. of Type	No. of total corpora Left	Right	L%*
Balaenoptera musculus	57	I	755	172	47.4
——*physalus*	297	I	1056	981	51.9
——*edeni*	54	I	147	155	48.7
——*borealis*	80	I	350	354	49.7
——*acutorostrata*	2	I	19	16	59.3
Megaptera novaeangliae	100	I	198	173	53.4
Eubalaena glacialis	3	I	7–8	9–10	41.2–47.1
Physeter catodon	298	I	909	853	51.6
Kogia sp.	1	I?	6	7	46.2
Berardius bairdii	13	I	47	52	47.5
Ziphius cavirostris	3	I	7	6	53.8
Delphinapterus leucus	16	II	51	21–23	68.9–70.8
Phocaenoides dalli	5	III	10	0	100.0
Grampus griseus	2	II?	9	4	69.2
Globicephala melaena	173	II	607	320	65.5
——*scammoni*	7	II	33	33	58.9
Orcinus orca	1	II?	4	1	80.0
Feresa attenuata	4	II	19	4	82.6
Lagenorhynchus obliquidens	1	III?	2	0	100.0
Tursiops truncatus	26	III	101	21	82.8
Delphinus delphis	6	III	46	6	88.5
Stenella attenuata	3	III	7	0	100.0
——*caeruleoalba*	333	III	1750	123	93.4

* Per cent of number of corpora in the left ovary to total corpora in both ovaries.

TAXONOMIC CONSIDERATION ON THE TYPES OF RELATIVE CORPORA ACCUMULATION IN CETACEA

In the previous chaper, I classified the relative corpora-accumulation curves into three kinds of types.

Among 23 species examined, there are only three genera in which more than two species are included (*Balaenoptera*, *Globicephala* and *Stenella*). But we can find that the sepcies included in same genus show the same type of corpora accumulation. Then, I arrange genera of living **CETACEA** in Table 3. Types of corpora accumulation and the combination of genera by Flower & Lydekker (1891), Winge (1918), Fraser (1938), Simpson (1945) and Nishiwaki (1963, 1964) are also recorded in this table.

To my regret, I could not examine the types of corpora accumulation on all

TABLE 3. TYPES OF CORPORA ACCUMULATION AND THE CONBINATION OF GENERA IN LIVING CETACEA BY FIVE AUTHORS

Genus	Type	Flower & Lydekker (1891)		Winge (1918)			Fraser (1938)		Simpson (1945)			Nishiwaki (1963-64)
Balaenoptera	I						Balaenopteridae			Balaenopteridae		
Megaptera	I			Balaenopterini								
Rhachianectus							Rhachianectidae			Rhachianectidae		
Neobalaena			Balaenidae			Balaenidae						
Eubalaena	I			Balaenini			Balaenidae			Balaenidae		
Balaena												
Physeter	I	Physeterinae		Physeteres-Physeterini			Physeteridae		Physeterinae	Physeteridae		Physeteridae
Kogia	I?								Koghinae			Kogiidae
Hyperoodon			Physeteridae	Hyperodontes		Physeteridae					Physeteraidae	
Berardius	I											
Ziphius	I	Ziphiinae			Ziphiini		Ziphiidae			Ziphiidae		Ziphiidae
Tasmacetus				Ziphii								
Mesoplodon												
Pontopoia										Stenodelphis		
Lipotes			Platanistidae				Platanistidae					Platanistidae
Inia						Platanistidae				Iniinae	Platanistidae-Platanistinoidae	
Platanista										Platanistinae		
Monodon				Monodontes			Delphinapterinae			Monodontidae		Monodontidae
Delphinapterus	II											
Neophocaena												
Phocoena				Phocaenae						Phocaenidae		Phocaenidae
Phocaenoides	III											
Orcaella								Delphinidae				Orcaellidae
Grampus	II?	Group A									Delphinoidae	Grampidae
Globicephala	II			Globicipites								
Orcinus	II?											Globicephalidae
Pseudorca						Delphinidae	Delphininae					
Feresa	II											
Lissodelphis			Delphinidae							Delphinoidae		
Lagenorhynchus	III?			Lagenorhynchii								
Tursiops	III											
Delphinus	III											Delphinidae
Steno		Group B		Delphini								
Stenella	III											
Sotalia												

living genera. Especially there is no material on RHACHIANECTIDAE and PLATANISTITIDAE. Now, three genera belonged to ***MYSTICETI*** are all included into Type I, and I guess all species of ***MYSTICETI*** has Type I corpora accumulation. In other words, we cannot divide ***MYSTICETI*** more than one group by only the corpora-acumulation curve.

