THE TWINNING IN SOUTHERN FIN WHALES

SEIJI KIMURA

The study on twinning gives many interesting problems to embryology, morphology, genetics and many other branches of zoology. But the reports on twinning in whales have been often fragmentary (Haldane, 1910; Risting, 1925; Wheeler, 1930; Matsuura, 1936, 1940; Paulsen, 1939; Omura, 1942; Brinkmann, 1948; Slijper, 1949). Most of them discuss the frequency of twins, though Matsuura (1940) attempted to analysis the monozygotic twins (EZ) and dizygotic twins (TZ) in blue and fin whales by means of Weinberg's differencial method, and Slijper presumed the relation between frequency of twins and the age of their mother.

The reason, why twinning studies in whales remain in primitive stage, is attributed to rare chances to get materials, and besides it is also one of the reasons that we have no necessity to consider their application to the whales research problem.

I consider, however, that the study of twinning is one of the ways in whales-population investigations. For example, the frequency of twins differs in races of man. This fact will be applied to distinguish the populations of whales. And the morphological study of EZ, TZ and multiple foetuses is the most effective means to catch hereditary characters of whales, of which brothers or sisters cannot be caught. We must consider the application of it to determine populations of whales. The study on number of ovulations in whales is a subject to be solved as a base of the age determination with corpora lutea in ovaries, and the study of twins will give suggestion to it. Furthermore, it has been known in humankind and some domestic animals that the occurrence of twins relates to ages of their mothers, so twin studies will confirm age characters of whales.

I studied multiple foetuses of southern fin whales (*Balaenoptera physalus*, L.) statistically, using the data of biological investigation on Japanese whaling fleets in the Antarctic waters (Area V) from 1946/47 to 1954/55 seasons. And I also used International Whaling Statistics (1933/34–1952/53) for this study.

My sincere thanks are due to Mr. Setsuo Nishimoto of the Fisheries Agency, to whom I am indebted for the precious photographs shown in figures 2, 12 and 13. And I am much indebted to Dr. Hideo Omura, the President of the Whales Research Institute, who kindly read my draft and critisized it. Thanks are also due to Dr. Masaharu Nishiwaki of the Whales Research Institute, and Assistant Professor Takashi Hibiya

of the University of Tokyo for many valuable suggestions.

FREQUENCY OF TWINS

In connection with the great bulk of their babies, the whales are uniparous, and the frequency of multiplets is very low.

Now, table 1 shows the frequency of twins in some baleen whales which were got by three biologists. These values were got before the 2nd World War, and number of whales examined are not enough. Since the reopening of the Antarctic whaling, a number of whales have been caught there, and consequently number of examined whales increased suddenly, especially in fin and sei whales.

TABLE 1. FREQUENCY OF TWINS BY THREE REPORTERS IN BALEEN WHALES

Species	Risting ('27)	Paulsen ('37)	Matsuura ('40)
Blue	0.7%	0.68%	0.4%
Fin	0.7	0·93	0.9
Sei	—	1.09	0.7
Humpback	—	0.39	0.4

TABLE 2. FREQUENCY OF MULTIPLETS IN SEVERAL BALEEN WHALES FROM THE ANTARCTIC REGION

Species	Pregnant whales	Twins	Triplets	Quadri-plets	Quintu-plets	Sextu-plets	Multiplets total
Blue	19,057	148	9	0	0	0	157
		0.777%	**0.047**	**0.000**	**0.000**	**0.000**	**0.824**
Fin	39,947	328	13	4	1	2	348
		0.821%	**0.033**	**0.010**	**0.003**	**0.005**	**0.872**
Sei	1,098	25	0	0	0	0	25
		2.277%	**0.000**	**0.000**	**0.000**	**0.000**	**2.277**
Humpback	2,979	17	0	0	0	0	17
		0.571%	**0.000**	**0.000**	**0.000**	**0.000**	**0.571**

I calculated the frequency of multiple foetuses (the number of multiplet pregnancy in % of the total number of pregnant females) as shown in table 2, using the International Whaling Statistics (I.W.S.) from 1933/34 to 1952/53.

The frequency of twins varies with the species of whales, that is to say, it is the highest in sei whales, and it is next in fin whales, but the latter is a half of the former. It is slightly lower in blue whales than in fin whales. The frequency in humpback whales is the lowest and it is a quarter of that in sei whales. This ranking is the same of that by Paulsen (1939), though the values are different. On the other hand, these values are slightly higher in sei and blue whales than the values calculated by Matsuura (1940). On the fin whales, Paulsen, Matsuura and I get nearly the same value.

When I calculate the frequency of multiple foetuses on the year when number of pregnant fin whales is more than 500, 0.19 % is the lowest, and 1.28 % is the highest, and the most are near the mean, so we cannot see notable fluctuations in the years. The frequency of twins is almost constant in the same species of mammals, and the value which I got above seems to show this phenomenon. However, it has been well known that there are tolerable variation in various races or in locality of one species. In the 4006 pregnant fin whales caught by Japanese whaling fleets from 1946/47 to 1954/55 in the Antarctic Area V, 40 whales have multiple foetuses, therefore frequency of multiple foetuses is 0.999 %. This is slightly higher than the mean. According

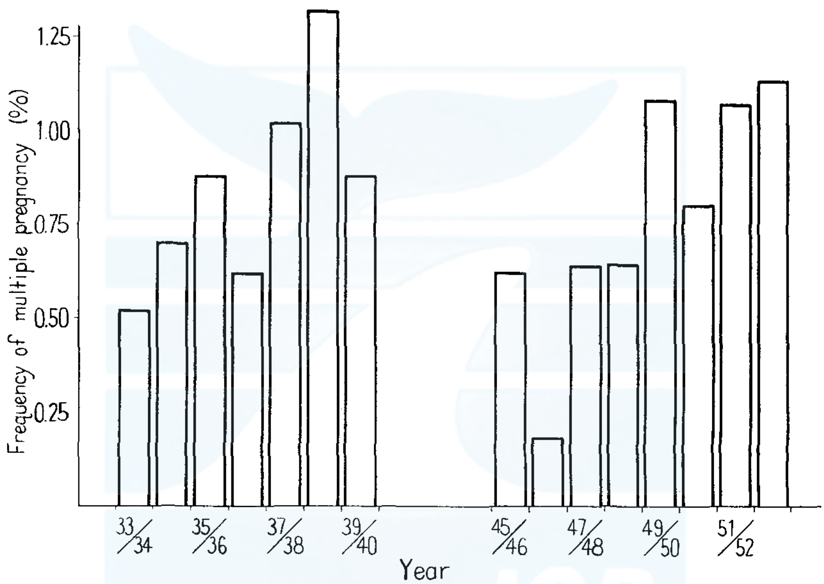

Fig. 1. Frequency of multiple pregnancy in the whaling seasons from 1933/34 to 1952/53.

to Brinkmann (1948), the frequency of twins is 1.93 % in the Antarctic Area II, III, and IV. This is considerably high, although it is calculated by the result in only one year, and so it is not final value. In order to solve the problem, we must get the frequency of twins in each areas.

In connection with the lowness of frequency of multiple foetuses in whales, it is noticed that they have only one pair of nipples. The relation between number of foetuses and number of nipples is already generally known.

Besides, it is known in sheep that those who intend to breed twins have more nipples than the normal. Therefore, whales have very suitable mammary organs for uniparous.

