AN ANALYSIS OF DATA OBTAINED FROM SHOW, NON-SHOW GUINEA PIGS, AND THEIR OFFSPRING

by

WAI SING WONG

B. S., Lingnan University, Canton, China, 1931

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1937

TABLE OF CONTENTS

INTRODUCTION

In most livestock shows, prizes are usually awarded to the owners of those animals having the conformation most characteristic of the breed. Our knowledge concerning the mode of inheritance of the characteristics that constitute a good conformation, however, is very meager. The reason is obvious. Our larger domesticated animals reproduce very slowly and are expensive to work with, and therefore they are not as suitable for experimental work as are the rodents. The latter, as for example rabbits and guinea pigs, are largely used by geneticists as experimental animals. It is taken for granted that what is learned from these animals can be applied to a great extent to the larger kinds of livestock.

Rabbits and guinea pigs are usually exhibited at "pet stock" shows and the awards are based to a fairly great extent on the conformation of the animals. Prize-winning animals should offer good material for the study of the mode of inheritance of the show type characteristics. Ibsen (1927) has made a genetic analysis of color in show guinea pigs, but states that little or nothing has been done with the conformation. He points out that some of the desirable characteristics are "Roman nose", drooping ears, and a

"crest" back of the ears. The present investigation was started with the object of analyzing genetically the desirable body characters possessed by show type guinea pigs. Included amongst these characters are size and fatness as well as the points above enumerated.

MATERIALS AND METHODS

The original parental stocks used in this investigation were produced in the Animal Husbandry guinea pig laboratory at Kansas State College of Agriculture and Applied Science. The work was begun in the fall of 1935 with two females and one male of the show type and a similar number of non-show type animals. The latter came from stock that had been inbred for a number of generations. All of the animals used were albinos. They were raised under practically identical conditions. Each kind of stock was increased by inbreeding the offspring. Usually they were mated when two months of age.

The same standard ration was fed to the animals throughout the investigation. It consisted of a "grain" mixture containing rolled oats (92 1/4 per cent), wheat shorts (3 per cent), skimmed milk powder (3 per cent), tankage (1/2 per cent), bone meal (1/2 per cent), salt (1/2 per cent) and vitamin D yeast (1/4 per cent). In addition, the animals were fed alfalfa hay, and green roughage, grown out-

doors, during the warmer months. Sprouted oats was substituted for the green roughage to supply vitamin C during the winter season.

As the animals grew, careful measurements both as to size and weight were taken at regular intervals for all animals of both types. These measurements included body length, body circumference, distance between eyes, distance between ears, head length from the base of ear to the tip of nose, head length from supra-occipital to the tip of nose, head depth, depth of the upper lip, length and width of ear, thickness of upper and lower parts of ear. Body weight was also recorded at the time the different measurements were taken of the animal. A steel ruler, graduated to the tenth of a centimeter, was used for taking the different head measurements. Thickness of ear was measured with a micrometer graduated to 0.01 mm. Body length was taken by pressing the animal flat on the edge of a table marked off with centimeters. Body circumference was obtained by placing a centimeter cloth tape around that part of the belly giving the greatest measurement. For the depth of head, a vernier caliper of steel, with roller adjustment, was used. The jaws of the caliper were so adjusted as to exert only a slight pressure on the face and the lower jaw of the animal during measurement. All measurements were

taken at birth and at 60, 120, 180, 270 and 360 days of age. Photographs were taken at a fixed distance for all animals measured in order to show the relative size and development of both types. Every measurement and photograph was taken by the writer in order to equalize the personal factor, which as a result may be considered to have been held at a minimum.

STATISTICAL ANALYSIS OF DATA

Up to the present nothing whatever has been published on the inheritance of conformation in guinea pigs. Meager results have been obtained on conformation of cattle by Gowen (1925) and on size and conformation of sheep by Ritzmann (1923). McPhee and Eaton (1931) have studied the differences in body weights of five inbred families of guinea pigs. Their conclusion is that the young produced by crossing heavy strains with light strains have a growth curve approaching that of the heavier line. They state that the influence of crossing persists into the second generation, although there is no indication of segregation of the genetic factors controlling weight. Sorin (1932) found that there was considerable fluctuation in growth, as measured by body weight, of 42 guinea pigs between birth and 340 days of age. His conclusion is that a part of the fluctuation is

due to such factors as temperature, food, and irritations of various kinds. Other causes for fluctuation are genetic factors and the size of litter.

In general, it is true that guinea pigs born in litters of two are heavier individually at birth than are those from litters of four or five. In the present investigation, however, the birth weight of show type stock is greater than that of the non-show type, even though the former may come from litters of four and the latter from very small litters. Nevertheless, within each type the animals from smaller litters are heavier at birth than are those from large litters.

Observations on the Differences in Morphology and Disposition Between the Show and Non-show Types

Certain differences between the two types of animals are quite evident even to the casual observer. The show type animals are invariably fatter and more quiet than the non-show type animals. The distance between the eyes in show animals is greater, and the ears are larger and more drooping. The eyes of show type animals are more prominent than are those of the non-show, and are also more sensitive to extremely bright light. Because they are more quiet, the show type animals are more easily handled than the non-show

in the taking of measurements, photographs, and weights. These observed differences can be shown to be statistically significant. The measurements obtained can also be used in determining the right proportions for a good show animal. All of the measurements taken are summarized in Tables I and III.

