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OBSERVATIONS ON THE STRENGTH OF THE CHIMPANZEE AND ITS IMPLICATIONS

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[*Plate 1*]

Some time after making the tests of the strength of the chimpanzee and orang described in the April issue of THE SCIENTIFIC MONTHLY, 1923, the author endeavored to secure further data, to interpret some of those already gained, and also to ascertain various implications which might open further fields of inquiry.

The dynamometer employed was of 2000 pounds maximum capacity. It is based upon the principle of an elongated metal loop which upon being placed under tension in the direction of its long axis shortens in the direction of its transverse axis, thus moving, in a metal chamber situated in the center of the oval, machinery which turns a pointer. This pointer automatically retains its position at the maximum reading until reset.

The dynamometer was at all times outside of the anthropoid's cage, the animal pulling on a looped rope which was passed through the bars and was attached to one end of the dynamometer, the other end of the latter being fastened firmly to the metal-work in front of the cage by a heavy steel chain. The end of the dynamometer farthest from the rope was fastened to a board on which it lay, the other end being left free in order that the entire stress should come upon the dynamometer itself. The board merely served to prevent the dynamometer from turning over, possibly catching the pointer on some object and thus giving a false reading. This point was carefully watched, but no difficulty was

experienced with the strong smooth pulls which were significant. The dynamometer has been used for testing the back and leg strengths of Muhlenberg College students for anthropometric records and was installed by the Narragansett Machine Company.

In the first of these endeavors only meagre success was attained, since a representative strength test can generally be secured only from an anthropoid of distinctly vicious disposition and then only in a limited interval of time.

The results were not wholly barren, however. Suzette showed none of her former zeal to pull the apparatus apart, and her attitude was such as to warrant the conviction that she remembered it, though the last test had been made many months previously. However, she made a very deliberate two-hand pull, without appearing to exert herself notably. The pull registered 905 pounds on the dial of the recording device. Although less than her previous 1260-pound test, this pull by its very deliberateness and absence of particular effort seemed almost more impressive to the author.

In the case of the good-natured ape Boma there was even stronger indication of recognition of the apparatus; both his previous fear and subsequent curiosity being completely lacking. In fact he acted precisely as he did at the close of the last strength test after he had lost interest in the now familiar apparatus.

Chimpanzee Fanny, who previously refused to have anything to do with the apparatus, was at this later time in her menstrual period, which in some, though not all, apes makes a radical difference in disposition for the time being. Unlike Suzette in whom menstruation makes no obvious difference, Fanny changes from her usual good nature to an extremely violent and vicious mood. No one, not even the keepers, dare trust themselves within her reach at such times; the sight of anyone closely approaching her cage seems to throw her into a veritable frenzy of rage and she grabs at them through the bars with a viciousness which one is tempted to call diabolical, uttering shrill screeches meanwhile. This hostility is not manifested toward her fellow chimpanzees, however.

The author naturally concluded that she would act like Suzette did in the first test, but it turned out very differently. She seized the rope loop, but instead of pulling on it whipped it to and fro violently, screeching at the top of her lungs. She also varied this procedure with furious futile attempts to grab the author and the keeper, who were standing beside the recording device. It was very illustrative of Fanny's trans-

port of rage that she should try to grab persons so far out of her reach. Suzette, though vicious, would not waste her energy in attempts having not the slightest prospect of success.

Plans to secure records at Chicago, Cincinnati, and Pittsburgh proved useless because these zoological gardens had no anthropoid apes of requisite size and disposition. An attempt was scheduled, with very good promise of results, to test the very vicious chimpanzee Mimi of the Philadelphia Zoological Garden, but two days before the date set she developed a limp which persisted until she died several months later, when it was discovered that a compound fracture of the hip bone sustained in some unknown manner had resulted in septicemia and numerous other serious ailments ending in terminal pneumonia, as mentioned in the author's work "Out of the Valley of the Forgotten."

Johanna, a chimpanzee almost as large as Boma (who is the largest chimpanzee at present in captivity), showed a most ludicrous fear of the apparatus. Only on one occasion did she make a pull, but she was at the time in a runway between her indoor and outdoor cages, in which she was cramped for room and moreover assumed so strange and awkward an attitude to pull, not even bracing herself against the framework, that her record of 378 pounds means little except that in so awkward a position the ape could pull more than the average man under the best conditions.

The two small orangs and a 95-pound chimpanzee at this garden were also tested, but did nothing worth recording. They just played with the apparatus.

The author wishes to take this opportunity to express his appreciation of the courtesies and helpfulness of Directors Brown and Hornaday of the Philadelphia and New York zoological gardens and to the keepers and veterinaries of these institutions which rendered feasible the tests, as well as to make grateful acknowledgment to his Alma Maters, Muhlenberg College and Lehigh University, for the loan of apparatus.