Pinnipedia, a sort of aquatic mammals, is uniparous, and has a pair of nipples, situated inguinally like Cetacea. In Sirenia there is a pair of axillary ones, but they occur practically upon the posterior border of the flippers (Howell, 1930). Probably it is an effect of adaptation for the aquatic life that typical aquatic mammals are uniparous and have only a pair of nipples.

DIFFERENTIATION OF MONOZYGOTIC (EZ) AND DIZYGOTIC TWINS (TZ)

It is well known in humankind that there are EZ and TZ. But they had believed until recent years that there was no EZ in domestic animals. But Kronacher (1932) corrected the mistakes by his study on cows.

About whales, Matsuura (1940) discussed the differentiation of EZ and TZ. He studied twins statistically by means of Weinberg's differencial method, and assumed that EZ were one ninth of total twins in fin whales, although he could not prove the evidence of EZ. It is regrettable that most of the report on multiple foetuses in the past are about only foetus length and sex, and the records to determine the differentiation of multiple foetuses such as condition of placenta and ovaries are seldom remained. Wheeler (1930), Matsuura (1940), Omura (1942) and Brinkmann (1948) noted the number of corpora lutea in ovaries. I think that the determination of the differentiation of EZ and TZ is easier and more exact in whales than in man and domestic mammals. Because, when we catch a whale, it is dissected directly, its uterus is opened, and we can observe placenta. Further more, by the removed ovaries we can confirm the result of ovulation. The differentiation of multiplets are naturally determined by the number of ovulated eggs. After ovulation, functional corpora lutea are formed, and they are clearly found in whales. Therefore, by the calculation of functional corpora lutea, we can determine the kind of multiplets. Mackintosh & Wheeler (1929) and Matsuura (1940) mentioned that it was considered that more than one egg might be formed in the same follicle. But I suppose that it will be almost ignored. My supposition is allowed by the fact that the twins of which mothers have one functional corpus luteum are all like-sexed. When two eggs are ovulated from two ovarian folliculs at the same time, and one of the two eggs is not fertilized and the other is fertilized into twins, there will be two functional corpora lutea in spite of EZ. Therefore, it must be strictly needful to examine the placenta. But I think that the differentiation of multiplets is practically determined by number of functional corpora lutea. When we determine the kind of multiplets by the functional corpora lutea, we can find EZ in the reports by Machintosh & Wheeler (1929), Matsuura (1940), Omura (1942), Brinkmann (1948) and Slijper (1949). And as stated below, EZ are also found in our materials.

TABLE 3. NUMBER OF LIKE- AND UNLIKE-SEXED TWINS

	♂♂	♂♀	♀♀	?
Number of pairs	94	102	86	4
Percent	33.3	36.2	30.5	—
Ratio to ♂♀	0.92	1.00	0.84	—

According to I.W.S. (1933/34–1950/51, 1952/53), the combination of sexes of twins in fin whales is shown in table 3.

If all the twins are TZ, ♂♂ : ♂♀ : ♀♀ must be equal to 0.5 : 1.0 : 0.5. Nevertheless, the value of like-sexed twins (♀♀, ♂♂) is higher than the theoretical value. This means that there are really EZ.

Weiberg's differential method is,

$$TZ=\frac{\text{unlike-sexed twins}}{2pq}$$

p : sex ratio of ♂
q : sex ratio of ♀

Now, in 23184 fin foetuses which are discovered and determined their sex in the Antarctic seasons from 1946/47 to 1952/53 (by I.W.S.), $p=50.59\ \%$ and $q=49.41\ \%$.

$$TZ=\frac{102}{2\times 0.5059\times 0.4941}$$

$$=204$$

Therefore, the percentage of TZ to total twins is

$$204/282\times 100=72.4\ \%$$

That is to say, a quarter of total twins is EZ. This value is higher than that calculated by Matsuura (1940).

According to Stern (1949), the ratio of EZ is 34.2 % in American white race, and is 28.9 % in American black race. The other hand, it is 72 % in Japanese.

Thus, the ratio of EZ and TZ in the twins in different in human races. So, such phenomena are supposed to be true in whales, too.

Table 4 shows the item of 40 multiplets discovered by Japanese whaling investigation in the Antarctic Area V from 1946/47 to 1954/55 (v. appendix). By the number of functional corpora lutea, the difference of twins was judged. One example of EZ is shown in figure 2.

The ratio of EZ to total twins is 42.9 %, and this is higher than that which was calculated statistically. And when we calculate the ratio of

TABLE 4. EXAMPLE OF MULTIPLE FOETUSES IN THE ANTARCTIC AREA V

Twins								
EZ		TZ				?	Triplets	Quadri-plet
♂♂	♀♀	♂♂	♂♀	♀♀	?	♂♂		
6	8	2	12	5	1	3	2	1
43.6%	56.4	10.0	60.0	25.0	5.0	—	—	—

Fig. 2. Monozygotic twin foetuses of a southern fin whale (*Balaenoptera physalus*, L.) and the ovaries of their mother. Individuals of No. 25 in appendix.

Male 3′10″ Male 3′10″

Number of corpora lutea

5 { Left 1+2
Right 0+2

(Photo. by Mr. Setsuo Nishimoto)

EZ in the Antarctic Area II, III, and IV by the report of Brinkmann (1948), it is 1/11 (9.0 %). This is very low value.

Regarding the sex ratio of twins (Table 4), ♂♂:♂♀:♀♀=33.3 %: 36.2 %:30.5 %, that is to say, ♂♂ is more than ♀♀. And ♂:♀=51.4 %: 48.6 %. But in the twins of the Area V, ♂♂:♂♀:♀♀=30.5 %:33.4 %: 36.1 %, and ♂:♀=47.2%:52.8 %. Therefore, ♀ is more than ♂.

About the sex ratio of EZ, ♂♂:♀♀=43.6 %:56.4 %. This differs a little from the theoretical value (♂:♀=50 %:50 %).

About the combination of sex in TZ, ♂♂:♂♀:♀♀=2:12:15=10.5 %: 63.2%:26.3%. However, theoretically, ♂♂:♂♀:♀♀=25 % : 50 % : 25 %. So, in our investigation the ratio of ♂♂ is especially low. But as the three examples which are not able to be determined their kinds are all ♂♂, the ratio of ♂♂ will really increase in EZ or TZ.

GROWTH OF TWINS

In the uniparous mammals, multiplet pregnancy will be abnormal in many points. Therefore multiplet pregnancy shows a little morbid tendency, and progress of its pregnancy is more restricted than that of usual pregnancy. The frequency of early birth and abortion is more in multiplet pregnancy than in the normal pregnancy. In man, this fact is well known.

According to Hervitt (1934), in cattle, twins are little lighter than normal baby when they are born. Apart from abortion, the rate of still-birth is the same as that of normal birth. And the pregnant period of twins is 8–10 days shorter than the normal.

In whales, it is difficult to know the rate of abortion, rate of still-birth, pregnant period and growth of foetuses.

In order to search for the rate of abortion, I calculated the frequency of multiple foetuses (number of multiplets/number of total foetuses) with the body length classes of discovered foetuses which had been reported in I.W.S. from 1933/34 to 1952/53 (excluded 1951/52). The values are about twice of the true frequency of multiple pregnancy, because I summed up all number of multiple foetuses, for example twin is constituted on two foetuses and triplet on three foetuses.