Since the beginning of this investigation in the fall of 1935 till May 4, 1937, the total number of young produced in the non-show type stock has been 66 (from 28 litters), and in the show stock, 40 (from 11 litters). Thus the average number of young per litter in the non-show type is 2.35, while in the show type it is 3.64. On the other hand, the mortality at birth percentage has been about twice as high in the show type as in the non-show type, thus making the number per litter that lived about the same. During the growth of the young, some from each type have died and a few have been discarded because of deformities. For this and other reasons, a varying number of individuals will be found in each of the different age groups.

Table I shows the marked difference in body weight of the two types. The body circumference difference is less marked than is that for body length, but both are significant statistically in the older animals, especially in the 270 day group, where the number of individuals is fairly

Table I. Body measurements and weights of show and non-show guinea pigs.

Types	Show						Non-show					
Age in days	At birth	60	120	180	270	360	At birth	60	120	180	270	360
No. of animals included	21	19	19	15	11	5	44	38	29	22	20	10
Body length	14.23 ± 0.14	24.03 ± 0.18	27.34 ± 0.17	28.66 ± 0.22	29.90 ± 0.15	30.60 ± 0.25	14.39 ± 0.09	23.63 ± 0.08	26.43 ± 0.07	27.33 ± 0.11*	28.38 ± 0.09	28.86 ± 0.13**
Body circumference	10.20 ± 0.11	19.57 ± 0.33	22.55 ± 0.29	23.36 ± 0.29	25.23 ± 0.15	25.40 ± 0.62	10.27 ± 0.09	18.71 ± 0.16	21.33 ± 0.18	22.23 ± 0.21	23.35 ± 0.23	23.55 ± 0.24
Body weight	85.09 ± 2.53	413.97 ±12.33	642.01 ±18.01	723.76 ±15.02	893.09 ±13.77	951.00 ±37.83	84.46 ± 1.39	383.84 ± 4.98	523.71 ± 5.47	598.56 ±10.09	672.20 ± 8.29	713.87 ± 8.36

* 24 animals measured
** 11 animals measured

high. In the present investigation no difference is considered statistically significant unless it is at least 4.5 times as large as its probable error.

Beginning with animals 120 days old, the differences between the two types is decidedly significant in regard both to body weight and body length. For body circumference, the present data show a decided difference only in the 270 day stage. As more data are acquired, it seems probable that significant differences will also show in other stages. Graphs based on mean body weights of show, non-show, and F_1 hybrids are shown in Fig. 1. Similar graphs based on body length and body circumference are shown in Fig. 2. The non-show curves are smoother chiefly because they are based on measurements taken from a larger number of individuals.

The number of F_1 animals born to June 10, 1937, is 23. These came from 10 litters and therefore averaged 2.3 per litter. On the above date the oldest were only slightly over 4 months old. Table II is a summary of the body weights, body length and body circumference. The data, so far as they go, show that the F_1 animals very closely approximate the P_1 show animals, indicating that the genes controlling show type are dominant to those for the non-show type. This resemblance is shown graphically in Figs. 1 and 2.

Table II. Mean body weights and measurements of the F_1 generation.

Age in days	newly born	60	120
Body length (cms.)	14.47 ± 0.13	24.88 ± 0.17	27.50 ± 0.15
Body circumference (cms.)	10.26 ± 0.01	20.16 ± 0.18	23.00 ± 0.31
Body weight (gms.)	89.18 ± 0.99	466.07 ±10.50	662.98 ± 16.23
No. of animals	23	9	5

Table III contains the head and ear measurements of the two parental types. The growth curves based on these measurements, and also including the F_1 results, are shown in Figs. 3 to 5. Since the show type is heavier throughout, one would expect the head to be larger also. The only exception is head length. The reason for this is that the show animals tend to have short, wide and deep heads, while those of the non-show are the reverse. Consequently, at 360 days of age the length of the show type head is approximately the same as that of the non-show type.

In every other respect the show type head is larger throughout the period of growth. This is even true when

Table III. Head and ear measurements of show and non-show guinea pigs.