On the contrary, ***ODONTOCETI*** are able to be divided at least three types by the corpora accumulation. *Physeter*, *Kogia*, *Berardius* and *Ziphius* are included into Type I. And Slijper (1958)'s discription must be added that in ***ODONTOCETI***, there are some species of which foetus may develope in either horn. By the way, recently many authors use the same the classification as Fraser (1938), that is, *Physeter* and *Kogia* are classified into PHYSETERIDAE and *Berardius, Hyperoodon, Ziphius, Tasmacetus* and *Mesoplodon* are classified into another family of ZIPHIIDAE. But Flower & Lydekker (1891) and Winge (1918) recognized they are belonged to subfamily of PHYSETERIDAE. And Simpson (1945) established Superfamily PHYSETEROIDEA combining PHYSETERIDAE and ZIPHIIDAE. The phenomena in corpora accumulation will support the taxonomic interrelationship between PHYSETERIDAE and ZIPHIIDAE.

I cannot show the type of corpora accumulation for PLATANISTIDAE. Abel (1913) made special researches on the fossil **CETACEA,** and he tried to determine their position to recent forms. According his genealogical tree, PLATANISTIDAE is included into ***SQUALOCETI*** with PHYSETERIDAE and ZIPHIIDAE. But Slijper (1936) shows that from primitive SQUALODONTIDAE separate four branchs of ***ODONTOCETI,*** and one of branches becomes to PLATANISTIDAE and PHYSETERIDAE. ZIPHIIDAE become from the second branch and DELPHINIDAE from the third branch. It is very interesting taxonomically that whether corpora accumulation shows Type I or the fourth type in PLATANISTIDAE.

Superfamily *DELPHINOIDEA* classified by Simpson (1945) and family DELPHINIDAE classified by Flower & Lydekker (1891), Winge (1918) and Fraser (1938) etc. does not show Type I. From this point of view, we will understand that so called DELPHINIDAE can be separated phylogenically from ***MISTICETI*** and *PHYSETEROIDEA*.

However, there are at least two types of species in *DELPHINOIDEA* by the examination on the corpora accumulation rate. That is to say, *Delphinapterus, Grampus, Globicephala, Orcinus,* and *Feresa* show Type II, on the contrary, *Phocaenoides, Lagenorhynchus Tursiops, Delphinus* and *Stenella* are considered to be included into Type III. Flower & Lydekker (1891) separated DELPHINIDAE into Groups A and B. The species included in Group B show Type III, but in Group A there are two types of corpora accumulation. Winge (1918) describes that DELPHINIDAE is divided into five subfamily; Monodontes, Phocaenae, Globicipites, Lagenorhynchi and Delphini, This classification is not contradictory to my result. Fraser (1938)'s classification of subfamily Delphininae which is widely used today is considered to be too large as Nishiwaki (1963) reported. Slijper (1936) and Simpson (1945) divided Delephininae by Fraser

(1938) into two families PHOCAENIDAE and DELPHINIDAE but their DELPHINIDAE must be divided at least two kinds from the view point of my typing of corpora accumulation. Recently Nishiwaki (1963, 1964) compared body lengths, number of vertebrae, fused bone in cervical vertebrae, shape of skull, number maxillary teeth and length of rostrum for 12 genera of ***ODONTOCETI,*** and he separated living ***ODONTOSETI*** into 10 families as shown in Table 3.

I have no data on the ovaries count for *Orcaella*, *Noephocaena*, *Phocaena Pseudorca* and *Lissodelphis* and I cannot conclude the typing of corpora accumualtion for *Grampus*. Excluding these 7 genera, the typing of corpora accumualtion agrees well with Nishiwaki's description. And on the standing point of only corpora accumulation, MONODONTIDAE and GLOBICEPHALIDAE is taxonomically near each other, because they show Type II of corpora accumulation, the other hand, PHOCAENIDAE (PHOCAENEA) and DELPHINIDAE (LAGENORHYNCHI and DELPHINI) show another type of corpora accumulation (Type III). They seem to be somewhat separated taxonomically from MONODONTIDAE and GLOBICEPHALIDAE. But, I consider that the difference between Type II and III is not so substantial as Type I. So, to my opinion, superfamily DELPHINOIDEA is needful for the classification of DELPHINIDAE-type species.

DISCUSSION

In DELPHINIDAE, especially Type III group, left ovary attaines at maturity first, and ovulations occure only from the left ovary in young generation, but after the right ovary attains at maturity, ovulations occure more frequently from the right ovary than from the left ovary. Such a phenomenon is interesting for the physiology of reproduction. The mechanism of control for maturity and ovulation in the each ovaries must be studied in future. As morphological approach, distribution of blood vessels and nerves, thickness of coatical layer of each ovary and their change according to age should be researched for the settlement of the mechanism.