As shown in figure 3, the frequency of multiplets increases till 13 feet of body length, and after that it decreases to the value of the early stages. It is difficult to explain these phenomena especially about the increasing period. I suppose that in the early stage of pregnancy the rate of abortion of single foetuses is higher than that of multiplets. Thus, the frequency of multiplets increase then. However, after 13 feet of body length, which is in the later stage of pregnancy, the rate of abortion of multiplets is higher than that of single foetuses.

Next, in order to estimate the growth of multiplets, I calculated the mean body length from September to April as shown in figure 4. The

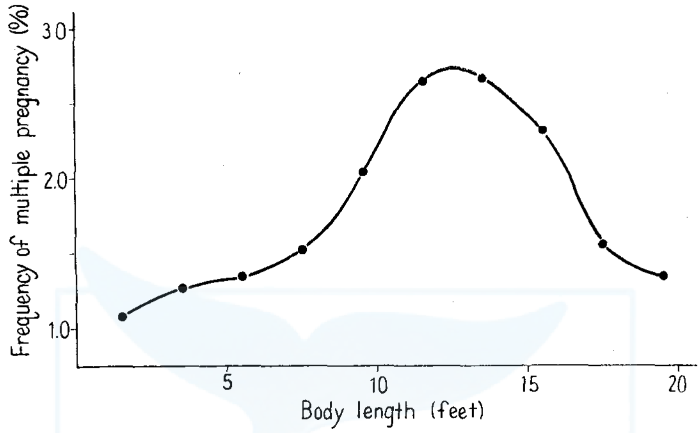

Fig. 3. Variation of the frequency of multiple pregnancy according to the body length of foetuses.

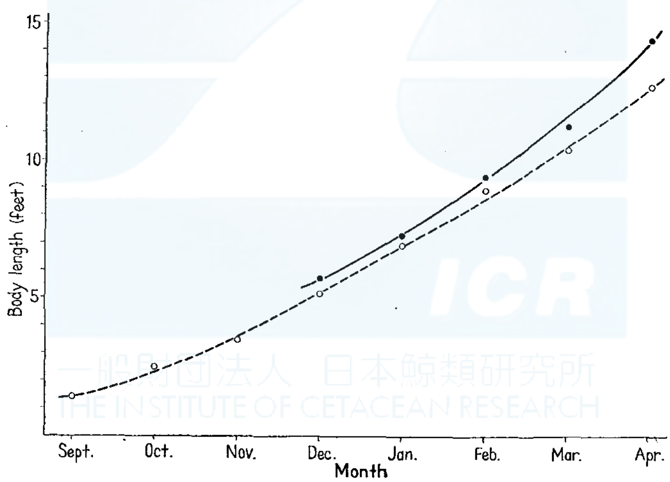

Fig. 4. Growth curve of foetuses.
Solid line····Multiplets, Broken line····Common foetuses

mean body length of multiplets is bigger than that of common foetuses in each month. Besides, the multiplets do not decline growth compared with common foetuses. Furthermore, if we move the growth curve of the multiplets to the right about 10 days, the two curves agree with one another.

By the facts stated above, two explanations are born. If the breeding season of multiplets is the same as that of common foetuses, the growth of multiplets is bigger than that of common foetuses. The other hand, if the growth rate of multiplets agree with that of common, the mean breeding season of multiplets is 10 days earlier than that of common. In this connection, Sanders (1935) states that the occurrence of twin is effected by the season in cattle. I can not deside which is true, but at any rate I can state that the growth of multiplets is not worse than that of the common. However, it is not clear which is longer, multiplet foetus or single foetus, when they are born. The longest twin which is reported is 20 feet.

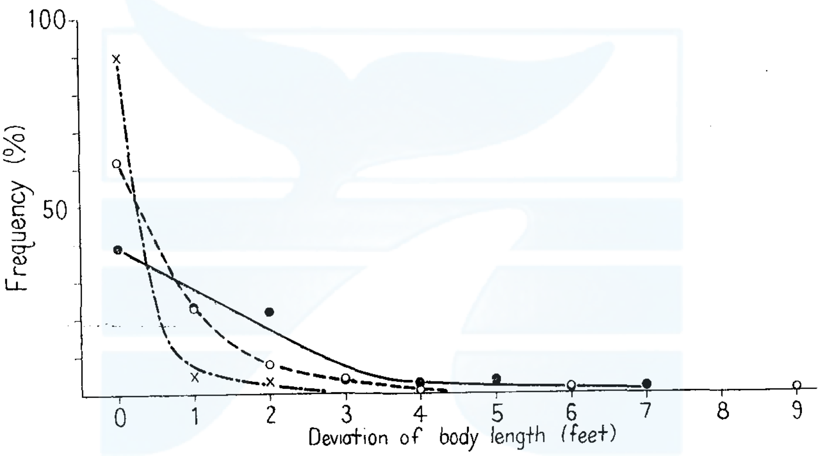

Fig. 5. Distribution of the deviation of the body length between two individuals of a couple of twins.
Chain line····1～5 ft. class, Broken line····6～10 ft. class
Solid line····11～15 ft. class.

As a matter of course about the growth or mortality rate of twins after they are born, we can not investigate. To know the individual variation of body length during growth is important to criticize the size composition, and especially, the individual variation of growth during foetal stage is a problem to consider for the calculation of pregnant period and body length in birth by means of the seasonal growth of foetuses. Now, the two foetuses of a couple of twins are fertilized in the same time, and we can know the individual variation of foetuses during their growth, by comparing the two foetues of a couple of twins.

Difference of body length of the two foetuses of a couple of twins is calculated from I.W.S. The most different twins are 13′0″ and 4′0″ (♀♀). In such a case, one of them will be dead, but the record on it has not been reported. Twinning of ♀♀ tends to be more different each other than that of ♂♂, but this tendency is not so remarkable. Difference of twinning of ♂♀ is bigger than that of ♂♂, but shorter than ♀♀.

Figure 5 shows the frequency of size distribution of the difference of foetal length in three classes of body length. In small foetuses (1–5 feet), the deviation of body length is very short, excluding an exceptional case in which the deviation is 6 feet. As the body length advances, the difference tends to be gradually bigger. In the size class of 11–15 feet, same length in the two individuals of a couple of twins compose only 40 % of the total.

When I get the mean deviation of body length with size class (Fig. 6), the tendency stated above becomes clearly. The longer the body length grow, the bigger the deviation becomes. It is supposed that the mean

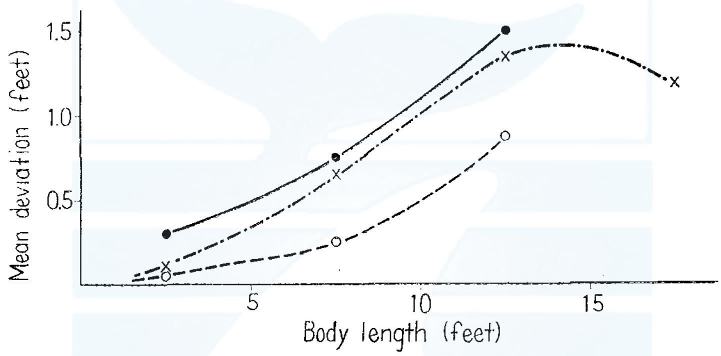

Fig. 6. Variation of mean deviation of the body length between two individuals of a couple of twins.
Solid line····EZ, Broken line····TZ,
Chain line····Twins (from I.W.S.)

deviation of foetal length will become 2 feet by the period when they are born. Therefore, it is clear that the deviation of body length during foetal growth is considerably big. And it is dangerous to regard the two foetuses which are the same length as the individuals which is fertilized in the same time.

