Size Distribution of Spermatozoa in some Mammals

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Abstract The volume of spermatozoa was measured in some mammals. The distribution range of O spermatozoa extended from 10 to 50 μ^3 , from 10 to 35 μ^3 , from 1.25 to 6.75 μ^3 , and from 5 to 45 μ^3 in mice, rats, guinea pigs, and swine, respectively. It was assumed that the value might be too small for guinea pigs. Monomorphic distribution was noted in O of swine and in all the cases of mouse, rat, and guinea pig. A peak of monomorphic curve was seen at about 20, 20, 2.5, and 14 μ^3 in mouse, rat, guinea pig, and swine, respectively. Dimorphic distribution was observed only in the W and S curve for swine. As compared with the O and W curve, the S curve shifted to the left in mouse and guinea pig. The S curve of swine was clearly dimorphic. Its two peaks were of the same height, except that the left peak was lower than right in the W curve. It is unknown whether or not the right and left peaks represent X- and Y-spermatozoa, respectively.

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Since the beginning of the 1910's many reports have been published to approve or disapprove the dimorphism of the head size of spermatozoa in domestic and other mammals. They dealt only with the length or area of the head of spermatozoa. There were no methods to measure the volume of the head of spermatozoa at that time. Recently, after 1960, the volume of such a small grain as the spermatozoon could be measured electronically. Only a few reports, have appeared on the volume of the head of the spermatozoon until the present time. On the other hand, many spermatozoa bearing X chromosome were found in the filtrate of human spermatozoa obtained through the column of Sephadex gel (G-50 fine). Some investigators, however, failed to find them. These points are regarded as subjects of basic studies on sex control.

The volume of spermatozoa ejaculated and derived from the cauda epididymidis, and that of those washed and filtrated through the Sephadex column were measured in some animals in this study.

Materials and Methods

Spermatozoa from the cauda epididymidis were used in mouse, rat, and guinea pig and ejaculated spermatozoa in swine. All the animals had been bred at the National Institute of Animal Health, except swine which had been bred at the Experimental Station of Animal Husbandry, Prefecture of Tokyo. Spermatozoa were diluted (ca $10^3 \sim 10^4$ /ml) or washed with Isotone (designated salt solution for the Coulter

counter). Their volume was measured several times in each animal by the Coulter Chanalyser, Model-C-1000 (Coulter Electronics, Inc., Florida, U.S.A.). When filtrated through the Sephadex (G-50 fine) column, spermatozoa were suspended in Locke's solution. The Sephadex column was 1 cm in diameter and about 3 cm in height.

Results

Spermatozoa ejaculated or collected from the cauda epididymidis were called O samples, those washed twice with Isotone W samples, and those filtrated through the Sephadex column S samples in this study.

Mouse spermatozoa (Fig. 1). The volume of O spermatozoa exhibited a sharp monomorphic distribution curve, as shown in Fig. 1. Almost all the spermatozoa were in a range from 10 to 50 μ^3 . A peak of the curve is seen at about 20 μ^3 . W spermatozoa showed no shift in the distribution curve. There is a slight fall in the right side area of the peak of the W curve. This fall, however, was not significant. The distribution curve of S spermatozoa shifted to the left, as compared with those of O and W spermatozoa. The S curve was very sharp. This means that S spermatozoa were smaller than O and W ones.

Fig. 1. Volume distribution curve of mouse spermatozoa.

Remarks for all figures. O...spermatozoa ejaculated or from the cauda epididymidis (origin). W...spermatozoa washed twice with Isotone. S...spermatozoa filtrated through the Sephadex column.

Fig. 2. Volume distribution curve of rat spermatozoa.

Rat spermatozoa (Fig. 2). Rat O spermatozoa revealed such a sharp monomorphic distribution curve as shown by mouse O spermatozoa. This curve was sharper than that of mouse O spermatozoa in the right region. Almost all the spermatozoa were in a range from 10 to 35 μ^3 , with a peak at about 20 μ^3 . The W curve shifted a little to the left of the O curve, but this shift was not significant statistically. Both O and W curves exhibited a slight fall near their top, but this fall was not significant. They were also monomorphic. No S curve could be obtained, because spermatozoa were difficult to pass through the Sephadex column in the rat. Spermatozoa varied in passability through the Sephadex column with the species of mammals. These results will be reported elsewhere.

Guinea pig spermatozoa (Fig. 3). Both O and W spermatozoa showed a monomorphic distribution curve. This curve was less sharp than that of presented by mouse and rat. The W curve was a little lower than the O curve. Almost all the spermatozoa were in a range from 1.25 to 8.75 μ^3 , with a peak at about 2.5 μ^3 . The guinea pig had the smallest spermatozoa of all animals used in this study. This will be discussed later.

Swine spermatozoa (Fig. 4). The distribution curve of O spermatozoa was monomorphic and less sharp than those of mouse and rat. The W curve, however, was dimorphic one, and its left side (smaller) peak was lower than its right side (larger)

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Fig. 3. Volume distribution curve of guinea pig spermatozoa.