It is notable that in the males both testes are almost equally mature and the difference of weight between both testes is very slight in the case of DELPHINIDAE so far as I investigated. Then, it is interesting why in the only females maturity and ovulations are different between each sides of ovaries. Ontogenical comparison is needful on the reproductive organs between both sexes for solution of this problem.

The asymmetry of maturity and ovulation in DELPHINIDAE is considered to be related to the asymmetry of skull of ***ODONTOCETI***, but PHYSETEROIDEA has same ovulatory pattern as ***MYSTICETI*** although the skull of it is asymmetry like DELPHINIDAE.

In the previous chapter I discussed the interrelationship between corpora-accumulation types and the taxomic position of **CETACEA,** and I found ovulatory pattern is related with the taxonomic status of the animals. Johnson & Ostenson (1959) describes that " modern taxonomic studies on specific and above must be based on more than simple morphologic comparison when complex relationships are involved. Further research into their biologic nature is necessary". And they showed several taxonomic methods. As one of modern morphologic comparisons, they showed the genital tracts and foetal menbranes reported by Mossman (1953). I believe in fact that the total biologic relationship and not any single taxonomic criterion is important as Johnson & Ostenson described. And the comparison of corpora-accumulation rate will be useful as one of the taxonomic criteria. For this purpose, we must gather more material on all species. Especially we have no or very small materials on PLATANISTIDAE and PHOCAENIDAE. I must say that comparison of corpora accumulation is only one method of taxonomical approaches and many other biological relationships are needful for the complete attainement to truth.

SUMMARY

1. Comparison of maturity and accumulation of corpora between the left and right ovaries is studied for 23 species of **CETACEA.**

2. Accumulation curves of **CETACEA** so far as investigated are classified into three kinds of types.

3. Type I: Maturity and ovulation occures from both ovaries equally. Following species are considered to be included in this kind of type:
Balaenoptera musculus, B. physalus, B. edeni, B. borealis, B. acutorostrata, Megaptera novaeangliae, Eubalaena glacialis, Physeter catodon, Kogia sp. Berardius bairdii and *Ziphius cavirostris.*

4. Type II: Corpora accumulation in the left ovary is rather more than the right in young stage. But the difference between both ovaries is not so much. Following species are considered to be included in Type II:
Delphinapterus leucus, Grampus griseus, Globicephala melaena, G. scammoni, Orcinus orca and *Feresa attenuata.*

5. Type III: For relatively long time, ovulation occures only from the left ovary, but after attainement of maturity of the right ovary, corpora accumulation of the right ovary becomes more frequently than the left. Following species are included into this type: *Phocaenoides dalli, Lagenorhychus obliquidens, Tursiops truncatus, Delphinus delphis, Stenella attenuata,* and *S. caeruleoalba.*

6. As regards the percentage of distribution of corpora in the left ovary, range and average values of above three types are counted as follows:

	Range (%)	Average (%)
Type I	45–55	52.0
Type II	58–83	65.6
Type III	82–100	92.7

7. Corpora accumulation in ***MYSTICETI*** and *PHYSETEROIDAE* is classified into Type I. On the contrary, DEPHINIDAE *seusu lato* shows other types, and they should be separated into at least two classification by consideration of corpora-accumulation types.

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APPENDIX. RELATION OF THE NUMBER OF CORPORA BETWEEN THE BOTH OVARIES AND THE LEFT OVARY

B: Number of corpora in the both ovaries.
L: Number of corpora in the left ovary.

TABLE 1. BALAENOPTERA MUSCULUS

L\B	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
0	2	2												4
1	5	1	2	3	—	1								12
2		1	1	7	2	1	1	2	1					16
3			—	1	2	—	1	2	2					8
4				—	—	3	1	2	—	—	2			8
5					—	—	—	1	2					3
6						—	1	—	—	—	—	1	1	3
7							—	—	1	—	—	—	1	2
8								—	—	—	1	—	—	1
Total	7	4	3	11	4	5	4	7	6	—	3	1	2	57

TABLE 2. BALAENOPTERA EDENI

L\B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
0	2	1	2													6
1	3	6	5	1	1											16
2		1	—	3	1	1	—	1								7
3			1	4	1	—	1	—	1	1	—	—	1			10
4					1	1	—	—	1	—	—	—	—	1		4
5						1	—	—	—	—	1					2
6							1	—	1	—	—	1	—	1		4
7								1	—	—	—	—	1	—	1	3
8													1	1		2
Total	6	8	8	8	4	3	2	2	3	1	1	1	3	3	1	54