The EZ is supposed to be less in variation of length than the TZ. But according to our material (Japanese whaling fleets, Area V, 1946/47–1954/55), the variation of EZ is higher than that of TZ. On this point, the cases in which the development of the two individuals of EZ is considerably different are known to exist. Komai (1934) states that the rate of body weight in the two twin babies is 1:0.85 in EZ as same as TZ in Japanese race. This shows that the former is more disturbed its development than the latter. Then, these facts are in agreement with my result.

TABLE 5. DEVIATION OF BODY LENGTH IN UNLIKE-SEXED TWINS

♂ > ♀ ·········	20
♂ = ♀ ·········	58
♂ > ♀ ·········	24

In order to know which is larger, males or females in foetal stage, table 5 is got by means of unlike-sexed twins. From this table, it is supposed that there is no variation of length by sex in foetal stage.

TWINS AND THEIR MOTHER'S AGE

The frequency of twins varies remarkably with their mother's age. And it increases in proportion with the mother's age. These phenomena are well known in man and domestic mammals.

On the whales, Slijper (1949) shows that the mode of size distribution of females which have twins and triplets is found at a greater length than the common pregnant females. And he supposes that the majority of twins are brought into the world by the mothers that have already attained to a greater length than the average corresponding with their age.

Figure 7 shows the size distribution of 35890 pregnant whales and 304 mothers of multiplets according to I.W.S. (1933/34–1952/53, excluded 1951/52). This figure is almost the same as that by Slijper (1949), and the mode is 72 feet in common pregnant whales, and 75 feet in mothers of multiplets. Mean body length is 71.93 feet in the former and 73.22 feet in the latter.

When I calculate the frequency of multiplets (% of number of multiple pregnancy to total pregnancy) in each body length class (Fig. 8), I find that the frequency of multiplets increases according to the increase of these mother's body length. That is to say, although the frequency is only 0.5 % in 70 feet, it is over 2.0 % in 78 feet. Nevertheless, it decreases in more than 80 feet long, but in this range, the whales examined are very few.

Now, as stated above, the individual variation of body length is fairly large in whales, and apart from mean body length, a big whale is not always relatively old. Therefore, as Slijper states, it is dangerous to discuss the relation between frequency of twins and the age of their mothers from this fact.

There have been many reports on the close relation between the number of corpora lutea in ovaries and the age of whales. I examined the relation between the frequency of twins and the number of corpora lutea of their mother turning my attention to this point. If we choose the number of corpora lutea as the standard of the age, and we get the same phenomena as in man and domestic mammals, the phenomena are known to be usual in mammaria, on the contrary, if so, we can

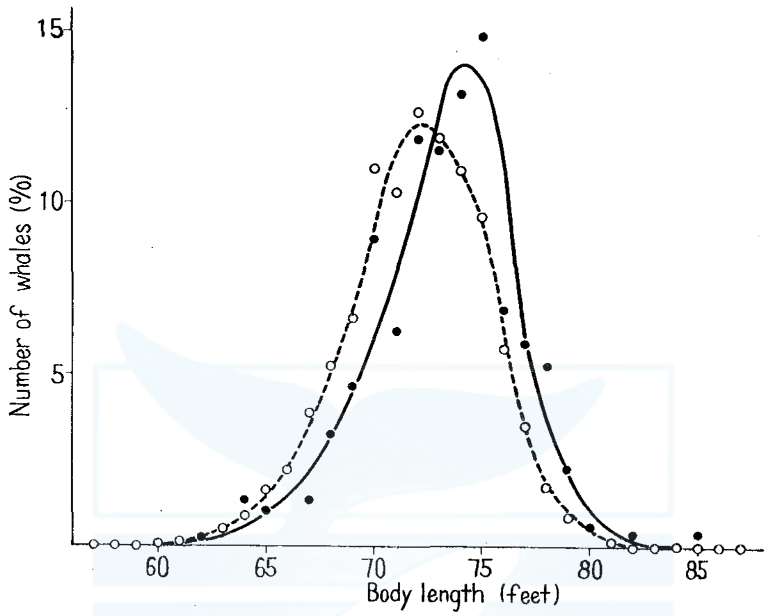

Fig. 7. Size distributions of the common pregnant whales and the multiply pregnant whales.
Solid line····Multiplet, Broken line····Common pregnant whales

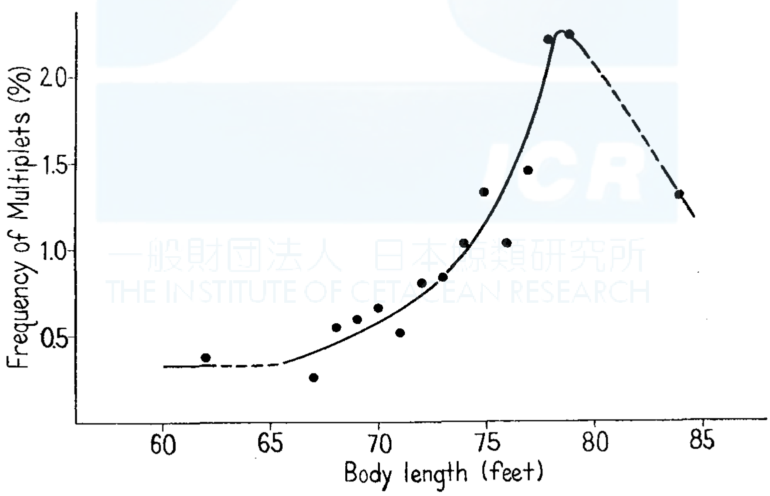

Fig. 8. Variation of the frequency of multiple pregnancy according to the body length.

give one more proof on the accuracy of number of corpora lutea as an age character in whales.

I use the material of biological investigation by Japanese whaling fleets (from 1946/47 to 1954/55). In these material the number of corpora lutea of twins are examined, and in the same time, we can know the number of corpora lutea of common pregnant females. In the first place, the distribution of the number of corpora lutea are got about EZ, TZ and common pregnant whales (Fig. 9). The distribution curve of EZ decreases with the increase of number of corpora lutea, and the curve agrees with that of common pregnant whales. On the other hand, the distribution curve of TZ is clearly different from the above two and it has one mode at 16–20. The each mean number of corpora

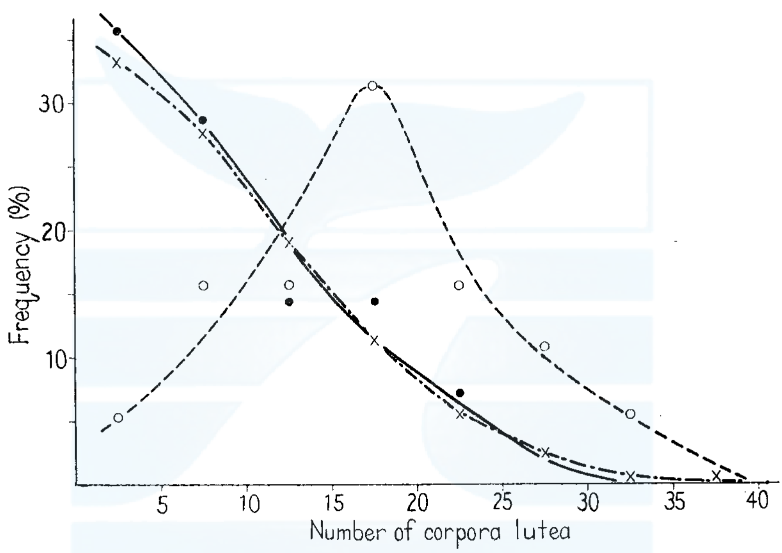

Fig. 9. Composition of the number of corpora lutea in EZ, TZ and common pregnant whales.
Solid line····EZ, Broken line····TZ,
Chain line····Common pregnant whales

lutea is 9.79 in common pregnant females, 9.0 in EZ and 17.3 in TZ. That is to say, the mean number of corpora lutea of EZ is almost the same as that of common pregnant whales, and that of TZ is more than those of the two.

