

excessive intensity of the fishery. Further investigations on this subject, in connection with size distribution and migration, would be of great importance biologically and also in relation to the size-limit. On this point there are yet large gaps in our knowledge.

In an appendix ELMHIRST gives notes on the growth of lobsters, based on rather a small number of observations in the aquarium. From these it is concluded that before maturity females grow faster than males, and after this, as is well known the reverse is the case. Consequently males and females are of equal size at about 10 years old. It would be interesting if such an intersection of the growth lines of males and females at an age of about 10 years should find further confirmation from observations in nature also.

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J. F. G. WHEELER. The Age of Fin-Whales at Physical Maturity with a Note on multiple Ovulations. *Discovery Reports*. Vol. II. pp. 403—434. Cambridge 1930.

In an earlier report MESSRS. MACKINTOSH and WHEELER dealt with "Southern Blue and Fin-Whales". In this paper, recently reviewed in this *Journal*, the authors dealt with the biology of the whale up to sexual maturity at the age of two years. Their material enables us to understand the growth conditions of the whale, and they have been able with fair exactitude to construct a growth curve for the foetus, the suckling calf and the young, sexually immature animal. After reaching the period of sexual maturity the results achieved by the authors were not, however, so sure and their conclusions regarding the length of life of the individual were, on account of the material then at hand, very speculative, as they themselves point out. At that time they relied chiefly on the number of corpora lutea in the ovaries, but they had also begun the investigation of the degree of physical maturity by means of the fused or unfused condition of the vertebral epiphyses.

This work has been continued and the result has been given in the above mentioned treatise by Mr. WHEELER.

The fusing of the epiphyses with the centra of the vertebrae takes place gradually, the intervening cartilage layer becoming thinner and thinner and ultimately disappearing entirely. After ankylosis a whitish line indicates for a time the join, but finally this also disappears. When the ankylosis is complete, the animal is physically mature and all growth in length ceases. Other investigators have found that the ankylosis begins at both ends of the column and proceeds forwards and backwards towards the middle. The author found that the ankylosis begins, no doubt, at both ends, but from the anterior end it does not reach much beyond the cervical vertebrae so that ankylosis is completed among the anterior thoracic vertebrae.

The author has therefore generally examined the following vertebrae:—one posterior lumbar vertebra, one middle lumbar vertebra, one posterior thoracic vertebra and one or two as far forward as possible i. e. the 2nd, 3rd or 4th thoracic vertebra. In this way a general idea has been obtained of the progression of the ankylosis. The author, along with Mr. F. D.

OMMANNEY, has examined nearly 300 female fin-whales and nearly 200 of these were sexually mature animals.

The individual length has not proved to be a certain indication of the age, as the smallest sexually mature female fin-whale was more than 2.5 metres shorter than the largest immature female fin-whale, and there also appears to be a great variation in the length at physical maturity. One whale measuring 21.05 metres and a number only slightly longer were physically mature, while the author has examined whales measuring over 23 metres where the epiphyses was not yet fused to the centra.

Only females were examined, for the object was to get data for comparison with the coincident investigation of the condition of the ovaries and the number of corpora lutea. Methodically the procedure in this investigation was the same as before but the author has taken up for renewed discussion the circumstances in regard to the formation of, and the persistence of, corpora lutea in the ovaries. This has led to the theory set forth in the previous report on "Southern Blue and Fin-Whales" being slightly — though in principle, immaterially — modified.

The results of the investigations of physical maturity and the number of corpora lutea have been arranged in synoptic tables and curves. Of 105 whales with less than 15 corpora lutea there were only 2 with, respectively, 11 and 12 corpora that were physically mature, with the epiphyses fused to centra; and of 66 whales with more than 15 corpora lutea there were only 4 physically immature. Consequently while the number of corpora lutea and still more the fusing of the epiphyses to the centra have no close relation to the length, their mutual relation is very clear. The age of the whale that has attained physical maturity must therefore be that which is required for the accumulation of 15 corpora lutea in the ovaries.

It is easy to understand from the relation between the physical maturity and the number of corpora lutea that the latter must stand in a certain relation to the age. In their number there appears a tendency to a grouping about definite figures, and this is explained thus: We take for example a group of whales in their first sexual season. At the close of the season the minimum number will be a functional corpus luteum and the whale will be pregnant. The maximum number of corpora lutea will show the maximum number of ovulations that are possible during one season. Among social animals with extensive, more or less simultaneous migrations, the maximum of successive pairings with the consequent fertilizations will occur in the course of a comparatively short time. There will therefore be a tendency towards the above mentioned grouping about a definite number of corpora lutea. Next season these animals will be lactating, and normally no new corpora lutea are formed. Thus the accumulation of corpora lutea will be continued every other season. This also appears in a graphic statement of the frequency of corpora lutea. There are distinct maxima with 1, 7 and 11 and an indication with 18 and 22 corpora lutea for the season 1929—30.

The whales may be grouped round these maxima; Group I including whales with 1 to 4 corpora, Group 2 with 5 to 9, Group 3 with 10 to 14, Group 4 with 15 to 19, and Group 5 with 20 to 24 corpora lutea. On the assumption of one young every other year, each of these groups includes

two year classes, the pregnant and the lactating animals one year older. Consequently we have here a means of estimating roughly the number of females in each year class.

There is an essential difference between Group 1 and the other groups as most of the animals have already become pregnant at their first ovulation. This the author explains by the fact that the young animals have a somewhat different migration and possibly find themselves in waters where the pairing takes place earlier than that of the older animals.

In the graphic representation of the number of corpora lutea we have therefore a means of determining the age of the females with a certain degree of probability up to eight years after sexual maturity or in all to the age of ten, when we remember that the whale requires two years to attain sexual maturity. We saw that the physical maturity, characterized by a complete ankylosis of the column, occurred simultaneously with the presence of about 15 corpora lutea in the ovaries, that is to say between what we call groups 3 and 4. Consequently the physical maturity should be complete from 4 to 6 years after the sexual maturity, or from 6 to 8 years after birth. If the average increase in the number of corpora lutea is 4 each year, then a fin-whale captured last season was at least 20 years old. The largest and heaviest ovaries were found in an animal with 18 to 20 corpora lutea and this suggests, possibly, that the maximum of reproduction is over at the age of ten. There is, however, no typical sign of a climacteric.

In the "Note on multiple Ovulations" the author calls attention to the peculiar circumstance that when several ovae are released at the same time, there will be just as many large functional corpora lutea as foetuses and that a corpus luteum perhaps reflects the fate of its own released ovum. There is, however, but a very small percentage of whales that have multiple ovulations and more than one foetus.

The author has succeeded in presenting his results in a clear and convincing manner and we now perceive that the theory he and MACKINTOSH advanced in their previous paper, that it should be possible to determine the age of females by means of the number of corpora lutea in the ovaries, has received considerable justification. Also this is the only means we have at present. We venture to hope that the author will continue with these interesting investigations and will make new and equally important contributions to our knowledge of the growth and age of the whale.

JOHAN T. RUUD.

A. B. KEYS. The Measurement of the Respiratory Exchange of Aquatic Animals. *Biological Bulletin*, Vol. LIX (No. 2), pp. 187—198. Lancaster, Pa., 1930.

The measurement of the gas-exchange of aquatic animals has assumed so important a place in physiological and ecological studies that a critical review of the various experimental methods employed, and the embodiment of their salient advantages in a new one, will be read with interest by all workers on the subject.

The methods in vogue are grouped by the author into three main