The second of the three objectives proved very interesting. Although Suzette's 1260-pound two-hand pull seems to have appeared more impressive to most people than Boma's right hand 847-pound pull, the author judged from the mechanical disadvantages of the position that the latter really was the more significant of the two.

To test this fact he secured the coöperation of a number of students of the college at which he was teaching, Augustana College, at Sioux Falls, South Dakota. Most of these students were members of the

college football team who had been working hard on the farm before coming to college that fall and were therefore well developed muscularly and in good condition.

Two series of tests were made. The first series was made in right-hand pulls in a position as nearly as possible identical with the one in which Boma made his pull and on the same apparatus. The second series was made in two sections, one of quick two-hand pulls and the other of slow two-hand pulls.

TABLE 1

Table of one-hand and two-hand pulls

TEST NUMBER	INDIVIDUAL	WEIGHT OF INDIVIDUAL STRIPPED	FORCE OF RIGHT-HAND PULL	TWO-HAND PULL	
				Speed	Force
		pounds	*pounds*		*pounds*
1	Mr. Fjellstedt	155	180	Fast	395
	Mr. Fjellstedt	155		Slow	368
2	Mr. E. Ormseth	140	No test	Fast	380
	Mr. E. Ormseth	140		Slow	382
3	Mr. Peterson	137	147	Fast	360
	Mr. Peterson	137		Slow	271
4	Mr. Green	145	170	Fast	328
	Mr. Green	145		Slow	393
4a	Mr. Green*	145		Fast	428
	Mr. Green	145		Slow	491
5	Mr. Anderson	166	No test	Fast	327
	Mr. Anderson	166		Slow	397
6	Mr. Gunderson†	170	210	Fast	360
	Mr. Gunderson	170		Slow	340
7	Mr. M. Ormseth	127	170	Medium	460

* This individual had not pulled exactly in the desired position in the previous test and the test was therefore repeated.

† This individual had a slight injury to one arm just before the two-hand pull, which accounts for its relative inferiority to his one-hand pull, in which he was able to exert his full strength.

The two-hand pulls were only roughly comparable with Suzette's on account of lack of perfect homology in the attitude, but the one-hand pulls were made in a practically identical position. The results were as indicated in the table of one-hand and two-hand pulls.

In considering the above data one fact is very significant, that these men, used to hard manual labor, had to use a folded cloth in the palm of the left hand (which held to a fixed support so that the full strength could be developed, otherwise the person would just have pulled him-

self up to the apparatus by his right hand) to prevent the fixed support from cutting the hand.

The author endeavored to use a fixed support as closely as possible comparable to the sharp cornered steel door frame which Boma held with his left hand during his pull, and was struck by the fact that while Boma's horny fingers could hold onto a fairly sharp cornered metal piece during an 847–pound pull these men with all the calluses developed on their palms by farm labor could not exert their pulls ranging from 147 to 210 pounds without the above mentioned protection.

In order to make a just comparison with the two series of tests it was necessary, of course, to reduce to an equal weight basis. Inasmuch as the small number of anthropoid pulls only established the fact that the ape *could* pull the figures shown, simple averages were employed and no attempt was made to use biometric methods on the data.

Two-hand pulls reduced to basis of Suzette's weight

1. Fast $\frac{395 \times 135}{155} = 344$ pounds. Slow $\frac{368 \times 135}{155} = 321$ pounds.
2. Fast $\frac{380 \times 135}{140} = 366$ pounds. Slow $\frac{382 \times 135}{140} = 367$ pounds.
3. Fast $\frac{360 \times 135}{137} = 355$ pounds. Slow $\frac{271 \times 135}{137} = 267$ pounds.
4. Fast $\frac{328 \times 135}{145} = 305$ pounds. Slow $\frac{393 \times 135}{145} = 365$ pounds.
5. Fast $\frac{327 \times 135}{166} = 266$ pounds. Slow $\frac{397 \times 135}{166} = 327$ pounds.
6. Fast $\frac{428 \times 135}{170} = 339$ pounds. Slow $\frac{491 \times 135}{170} = 389$ pounds.
7. Medium $\frac{460 \times 135}{127} = 489$ pounds.

Suzette's superiority in strength, taking the fast pulls as most comparable

1. $\frac{1260}{344} = 3.66$
2. $\frac{1260}{366} = 3.44$
3. $\frac{1260}{355} = 3.55$
4. $\frac{1260}{305} = 4.13$
5. $\frac{1260}{366} = 4.73$
6. $\frac{1260}{394} = 3.20$
7. $\frac{1260}{589} = 2.57$

One-hand pull (right) reduced to basis of Boma's weight

1. $\frac{180 \times 165}{155} = 191$ pounds.
2. Not in this test.
3. $\frac{147 \times 165}{137} = 177$ pounds.
4. $\frac{170 \times 165}{145} = 182$ pounds.
5. Not in this test.
6. $\frac{210 \times 165}{170} = 204$ pounds.
7. $\frac{170 \times 165}{127} = 220$ pounds.