Age in days	At birth		60		120		180		270		360	
	No. of animals included	Measurement (cm.)	No. of animals included	Measurement (cm.)	No. of animals included	Measurement (cm.)	No. of animals included	Measurement (cm.)	No. of animals included	Measurement (cm.)	No. of animals included	Measurement (cm.)
SHOW TYPE												
Distance between eyes	21	2.04 ± 0.03	19	2.62 ± 0.02	19	2.84 ± 0.02	15	2.95 ± 0.02	11	2.96 ± 0.02	5	3.02 ± 0.04
Distance between ears	20	1.96 ± 0.03	19	2.48 ± 0.02	19	2.77 ± 0.02	15	2.91 ± 0.03	11	2.96 ± 0.03	5	3.04 ± 0.07
Length of ears	17	2.56 ± 0.03	15	3.17 ± 0.03	17	3.43 ± 0.03	15	3.58 ± 0.02	11	3.66 ± 0.02	5	3.66 ± 0.04
Width of ears	12	1.66 ± 0.05	15	2.19 ± 0.03	17	2.32 ± 0.02	13	2.39 ± 0.03	10	2.48 ± 0.03	6	2.51 ± 0.04
Thickness of ears: upper			15	0.72 ± 0.01 (mm.)	17	0.85 ± 0.01 (mm.)	15	0.89 ± 0.02 (mm.)	11	0.92 ± 0.02 (mm.)	5	0.96 ± 0.02 (mm.)
Thickness of ears: lower				0.94 ± 0.01		1.03 ± 0.02		1.07 ± 0.02		1.07 ± 0.01		1.16 ± 0.04
Head length from base of ear to tip of nose	21	3.67 ± 0.03	19	5.08 ± 0.04	19	5.44 ± 0.04	15	5.62 ± 0.05	11	5.79 ± 0.06	5	6.04 ± 0.07
Head length from supra-occipital to tip of nose	12	4.58 ± 0.05	15	6.49 ± 0.05	17	7.10 ± 0.06	13	7.18 ± 0.07	12	7.52 ± 0.06	6	7.57 ± 0.06
Head depth	17	2.08 ± 0.01	15	3.01 ± 0.02	17	3.35 ± 0.02	15	3.51 ± 0.02	11	3.62 ± 0.02	5	3.74 ± 0.03
Depth of upper lip	17	1.45 ± 0.02	19	2.13 ± 0.02	19	2.36 ± 0.02	15	2.51 ± 0.02	11	2.51 ± 0.04	5	2.64 ± 0.03
NON-SHOW TYPE												
Distance between eyes	44	1.99 ± 0.01	38	2.47 ± 0.01	29	2.61 ± 0.02	24	2.63 ± 0.02	20	2.71 ± 0.02	11	2.76 ± 0.03
Distance between ears	44	1.89 ± 0.02	38	2.32 ± 0.02	29	2.56 ± 0.02	24	2.62 ± 0.02	20	2.73 ± 0.04	10	2.71 ± 0.04
Length of ears	34	2.48 ± 0.02	34	2.97 ± 0.02	29	3.11 ± 0.01	24	3.17 ± 0.01	20	3.24 ± 0.01	10	3.30 ± 0.02
Width of ears	34	1.66 ± 0.01	29	1.98 ± 0.01	25	2.08 ± 0.01	24	2.08 ± 0.01	19	2.15 ± 0.02	10	2.25 ± 0.02
Thickness of ears: upper			32	0.66 ± 0.01 (mm.)	29	0.71 ± 0.01 (mm.)	24	0.74 ± 0.01 (mm.)	20	0.75 ± 0.01 (mm.)	10	0.81 ± 0.01 (mm.)
Thickness of ears: lower				0.86 ± 0.01		0.89 ± 0.01		0.93 ± 0.01		0.93 ± 0.01		1.00 ± 0.02
Head length from base of ear to tip of nose	44	3.83 ± 0.03	38	5.10 ± 0.02	29	5.43 ± 0.03	24	5.57 ± 0.04	20	5.74 ± 0.04	11	5.78 ± 0.06
Head length from supra-occipital to tip of nose	32	4.89 ± 0.09	29	6.51 ± 0.04	25	6.99 ± 0.04	24	7.26 ± 0.05	19	7.32 ± 0.05	10	7.53 ± 0.06
Head depth	38	2.09 ± 0.01	34	2.88 ± 0.02	29	3.10 ± 0.01	24	3.18 ± 0.02	20	3.26 ± 0.02	10	3.37 ± 0.03
Depth of upper lip	43	1.48 ± 0.02	38	1.97 ± 0.02	29	2.23 ± 0.01	24	2.30 ± 0.01	20	2.30 ± 0.02	11	2.24 ± 0.02

animals of the same weight, belonging to the two types, are compared. For example, show animals 180 days old are approximately the same weight as non-show 360 days old. Yet they have heads that are larger, except in length, than the non-show. With the small numbers involved, these differences are not significant, but there is every reason for believing that with additional data it will be shown that the show type head is distinctly different from the non-show.

Measurements have also been made of the ears, and it has been demonstrated that the show type ears are thicker and larger than the non-show. Graphs have been made to show both the head and the ear measurements (Figs. 3 to 5). These figures also contain the F_1 graphs, and show that the F_1 animals closely resemble the P_1 show type stock.

The means of the head and ear measurements of the F_1 animals have been placed in Table IV, and are the basis for the F_1 graphs shown in Figs. 3 to 5.

In Plates I to III are photographs of typical show type, non-show type, and F_1 animals.

Table IV. Mean head and ear measurements of the F_1 generation.

Age in days	Newly born	60	120
Distance between eyes (cms.)	2.02 ± 0.014	2.47 ± 0.023	2.72 ± 0.044
Distance between ears (cms.)	1.92 ± 0.013	2.53 ± 0.030	2.78 ± 0.052
Head length from base of ear to tip of nose (cms.)	3.73 ± 0.031	5.06 ± 0.035	5.54 ± 0.070
Head length from supra-occipital to tip of nose (cms.)	4.69 ± 0.032	6.37 ± 0.038	6.96 ± 0.070
Head depth (cms.)	2.07 ± 0.014	2.96 ± 0.021	3.26 ± 0.033
Depth of upper lip (cms.)	1.43 ± 0.013	2.04 ± 0.030	2.32 ± 0.075
Length of ear (cms.)	2.58 ± 0.044	3.15 ± 0.019	3.40 ± 0.019
Width of ear (cms.)	1.78 ± 0.022*	2.22 ± 0.025	2.30 ± 0.019
No. of animals	23	9	5

* Only 22 animals were measured.

Feed Consumption in Relation to Gain in Body Weight

Since the two types of animals grow at different rates, the difference in body weight may be due to the fact that one type either eats more feed or utilizes it better than does the other. There is also the possibility that the faster growing type does both, i.e., eats more and makes better use of its feed. The results obtained with a few animals favors this last mentioned possibility.