In order to make this relation clear, the frequency of EZ and TZ for the pregnant whales with the number of corpora lutea are calculated. As shown in figure 10, the frequencies of EZ are clearly different from that of TZ. That is to say, the frequency of EZ is constant in every year classes, and the value is about 0.3 %. The frequency of TZ, on the contrary, is low in the few number of corpora lutea, but it increases remarkably with the increase of the number. This shows that the experience of ovulation (age) is the factors for the appearance of TZ.

Such phenomena seen in fin whales resemble closely to the result which was got in man (Endors & Stern, 1948). However, in man the frequency of EZ increase very slightly with the increase of the age, and that of TZ decreases suddenly after 40 years old. In fin whales, the frequency of TZ does not decrease in 31–35 corpora lutea. This fact will show that the sexual activity does not grow weak in these ages. In this connection, whales are regarded to have no climacteric, and there are the female fin whales which have more than 60 corpora lutea in the ovaries.

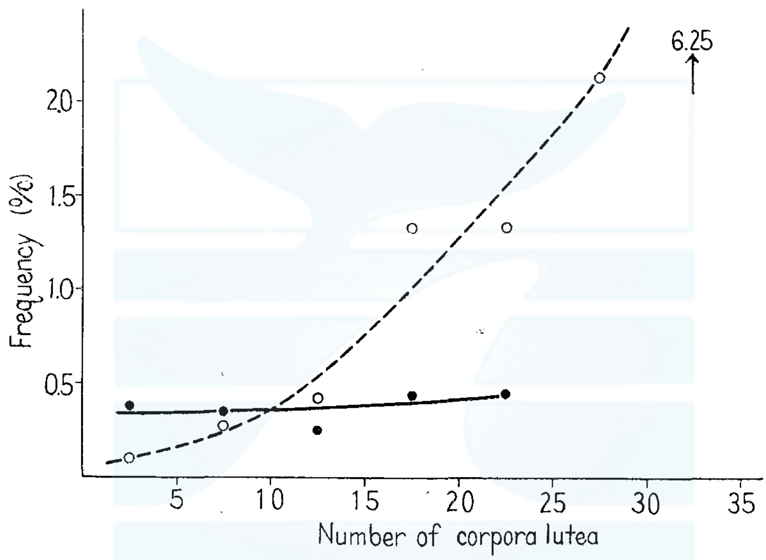

Fig. 10. Frequency of EZ and TZ according to the number of corpora lutea.
Broken line····TZ, Solid line····EZ

As mentioned above, when I use number of corpora lutea as the standard of age, I get the results which are very resemble that in other uniparous mammals. By this fact, I suppose that fin whales ovulate periodically.

The ratio of EZ or TZ in total twins relates with the number of corpora lutea, and most of twins are composed of EZ in few number of corpora lutea. But when the ratio of TZ increase and in more than 26 corpora lutea, almost of all twins will be TZ. (Fig. 11).

The TZ come into existence by the ovulation of two eggs and the fertilization of them. In my examination, the frequency of TZ is high in many number of corpora lutea. Then the following question occures. The mothers of TZ may ovulate more than normal females abnomally in a breeding period, and if so, can we not regard both the mother of TZ and the normal female who have same number of corpora lutea as the same year class?

In order to answer the question, we must compare them with other age characters which have no relation with the ovulation. In whales, however, reliable age characters have not been taken yet. And the age characters examined in biological investigation of Japanese whaling fleet are generally only body length, white scars the condition of ossification of vertebrae and baleen plates, though recently we have collected ear plug. In them, the former two are considerably valuable in individuals, therefore

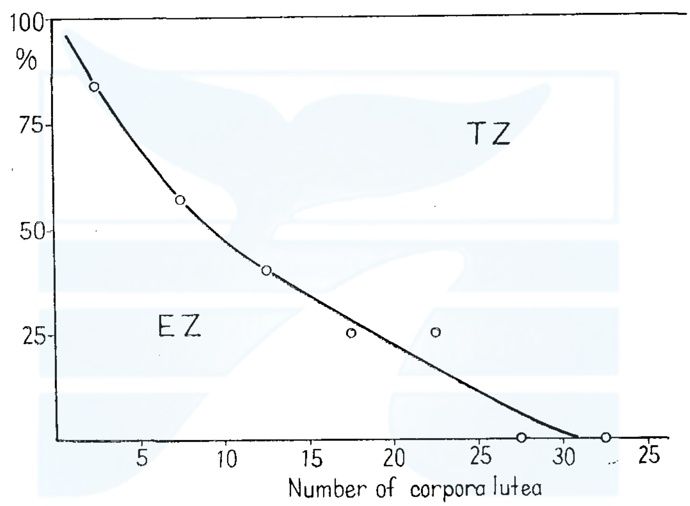

Fig. 11. Relation between the composition of EZ and TZ, and the number of corpora lutea.

they cannot be used. About the ossification of vertebrae, the usefulness for the age character is admitted by many biologists. Wheeler (1930), Peters (1939), Brinkmann (1948) and Kimura (unpublished results) show that the ossification of vertebrare finished in 13–16 corpora lutea in the case of fin whales. If the mother of TZ ovulate more than the common females in a breeding season, the number of corpora lutea in the time of the ossification of them must finish in more than 13–16 corpora lutea.

In Japanese investigations, the ossification of vertebrae is judged by means of observation of the epiphyses in the middle of thorathic and lumber.

The results are shown in table 6. Although the number observed are very few, those who has more than 16 corpora lutea in ovaries are all ossificated. This does not differ from common females. Therefore the females which are pregnant with TZ will not ovulate more than common females, abnormally.

TABLE 6. STAGE OF OSSIFICATION OF VERTEBRAE IN THE MOTHERS OF TZ

Stage of ossification	Number of corpora lutea				
	16	17	22	23	27
aA	2				
AA	2	1	1	1	1

Remarks: a····fused but not completed
A····fully fused

MULTIPLE FOETUSES

Appearances of multiple foetuses are recognized in whales, though they are very rare.

The numbers of multiple foetuses in I.W.S. (from 1933/34 to 1952/53) were already shown in table 2. The example of the fin whale who had more than 7 foetuses has never been reported, although in blue whales there were one example of 7 foetuses (Risting, 1925).