TABLE 3. BALAENOPTERA BOREALIS

L\B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
0	1	2	1	1																	5
1	2	1	2	—	2	—	1														8
2		2	4																		6
3			1	1	3	—	2	2	4												13
4					1	—	1	3	5	3	1	1									15
5							1	2	2	—	1	—	2								8
6								2	1	—	2	2	1	1	—	1					10
7												2	1								3
8												1	1	—	—	—	1	—	1		4
9														1	—	1	1	—	—	1	4
10															1	—	1	—	1		3
11																					—
12																			1		1
Total	3	5	8	2	6	—	5	9	12	3	4	6	5	2	1	2	3	—	3	1	80

TABLE 4. BALAENOPTERA PHYSALUS

L\B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	18	20	21	22	23	24	25	26	27	28	29	30	35	47	69	Total
0	12	8	1																															21
1	21	24	19	7	5	2	1	—	—	—	1																							80
2		8	12	15	6	7	3	1																										52
3			6	8	9	5	2	2	5	—	1	—	—	—	1	1																		40
4				2	3	3	9	3	4	—	1	—	1	1																				27
5					2	—	2	5	3	1	4	3	2																					22
6								2	—	2	1	3	—	1	—	—	—	—	1															10
7								1	1	—	1	2	—	—	1	—	—	—	—	—	—	1												7
8									1	—	2	3	4	—	—	—	1	—	1															12
9												1	1	3	—	—	—	1	—	—	—	—	—	—	—	1								7
10													1	—	1	—	1	1	—	—	—	1												5
11															1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1				3
12																	1	1	—	—	—	1	—	—	1									4
13																																		—
14																	1																	1
15																								1										1
16																											1							1
17																																		—
18																											1	—	—	—	1			2
19																																1		1
35																																	1	1
Total	33	40	38	32	25	17	17	14	14	3	11	11	9	5	4	2	4	3	2	—	—	3	—	1	1	1	2	—	—	1	1	1	1	297

TABLE 5. MEGAPTERA NOVAEANGLIAE

L\B	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
0	9	2	1	1										13
1	13	11	5	3	1									33
2		7	7	2	4	1	1							22
3			2	5	3	4	2	—	1					17
4					2	3	2							7
5							2	—	2	—	—	1	1	6
6										1	1			2
Total	22	20	15	11	10	8	7	—	3	1	1	1	1	100

TABLE 6. PHYSETER CATODON

L\B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	24	25	37	Total
0	7	5	2	2																	16
1	12	16	16	7	1	1															53
2		5	26	26	13	6	5														81
3			4	11	11	7	11	6	7												57
4				2	3	8	5	7	4	2	2	1									34
5						2	2	5	3	4	1	2	—	—	—	—	1				20
6							2	1	1	2	1	5	2								14
7									1	1	1	—	2	2	2						9
8									1	—	1	—	—	1	1	1					5
9													2	1	2						5
10											1										1
11																					—
12																			1		1
13																		1			1
20																				1	1
Total	19	26	48	48	28	24	25	19	17	9	7	8	6	4	5	1	1	1	1	1	298

TABLE 7. GLOBICEPHALA MELAENA

L\B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
0	3	1	1	2	—	—	—	1							8
1	20	6	2	3	—	1	1								33
2		5	17	3	—	—	1								26
3			10	4	7	2	2	1	2						28
4				6	3	2	3	—	3						17
5					6	6	6	3	3	2	1		1		27
6							3	6	4	4	1	2	1		21
7							1	1	—	1	—	1			5
8												3			3
9									1	1					2
10													1	1	2
11															—
12													1		1
Total	23	12	30	18	16	11	17	12	13	8	2	6	4	1	173