Method and Feeds Used. Two animals of opposite sex were selected respectively from the show, non-show and hybrid stocks. All six animals were slightly over two months old and therefore were approximately the same age. Even at that time the show and F_1 animals were larger than the non-show. The non-show female died about a week after the experiment was started and therefore her data are not included.

In an experiment of this kind, it is necessary that the feed be as uniform as possible. For that reason a special commercial ration was used. The ration has a guaranteed analysis as follows:

Crude Protein not less than	13.5%
Crude Fat not less than	2.5%
Crude Fiber not less than	16.0%
Nitrogen-Free Extract not less than	47.0%

Ingredients: Wheat germ, soy bean oil meal, chopped alfalfa, crushed oats, wheat middlings (standard), corn germ meal, cracked corn, molasses, calcium carbonate, .5% iodized salt.

The ration, as purchased, consisted of clumps of various sizes and kinds, which made it possible for the guinea pigs to practice selection, thus making it difficult to get them to eat the residue. This feature was eliminated by grinding the feed into a fairly coarse homogeneous mixture. Besides being fed weighed amounts of this ration, each animal was given daily by means of a pipette, 3 milligrams of Cevitamic acid (or l-ascorbic acid) in aqueous solution, to prevent it from getting scurvy. The solution was obtained by dissolving two tablets (25 milligrams each) into 25 cc. of ordinary tap water. The non-show female struggled so violently each time she was given the solution that this either directly or indirectly led to her early death. Each animal was forced to clean up all of its feed before any more was given to it. As previously stated, a record was kept of the weight of the feed eaten.

The cages were so constructed that no bedding could be touched. The bottoms consisted of two layers of screens, the upper of which had larger holes to allow the feces to go through, and the lower was fine meshed enough so that the feces collected on it. The urine went through both layers and was absorbed by fresh wood-shavings placed on the bottom of the cage. The animal thus rested on the upper layer of wire mesh about 3 inches above the wood-shavings. Water in a dish and a piece of salt were supplied to each animal. Thus all the animals were kept under uniform conditions. The results are summarized in Table V.

Presentation of Results Obtained. The data presented in Table V are by no means conclusive because of the small number of animals used, but since the differences are so exceedingly great between the two show animals and the one non-show, there is justification for assuming that further tests will lead to similar results. It will be noted that the non-show male required three times as much feed as the show male to make the same amount of gain, and thus, in spite of the fact that the show male was considerably larger throughout the experiment, the latter not only ate more feed, but made much better use of it.

The F_1 animals as a whole resemble the show type fairly closely. One would therefore expect that this resemblance would be evident in the feeding trials. This proved

Table V. Food consumption and gain in body weight of show, non-show and F_1 animals.

Kind	Sex	Initial body wt. in grams	Days on feed	Final body wt.	Total feed consumed in grams	Daily feed in grams	Total body wt. gain in grams	Daily body wt. gain in grams	Feed per 100 grams gain
Show	Female	495.8	64	632.0	2309.2	36.08	136.2	2.130	1696.0
	Male	582.0	60	890.2	3001.0	50.02	308.2	5.180	973.7
F_1	Female	510.5	64	633.5	2266.8	35.42	123.0	1.921	1842.9
	Male	495.3	60	736.2	2453.7	40.89	240.9	4.015	1018.5
Non-show	Male	468.5	60	542.3	2234.6	37.24	73.8	1.230	3027.0

to be the case. The two F_1 animals were slightly under the two show type in their ability to make gains per unit of feed consumed.

One expected result was that the two females did not utilize their feed to as great advantage as did their respective males. The difference between the sexes in the two pairs is considerable, but it seems advisable to make many more tests before drawing any conclusions.

SUMMARY

1. Show type guinea pigs grow at a more rapid rate and become larger than do the non-show animals.

2. The head of the show animal is wider, deeper, but proportionately shorter, than the non-show. In actual head length the two types are very similar.

3. The ears of the show animal are larger, thicker, and more drooping than those of the non-show.

4. The F_1 animals very closely resemble the show type parent, thus furnishing evidence that the show type characteristics are due to dominant genes.

5. When tested under uniform conditions, two show type animals of opposite sex were found to make gains in body weight on a proportionately much smaller amount of

feed than did a non-show type male.

6. The two F_1 animals of opposite sex that were tested resembled the two show type individuals fairly closely, but did not make their gains in body weight quite as economically.

7. The show type female and the F_1 female required more feed per unit gain than their respective males.

ACKNOWLEDGMENT

The writer wishes to express his gratitude to Dr. H. L. Ibsen for his critical interest in undertaking the matings of animals, and for his kind instructions and untiring guidance throughout the investigation, and to Dr. J. S. Hughes, Dr. C. H. Whitnah and Prof. A. D. Weber for their valuable suggestions in the feeding experiment.

LITERATURE CITED

Gowen, J. W.
Studies on conformation in relation to milk producing capacity in cattle. IV. The size of the cow in relation to the size of her milk production. Jour. Agri. Research, 30(9):865-869. 1925.

Ibsen, H. L.
Genetics and the production of show type animals. The application of scientific methods to the production and the analysis of show type animals with special reference to guinea pigs. Jour. of Heredity, 18(16): 241-243. 1927.

Mcphee, Hugh C. and Orson N. Eaton.
Genetic growth differentiation in guinea pigs. U.S. Dept. Agr. Tech. Bul. 222:1-36. 1931.