TABLE 7. FREQUENCY OF MULTIPLETS

	Pregnant whales	Twins	Triplets	Quadri-plets	Quintu-plets	Sextu-plets
Actual number	39,947	328	13	4	1	2
Multiplets:Preg. whale		1:121.8	1:3073	1:10000	1:40000	1:20000
Multiplets/Preg. whale		1/121.8	$1/55.4^2$	$1/21.5^3$	$1/14.1^4$	$1/7.25^5$

TABLE 8. COMBINATION OF SEX IN TRIPLETS

♂♂♂ ···· 2 cases
♂♂♀ ···· 6
♂♀♀ ···· 1
♀♀♀ ···· 1
? ···· 1

With the increase of the number of foetuses, the frequency of them decrease. About the frequency of multiple foetuses in man, there is Hellin's law, that is, if the frequency of twins is presumed to $1/n$, that of triplets is $1/n^2$, and that of quadriplets is $1/n^3$. But in fin whales, the frequencies of triplets and quadriplets are relatively high as shown in table 7. Therefore, Hellin's law can not be applied to the fin whale.

Triplet: The combination of 11 examples recorded in I.W.S. is shown in table 8. In man, like-sexed triplets are more than unlike-sexed triplets, on the contrary, the latter are more than the former in fin whales. And ♂♂♀ are the most of unlike-sexed triplets. About the number of ova of triplets, 3 examples are recorded by Japanese whaling investigations (Table 9). The first example has only one corpus luteum, so it is probably monozygotic triplets. And it is like-sexed as a matter

TABLE 9. THREE CASES OF TRIPLETS DISCOVERED BY JAPANESE FLEET

Date	Body length	Foetuses	No. of corpora lutea
'39-3-14	68 feet	♂ 8'-2", ♂ 9'-11" ♂ 2'-1"	1+0 (Matsuura, '40) 0+0
'53-2-9	68	♂12'-3", ♂12'-8" ♀12'-4"	2+8 1+4
'52-1-10	74	♀19'-8", ♀15'-0" ♂ 5-2"	1+1? 0+13

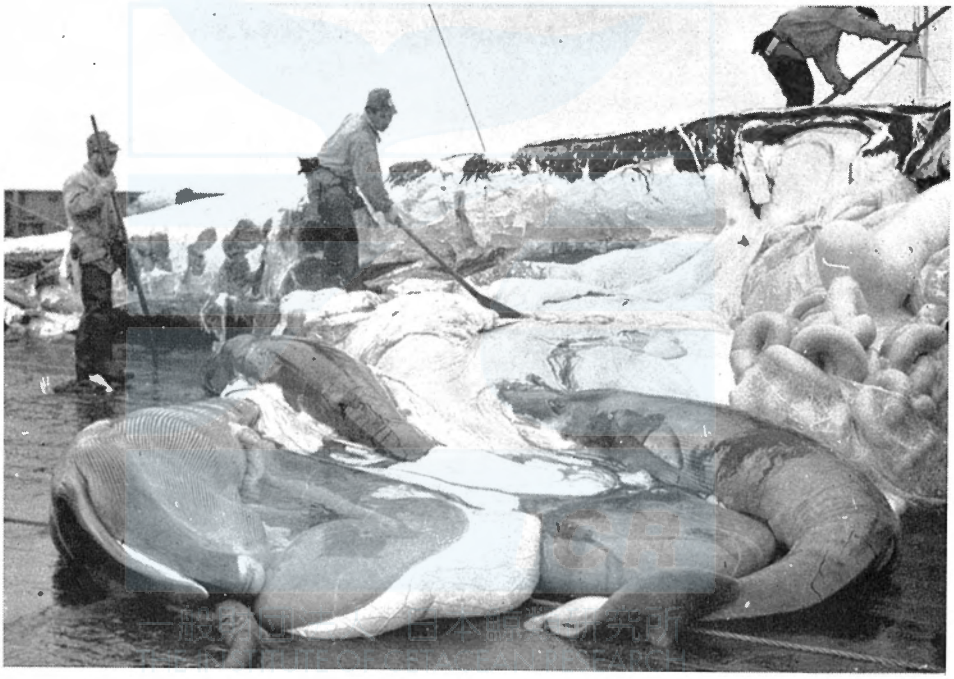

Fig. 12. Trizygotic triplet foetuses of a southern fin whale (*Balaenoptera physalus*, L.) Individuals of No. 26 in Appendix.
Male 12'3" Male 12 8" Female 12'4"
(Photo. by Mr. Setsuo Nishimoto)

of course. The body length of one foetus in this example is very smaller than the others, and it was recorded that the last one had been dead. The second case is exactly trizygotic triplets as shown in figure 12 and 13. The third example is unlike-sexed, in spite of having only one functional corpus luteum. But, in it, the larger two female foetuses are recorded to have been dead before then. Therefore, it is supposed that a couple of twins (♀♀) remains in mother's uterus after they were dead, then by the next ovulation, one male foetus (5′2″) were fertilized. And I consider that the third triplet consists of a couple of dead twins and one single foetus.

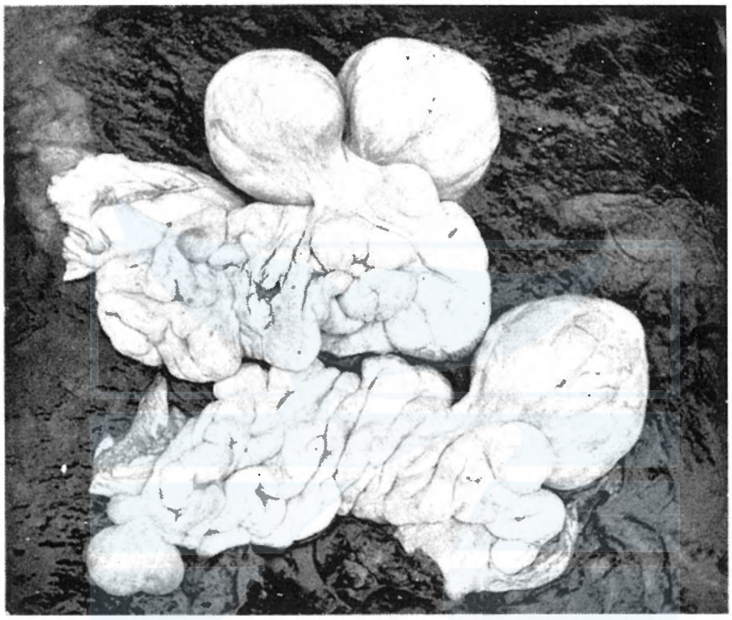

Fig. 13. The ovaries of the mother of trizygotic triplet foetuses (Fig. 12).
Number of corpora lutea

$$15\left\{\begin{array}{ll}\text{upper} & 2+8\\ \text{lower} & 1+4\end{array}\right.$$

(Photo. by Mr. Setsuo Nishimoto)

The sex ratio of 10 triplets in I.W.S. is 19♂ : 11♀ (63.7 % : 36.3 %), so the rate of male is more than that of the female.

Quadriplet: Four quadriplets are reported in I.W.S. (1933/34–1952/53), and the three records are shown in table 10.