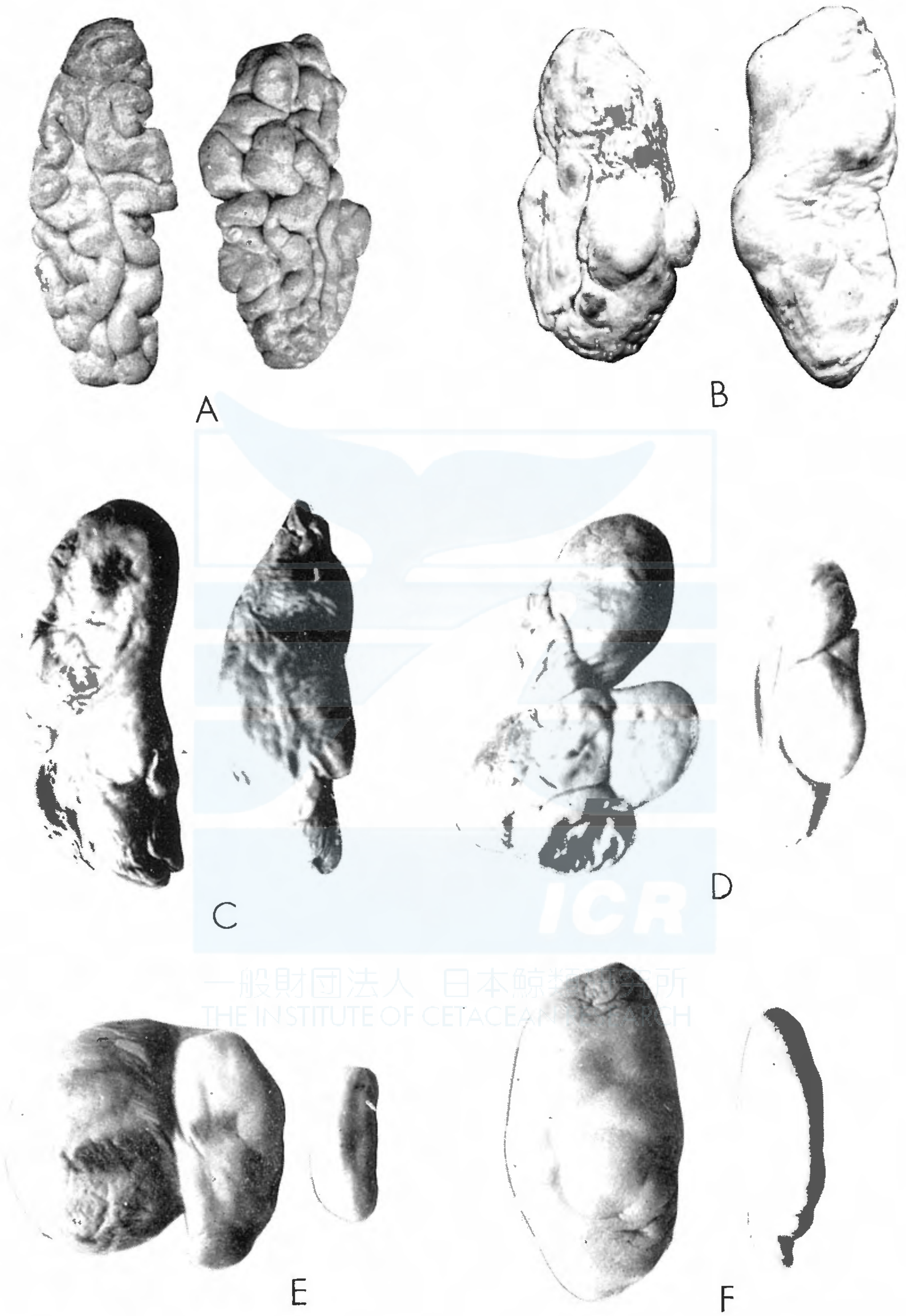
TABLE 8. STENELLA CAERULEOALBA

L\B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total
0																						—
1	33	1																				34
2		38	—	1																		39
3			44	1	1																	46
4				38	1																	39
5					41	1	1															43
6						24	2	3	—	1	—	1										31
7							19	1	—	—	—	—	—	—	1							21
8								19	—	—	2	1										22
9									14	1	—	—	1	—	1							17
10										10	2	1	—	1	2	—	1					17
11											5	1	—	—	—	2	—	1				9
12												4	1	—	—	—	—	1				6
13													2	1	—	—	—	—	1			4
14														2	1							3
15																						—
16																	1	—	—	—	1	2
Total	33	39	44	40	43	25	22	23	14	12	9	8	4	4	4	3	2	2	1	—	1	333

EXPLANATION OF PLATE

Left side shows the left ovary and the right side shows right ovary in each figure. Numbers of corpora are shown as follows ; a-b : a is the number of corpora lutea, and b is the number of corpora albicantia.

A:	*Balaenoptera physolus*, L: 0–6, R: 0–9	(×0.17)
B:	*Physeter catodon*, L: 0–3, R: 0–2	(×0.33)
C:	*Kogia sp.*, L: 0–6, R: 0–7	(×1.1)
D:	*Feresa attenuata*, L: 0–3, R: 0–1	(×1.1)
E:	*Phocaenoides dalli*, L: 1–1, R: 0–0	(×1.3)
F:	*Stenella caeruleoalba*, L: 0–2, R: 0–0	(×1.4)


A
B
C
D
E
F