Ritzman, E. G.
Inheritance of size and conformation in sheep. New Hampshire Tech. Bul. 25, 36 p. 1923.

Sorin, E. N.
Das Wachstum der Meer-schweinchen bei ausreichender, gemischter Nahrung, mit besonderer Berucksichtigung der Einlinge, Zwillinge, Drillinge und Vierlinge. Wiss. Arch. Landwirtsch. Abt. B. Arch. Tiererhähn. u. Tierzucht, 7(3):328-345. 1932.

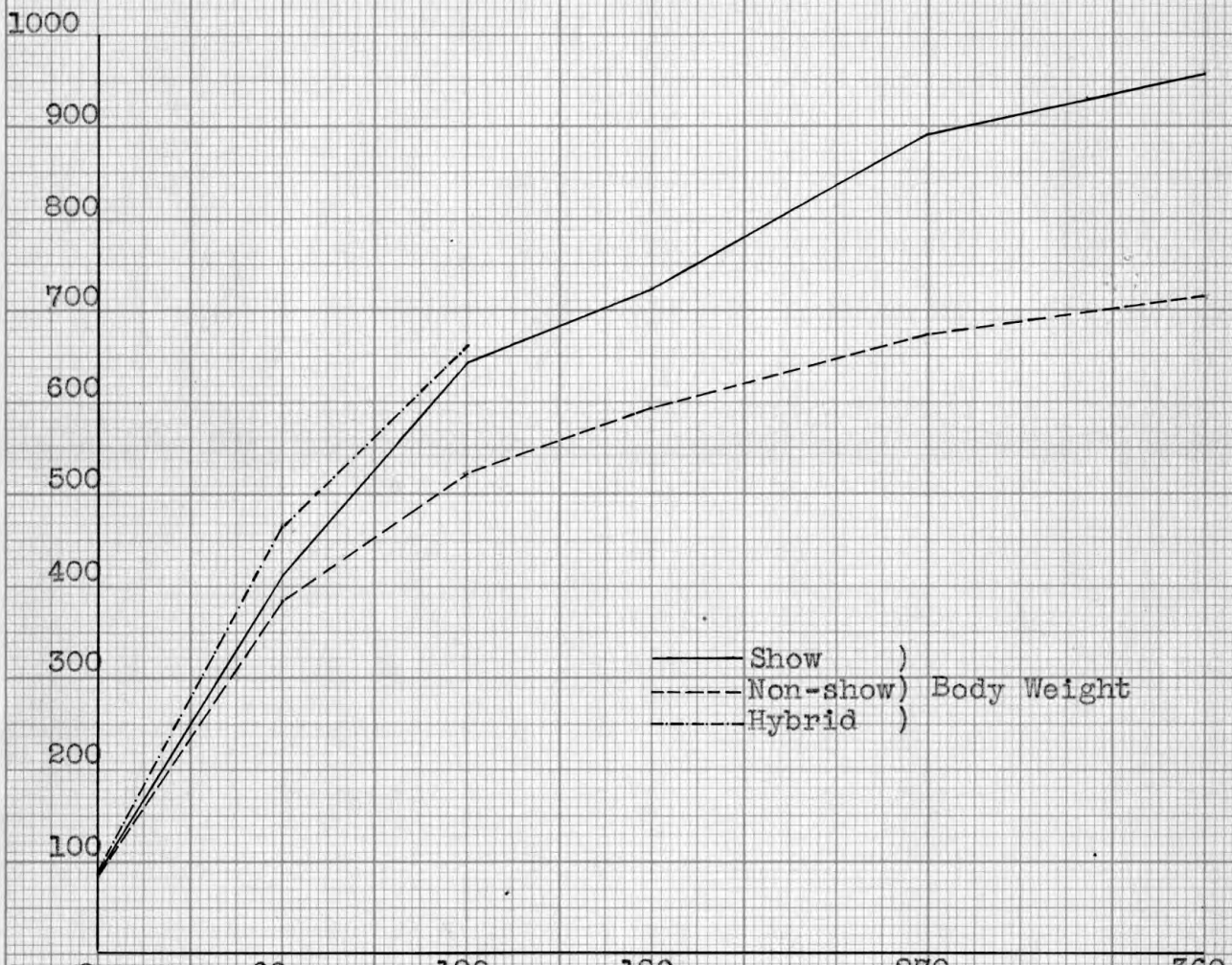

Fig. 1. Graphs showing growth in body weight.