Sex ratio is 8♂ : 3♀ (72.7 % : 27.3 %), so the ratio of male is more than that in triplet. Table 11 shows the relation between number of

TABLE 10. QUADRIPLETS

Date	Body length	Foetuses			
'39-1-27	74 feet	♂ 8′-0″	♂ 8′-0″	♂ 8′-0″	♂ 8′-0″
'50-12-23	71	? 1′-4″	♀ 4′-2″	♂ 7′-11″	♀ 19′-1″
'53-2-10	72	♂ 9′-0″	♂ 10′-0″	♂ 11′-0″	♀ 13′-0″

foetus and the sex ratio. With the increase of the number of foetues, the ratio of males increases. These phenomena are contrary to that in man.

TABLE 11. SEX RATIO OF MULTIPLETS

	♂	♀
Common foetus	50.6%	49.4%
Twin	51.4	48.6
Triplet	63.7	36.7
Quadriplet	72.7	27.3

Quintuplet: Only one quintuplet is reported in I.W.S. The example is shown below.

TABLE 12. A CASE OF QUINTUPLET

Date	Body length	Foetuses				
'48-2-28	79 feet	♂ 6′-8″	♂7′-5″	♂ 7′-6″	♂ 8′-4″	♂ 8′-9″

Sextuplet: 2 case of 6 foetuses are recorded in I.W.S.

TABLE 13. TWO CASES OF SEXTUPLETS

Date	Body length	Foetuses			
'50-2-24	69 feet	♂ 3′-4″	♀ 5′-4″	♀11′-1/2″	♀10′-1/2″
		♀10′-9″	♀10′-11″		
'53-2-21	72	♂ 8′-10″	♀ 8′-0″	♂ 9′-10″	♀ 9′-0″
		♀10′-0″	♀12′-0″		

Jonsgård (1953) reported on the latter case.

DISCUSSION

The existence of TZ in whales is clear because of the existence of unlike-sexed twins. But about EZ only Matsuura (1940) stated on the possibility of it, and Slijper (1949) stated that the twin whose mother had only one functional corpus luteum was not always EZ.

However, we assume the existence of it by calculation using Weinberg's differential method. And according to our material which were got by our biological investigation of whales, the twins whose mothers have only one functional corpus luteum in ovaries are all like-sexed. The difference of two body lengths of a couple of twins are considerably small, and in these cases the one of a pair is not regarded to have been dead. The fact that there is a single foetus whose mother has two functional corpora lutea in ovaries, shows that when two ova are ovulated in the same time and the one is not fertilized or disappeared, the two corpora lutea maintained to be functional even if only the other is fertilized. While, Wheeler (1930) stated, ' A close and somewhat exclusive relation between corpus luteum and foetus. If two ova are fertilized, then two corpora lutea will remain functional, if one corpus is developing then one corpus luteum is sufficient. Perhaps, indeed, the corpus luteum reflects the fate of its own released ovum'. But in his data, one fin whale with unlike-sexed twin foetuses has three functional corpora lutea. The second one with no foetus has two functional corpora lutea. The third one with a foetus has two functional corpora lutea. These facts cannot be explained by his theory, and they are not contradictory to my explanation. In the other hand, as shown in chapter of 'multiple foetuses', there is unlike-sexed triplet foetuses whose mother has only one functional corpus luteum. But in this case, the larger two foetuses clearly have been dead in the uterus before then. So I consider that the corpora lutea of the two foetuses have dwindled and from the next ovum a single small foetus developed. That is to say, after all foetuses in uterus died, the corpora lutea dwindle. On the contrary if there is no dead foetus, the multiple foetuses whose mother has only one functional corpora lutea are monozygotic multiplet.

As stated above, there are a few cases in which dead foetuses remain in their mother's uterus. For example, one (4′–0″) of a couple of twins (♂11′–5″, ♂4′–0″) of which genesis is unknown had been dead. In this case if the number of functional corpora lutea is only one, it is doubtful whether the twin is monozygotic or one foetus developed by the next ovulation after the other died. In such a case we must investigate the condition of placenta.

Furthermore, as there will be such cases in I.W.S. the number of foetuses does not show the true number of multiplet, we should pay attention to the case. It is dangerous when the difference of body length of foetuses is very large.

The morphological studies of twins are important to the basal investigation of races in whales. We must catch the characters which are truly hereditary, and the precise investigation of monozygotic and dizygotic twins makes it clear. However, we have not had the morphological data of twins. This will be the important subject to survey in future.

SUMMARY

1. Using the International Whaling Statistics (1933/34–1952/53) and the results of biological investigation of Japanese whaling fleets in the Antarctic Area V (from 1946/47–1954/55), the twinning in southern fin whales were studied.

2. The frequency of twins is 0.821 % (0.872 %, in total multiplets) of

all pregnant females. The value is seemed to be slightly different in various areas.

3. It is certain that there are monozygotic and dizygotic twins in fin whales.

The ratio of the frequency of monozygotic twins to that of dizygotic is 27.6 % : 72.4 %. The value also is seemed to be different in various areas.

4. The growth of twins is not inferior to the common foetuses.

The difference of body length of two individuals in a couple of twins increases with the growth, and it will be 2 feet long when they are born. The difference of body length between two individuals of monozygotic twins is more than that of dizygotic twins.

In foetal stage, the difference of body length is not recognized between the both sexes.

5. The frequency of twins increases with the increase of their mother's length.

6. The frequency of monozygotic twins is constant in any number of corpora lutea of their mother. On the contrary, the frequency of dizygotic twins increases with the increase of the number of corpora lutea in the ovaries of their mother.

7. The mother of dizygotic twins has not tendency to ovulate more than normal females.

8. The multiplets exist in fin whales. But 7 or more than 7 foetuses have not been reported yet.

Concerning the frequency of multiple foetuses of fin whales, Hellin's law cannot be applied.

The sex ratio of males increase with the increase of the number of foetuses.

REFERENCES

BRINKMANN, A. (1948). Studies on female fin and blue whales. *Hvalradets Skrifter*, no. 31, 38 p.

FISHER, R. A. (1919). The genetics of twins. *Genetics*, 4: 489–99.

HAULDANE, R. C. (1910). Zoological notes. Extraordinary fecundity of a whale (*B. musculus*). *Ann. Scot. Nat. Hist.* 117 p.

HEWITT, A. C. T. (1934). Twinning in cattle. *J. Daiey Res.*, 5 (2).

HOWELL, A. B. (1930). *Aquatic mammals*. 1st edition, 338 p, Baltimore.

INTERNATIONAL WHALING STATISTICS, VI, VII, VIII, X, XII, XIV, XVII, XVIII, XX, XXII, XXIV, XXVI, XXVIII, XXX, XXXII. Oslo, The Committee for Whaling Statistics, 1935–54.

JONSGÅRD, A. (1953). Fin Whales with six foetuses. *Norsk Hvalfangst-Tid.*, no. 12: 685–6.

KOMAI, T. (1934). [Twins of mankind]. *Botany and Zoology*, 2 (1): 1–15. (In Japanese).

KRONACHER, C. (1932). Zwillingsforschung beim Rind. *Zeitsch. f. Zücht. Reiche*, 25 (3): 142–56.

MACKINTOSH, N. A. & WHEELER, J. F. G. (1929). Southern blue and fin whales. *Discovery Rep.*, 1: 257–540.

MATSUURA, Y. (1936). Statistical studies on the whale foetuses. 1. Blue whale and fin whales in the Antarctic. *Bull. Jap. Soc. Sci. Fish.*, 5 (1): 25–32. (In Japanese)

——— (1940). On the multiple pregnancies and the multiple ovulations of the baleen whales. *Jap. J. Zool.*, 52 (11): 407–14. (In Japanese).