Fig. 4. Volume distribution curve of swine spermatozoa.

one. The S curve was more clearly dimorphic than the W curve. Its two peaks were almost the same height. Dimorphism was statistically significant in the W and S curves. Almost all the O and W spermatozoa were in a range from 5 to 45 μ^3 , with a peak at about 14 and 22 μ^3 , respectively.

Discussion

When literature on domestic and experimental animals was reviewed, many papers dealt mainly with the length or area of the head of spermatozoa. The present study was carried out on the volume of the whole spermatozoon. Therefore, it cannot be compared directly with any previous work.

Three steps were found in the development of studies on the size of the head of spermatozoa. Of them, the first step was to study the length of the head, the second step the area, and the third step the volume. The length of the head of spermatozoa was studied in swine^{1,5)}, horse²⁾, cattle^{3,4)}, sheep⁴⁾, and dog⁴⁾. Dimorphism was observed in it in these animals. It was not noted in goats⁶⁾ or rabbits⁷⁾. No dimorphisms was recognized in the head area of spermatozoa of guinea pigs⁸⁾ or swine⁹⁾.

The volume of the bovine spermatozoon was measured electronically. Its head and tail was 3.7 and 2.8 μ in diameter as a sphere, respectively¹⁰⁾. The head volume of the spermatozoon was measured by the Coulter counter, Model B, in cattle, swine, and man. It was found that the volume varied with the species of animals¹¹⁾. The volume of ejaculated spermatozoa of cattle, sheep, and swine was in a range of 19–25, 25–29, and 21–29 μ^3 , respectively¹²⁾. No comparable report, however, was made on the volume of mouse or rat spermatozoa. As far as the authors know, there are only two previous papers^{11,12)} on the volume of spermatozoa of swine. The distribution range of swine spermatozoa in this study was wider than that ever reported¹²⁾.

The volume of spermatozoa was much smaller in guinea pigs than in mice or rats in this study. It was very small as compared with the head area⁸⁾, too. This result suggests that spermatozoa have been broken into small fragments, although no destruction of spermatozoa was confirmed.

Only one animal species, swine, revealed dimorphism in the W and S curve in the present study. No dimorphism was seen in the O spermatozoa of swine. It was presumed that a one-peaked curve might have been expressed due to the presence of particles in the semen, and that by washing these particles might have been removed to make a fall appear. This presumption could not be verified. It cannot be explained why the fall became more clear in the S curve.

The S curve showed a shift to the left side (smaller). It became very sharp in mice and guinea pigs in this study. A fraction rich in X-spermatozoa was obtained from human spermatozoa by filtration through the Sephadex column¹³⁾. It has been reported that the head of the X-spermatozoon is larger than that of the Y-spermatozoon. It is well known that a high molecular substance can pass through the Sephadex column, but a low molecular one cannot. From these facts, it can be said that a fraction of large spermatozoa is obtained by filtration. The result of this study was opposed to these facts. It was reported that the collection of X-spermatozoa could not be attained by Sephadex filtration¹⁴⁾. The reason for the shift of the S curve in this study cannot be explained.

In swine, the left peak was lower than the right one in the W curve. On the

contrary, the left peak was a little higher than the right one in the S curve, although the difference was insignificant. The reasons for these phenomena were unknown. It could not be determined whether or not the two peaks indicated the Y- and X-spermatozoa, respectively.

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2, 3 哺乳動物の精子の体積について

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マウス, ラット, テンジクネズミ, ブタの精子全体(頭~尾)の容積を Coulter Chanalyser, Model-C-1000 を用いて測定した。ブタでは射出精子, 他動物では精巢上体尾精子を用いた。これらを O, Isotone で 2 回洗滌したものを W, Sephadex (G-50 fine) gel 柱で濾過したものを S 材料とし, ラット以外の各動物において O, W, S の 3 種精子の体積を測定した。ブタの O, マウス, テンジクネズミの O, W, S, ラットの O, W 精子は単峰曲線分布を示し, ブタの W, S は双峰曲線を示した。O の大部分の精子はマウス, ラット, テンジクネズミ, ブタにおいて, それぞれ 10~50, 10~35, 1.25~8.75, 5~45 μ^3 の範囲に分布した。O 曲線の峯はそれぞれ約

20, 20, 2.5, 14 μ^3 にみられた。テンジクネズミ精子は他動物のものに比し非常に小さかった。確認はできなかったが, 精子は破壊されたものと考えられる。ラット精子は Sephadex 柱通過困難で, S 曲線は得られなかった。マウス, テンジクネズミでは S 曲線は O, W に比し, 左方(小)に移動した。ブタの W, S 曲線は双峰性を示し, とくに S において明らかであった。W 曲線では左峯よりも右峯が高いが, S 曲線では 2 峯はほぼ同じ高さを示した。これら左, 右の峯が, それぞれ Y および X 精子を示すかどうかは不明である。

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