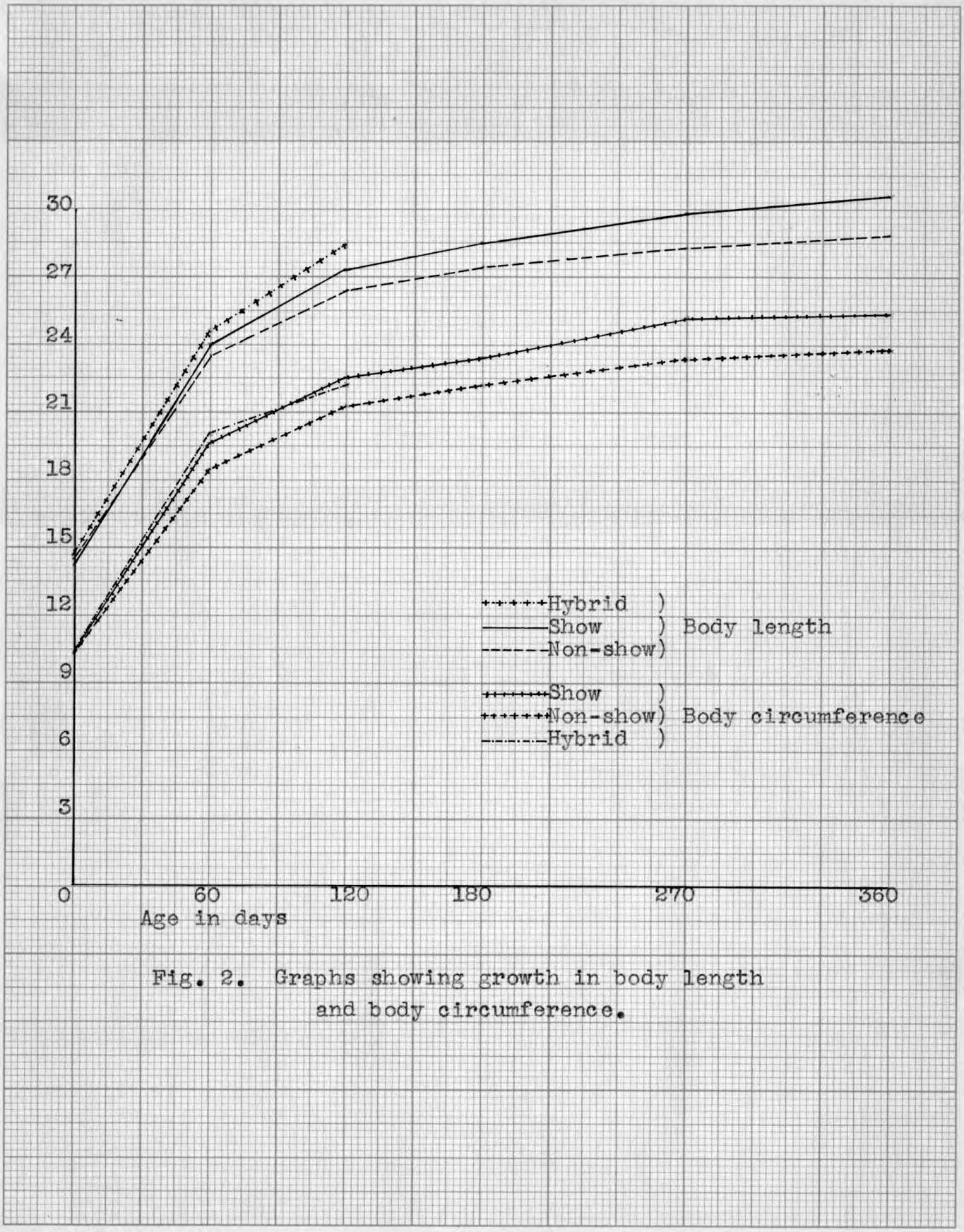

Fig. 2. Graphs showing growth in body length and body circumference.