OMURA, H. (1942). [Whales]. *Fishery Prossessing Technology Series*, vol. 7, 136 p. (In Japanese).

PAULSEN, H. B. (1939). Foetus measurements and occurrences of twins and multiple foetuses. *Norsk Hvalfangst-Tid.*, no. 12: 464–71.

RISTING, S. (1925). Sjelden forsterforekomst. *Norsk Hvalfangst-Tid.*, no. 9. (Cited from Wheeler, 1930).

——— (1928). Whales and whale foetuses. Statistics of catch and measurements collected from the Norwegian whalers association 1922–25. *Rapp. Proc. Verb., Conseil. Internat. l'Exploration*, vol. 50, 122 p.

SANDERS, D. (1935). Untersuchungen zweieigen Rinderzwillingen hinsichtlich der Ahnlichkeit morphologischer, physiologischer und psychologischer Merkmale. *Zeitsch. f. Züicht Reiche*, 32: 223–68.

SLIJPER, E. J. (1949). On some phenomena concerning pregnancy and parturition of the cetacea. *Bijderagen tot de Dierkunde*, 28: 416–42.

STERN, C. (1949). *Principles of human Genetics*. 418 p. San Francisco.

TANIGUCHI, T. (1935). *Study on Twinning*. 225 p. Tokyo. (In Japanese).

WHEELER, J. F. G. (1930). The age of fin whales at physical maturity with a note on multiple ovulations. *Discovery Rep.*, 2: 403–34.

EXPLANATION OF THE APPENDIX

Examples of multiple foetuses discovered by Japanese whaling fleets from 1946/47 to 1954/55.

Remarks 1. Number of corp. lut. A+B A: Corpus luteum graviditatis
B: Corpora albicans

2. Ossification N: not fused n: not fused but not completed
a: fused but not completed A: fully fused
XY X: Thorathic Y: Lumber

APPENDIX

No.	Date captured	Body length of mother (feet)	Foetuses sex and body length (feet–inch)	Number of corp. lut. Left	Right	Total	Diameter of functional corp. lut. (cm)	Ossification
1	7/1/47	70	♂ 5- 1, ♀ 5- 1	1+ 6	2+ 8	17	——	AA
2	5/3/49	75	♀ 10-11, ♀ 11-10	1+ 3	0+ 3	7	——	aa
3	14/3/49	71	♂ 12- 6, ♀ 12- 0	1+ 5	1+ 9	16	(10× ? × ?) (12× ? × ?)	aA
4	23/12/50	71	? 1- 4, ♀ 4- 2, ♂ 7-11, ♀ 19-1	9	8	17	——	AA
5	15/1/51	72	♂ 3- 3, ♂ 3- 4	0+ 2	1+ 2	5	(9 ×10×13)	na
6	16/1/51	74	♀ 5-11, ♀ 6- 0	0+ 3	1+ 5	9	(9 × 9 ×10)	na
7	22/1/51	70	♀ 9- 2, ♂ 11- 7	0+12	2+ 2	16	(12× 9 × 6) (13× 9 × 7)	AA
8	1/2/51	72	♂ 11- 5, ♂ 4- 0(dead)	?	0+ 8	8+	——	AA
9	21/2/51	70	♂ 8- 5, ♂ 8- 7	1+ 3	0+ 2	6	(10×10×13)	na
10	22/2/51	72	♀ 15- 2, lost	2+13	0+12	27	(7 × 8 ×11) (6 × 9 ×11)	AA
11	22/2/51	73	♀ 1- 0, ♀ 0-11	0+ 8	1+ 7	16	——	aa
12	2/1/52	68	♂ 7- 2, ♂ 7- 2	1+ 7	0+ 4	12	(12.5×10.5×9.0)	nN
13	5/1/52	73	♀ 11- 0, ♀ 10- 0	0+ 7	2+ 4	13	——	—
14	9/1/52	69	♀ 5-10, ♀ 4- 6	1+ 3	0+ 4	8	(9 ×11× ?)	—
15	10/1/52	73	♂ 10- 2, ♂ 10- 4	1+10	1+ 4	16	(11×13×11.5) (11.5×12.5×12)	AA
16	10/1/52	74	♀ 19- 8 (dead), ♀ 15-0 (dead), ♀ 5-2	1+12	0+13	26	(18×11× ?)	—
17	11/1/52	68	♂ 9- 1, ♂ 8- 9	1+ 7	0+ 6	14	(10×13.5×15)	aA
18	13/1/52	73	♀ 10- 4, ♀ 10- 2	2+14	0+ 6	22	(9.5×13.5×10) (9 × 7 ×7.5)	AA
19	15/1/52	73	♂ 3- 0, ♂ 2-11	1+ 9	0+ 9	19	(11×12× ?)	—
20	9/2/52	71	♀ 12- 5, ♂ 12- 7	0+11	3+17	31	(11.5×8.5) (13×10) (8×6.5)	—
21	15/2/52	73	♀ 13- 3, ♂ 13- 5	1+ 6	1+ 8	16	(9.5×18×15) (9×15×16)	aA
22	13/2/52	70	♀ 12- 5, ♀ 10- 4	0+11	1+10	22	(12×10)	—
23	26/2/52	74	♀ 14-10, ♂ 14- 2	1+ 0	1+ 8	10	(12×10) (15×12)	—
24	7/1/53	76	♀ 8-11, ♀ 9- 0	1+10	1+ 3	15	——	—
25	15/1/53	71	♂ 3-10, ♂ 3-10	0+ 2	1+ 2	5	(16× ? × ?)	—
26	9/2/53	68	♂ 12- 3, ♂ 12- 8, ♀ 12-4	2+ 8	1+ 4	15	(13× ? × ?)	—
27	12/2/53	70	♀ 8-10, ♀ 8- 0	1+ 0	0+ 0	1	——	—
28	13/2/53	65	♂ 12- 0, ♀ 10- 7	2+ 0	0+ 1	3	——	—
29	13/2/53	76	♀ 13- 0, ♀ 12- 6	1+ 5	1+ 3	10	——	—
30	18/1/54	68	♂ 11- 3, ♂ 10- 6	——	——	—	——	—
31	24/1/54	72	♀ 10- 6, ♂ 10- 9	1+ 4	1+13	19	——	—
32	26/1/54	73	♂ 9- 4, ♂ 9- 3	1+ 4	1+17	23	——	AA
33	26/1/54	76	♀ 6- 9, ♀ 6- 5	1+ 3	1+ 4	9	——	—
34	2/2/54	68	♀ 9- 0, ♀ 5- 9	1+ 0	0+ 0	1	——	—
35	11/2/54	70	♀ 4-10, ♂ 4- 7	4+ 6	5+15	30	——	—
36	24/2/54	70	♀ 10-10, ♀ 10- 5	2+16	0+ 3	21	——	—
37	14/2/55	65	♀ 11- 2, ♂ 10- 1	——	——	—	——	—
38	15/2/55	72	♀ 6- 4, ♀ 7- 0	1+ 0	0+ 1	2	——	—
39	15/2/55	69	♂ 12-10, ♂ 10-11	——	——	—	——	—
40	25/2/55	71	♂ 8- 9, ♂ 8-10	2+ 4	0+ 8	14	——	—