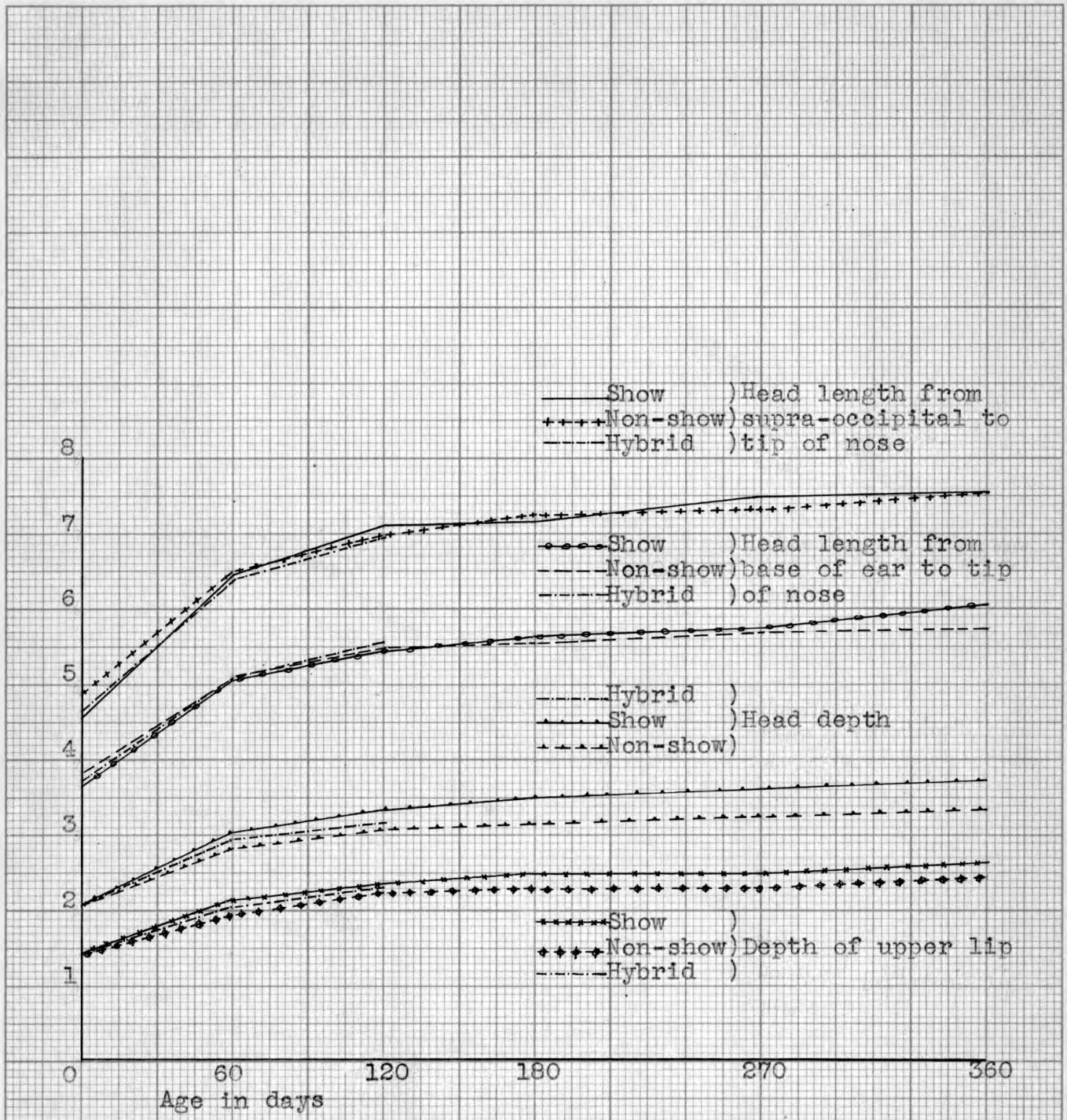

Fig. 3. Graphs showing growth in certain head measurements.

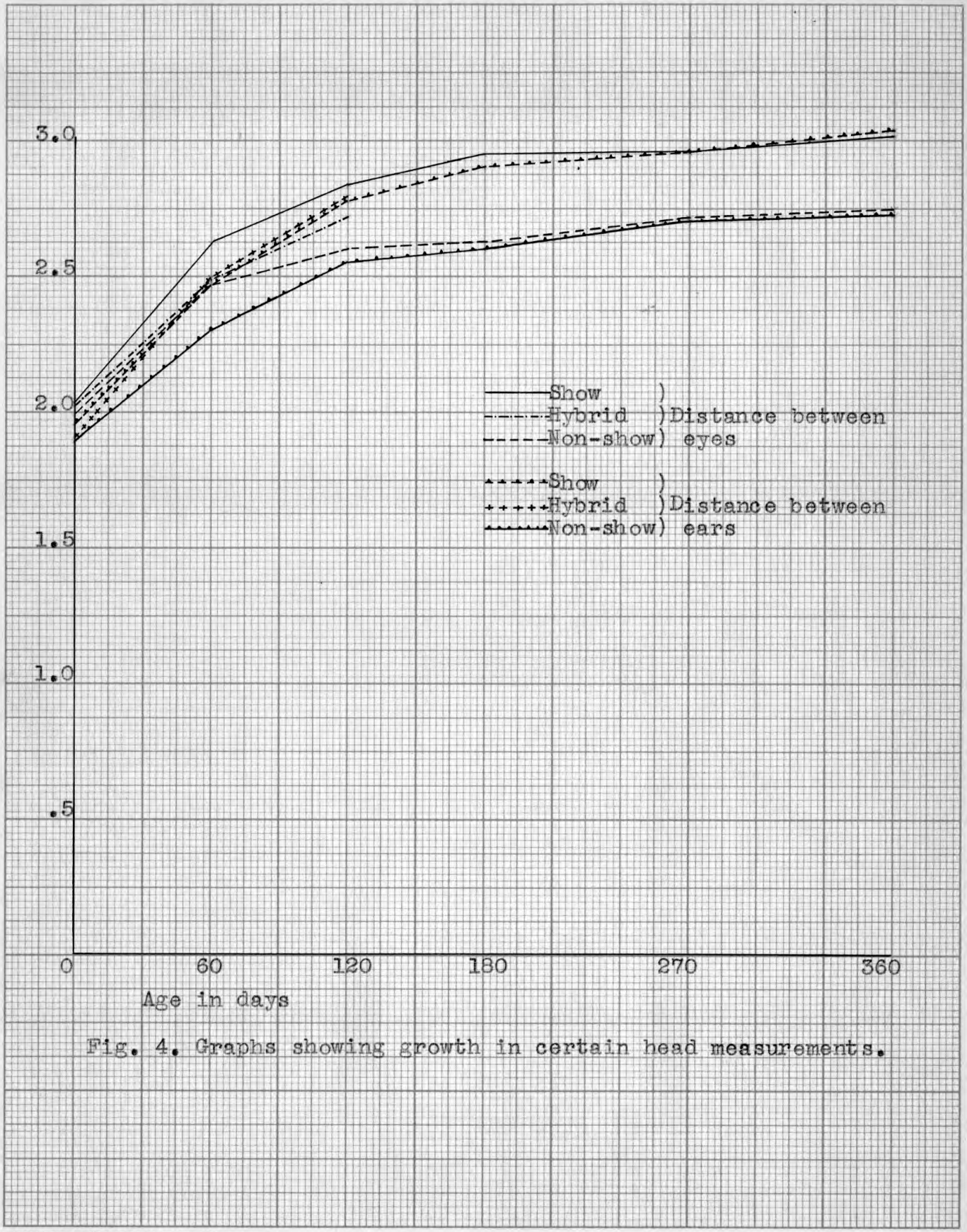

Fig. 4. Graphs showing growth in certain head measurements.

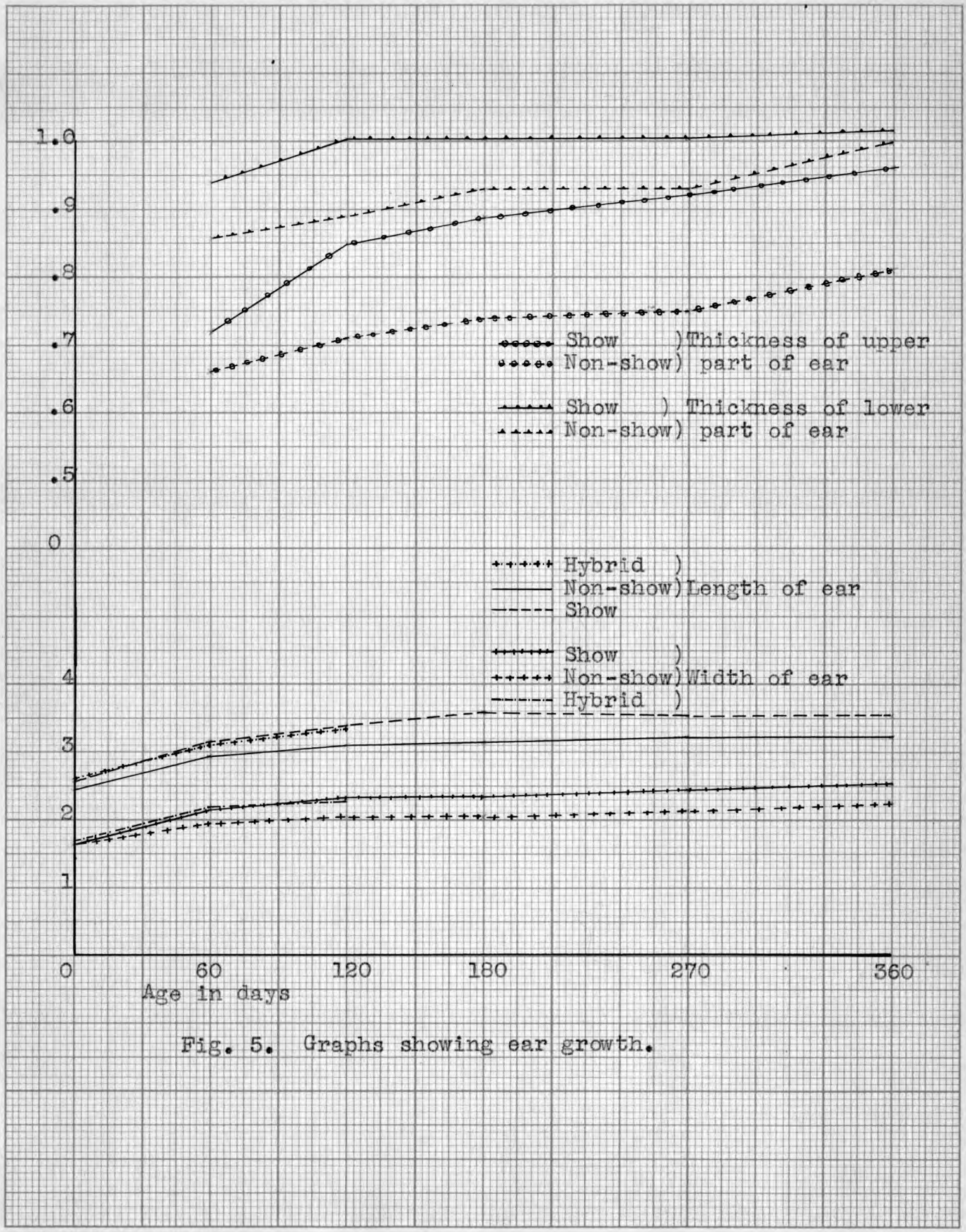

Fig. 5. Graphs showing ear growth.

Explanation of Plates I to III

Plate I

Side and front views of S-85.3, show type female, at 9 months of age.

Plate II

Side and front views of S-259.3, non-show female, at 9 months of age.

Plate III

Side and front views of S-878.3, F_1 female, at 6 months of age (at present no F_1 animal is 9 months of age).

Plate I

Plate II

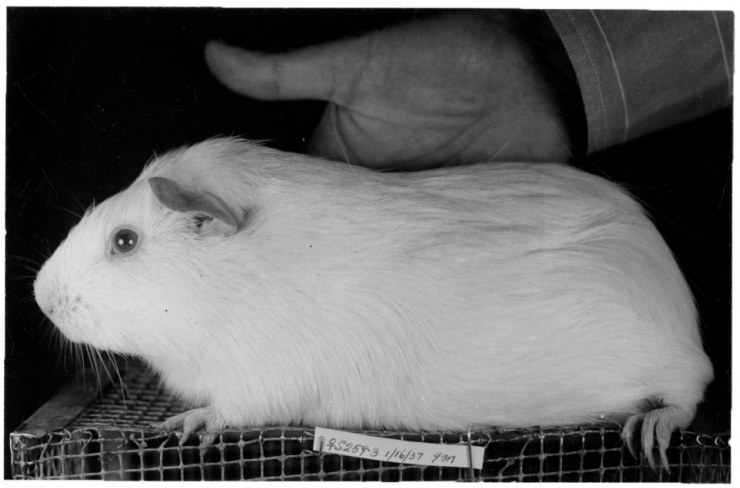

Plate III