It is remarkable that only two out of five of these husky farm lads could approximate one fourth of Boma's pull, the position being fully as handy for man as for ape.

Expressing relative strength fractionally

1. Boma pulled $\frac{847}{191} = 4.43$ times this individual's maximum pull.
2. .....
3. Boma pulled $\frac{847}{177} = 4.78$ times this individual's maximum pull.
4. Boma pulled $\frac{847}{182} = 4.65$ times this individual's maximum pull.
5. .....
6. Boma pulled $\frac{847}{204} = 4.15$ times this individual's maximum pull.[1]
7. Boma pulled $\frac{847}{220} = 3.85$ times this individual's maximum pull.

The next step was to make an estimate, based on the proportion between the students' one-hand and two-hand pulls, of what Boma could pull with both hands; and then reduce this to an equivalent weight basis for a comparison with Suzette's strength. Fast pulls were used as the basis.

[1] Number 6, it may be remarked, was the captain of the football team and a line plunger noted throughout the state of South Dakota, yet he did not average quite one quarter of Boma's strength.

Ratios of two- to one-hand pull

1.	395 : 180 = 2.19	2.19
2.	Only in one test.	2.45
3.	360 : 147 = 2.45	1.93
4.	328 : 170 = 1.93	2.04
5.	Only in one test.	2.71
6.	428 : 210 = 2.04	
7.	460 : 170 = 2.71	5)11.32

2.26 average ratio between two- and one-hand pulls

$847 \times 2.26 = 1914.22$ pounds. (*Boma's estimated two-hand pull*)

$\frac{1914.22 \times 135}{165} = 1566$ pounds. (*If Boma weighed as much as Suzette*)

$$\frac{1560}{1260} = 1.24$$

Boma therefore appears to be 1.24 times as strong weight for weight as Suzette; as he is, his comparative strength comes out $\frac{1914}{1260} = 1.52$. He is half again as strong as his mate therefore. It is of interest to note that the figures 1.24 for relative and 1.52 for absolute superiority in strength are very common ones for human couples.

The third objective is pregnant with scientific interest. First since chimpanzees are so much stronger weight for weight, and also muscle girth for muscle girth, than men, to what factors do they owe this very striking superiority? Is the chimpanzee muscle of superior contractile quality square centimeter for square centimeter? Or is superior nervous stimulus exerted on the muscle fibres? Or is it partly one and partly the other? These questions are fraught with the greatest interest to the physiologist; a three or four to one difference certainly demands an explanation. No one could attribute it to exercise in comparing long captive chimpanzees with students fresh from strenuous farm labor.

Heredity suggests itself immediately, and rightfully so, but as the exigencies of an arboreal life in which strength is a prime asset have probably resulted in natural selection maintaining this high strength level, the further question suggests itself: Did our own arboreal ancestors possess a comparable strength, and if so at what period did such a high degree of strength cease to be an object of stringent selection and gradually diminish to a lower level? Furthermore heredity and selection might explain the original acquirement and subsequent transmis-

sion of such strength, but they leave the physiological problems of its immediate causation unexplained. It is the physiologist who must deal with these.

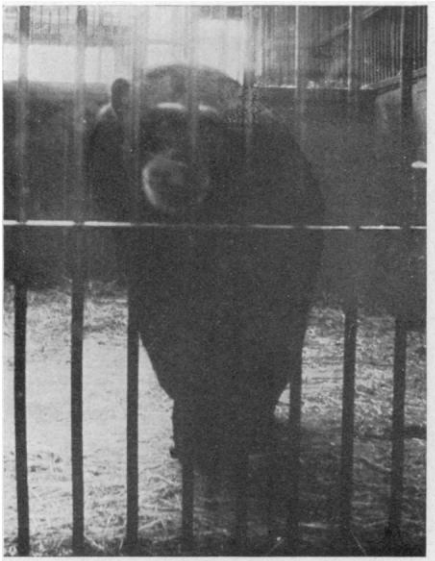
Taking a comparative view we find that, making the necessary allowances for difference in stature and amount of cross-section of muscle in proportion to body weight, man compares favorably with many, probably with most, other animals. We rank considerably above the Ungulata, and the oft-cited strengths of the beetle and ant, when duly corrected as just indicated, appear to be materially less than our own. Probably cross-section for cross-section of muscle man stands materially above the bulk of the animal species. The animals out-ranking him it would seem are the Carnivora, the other Primates, and such animals as the mole, etc.

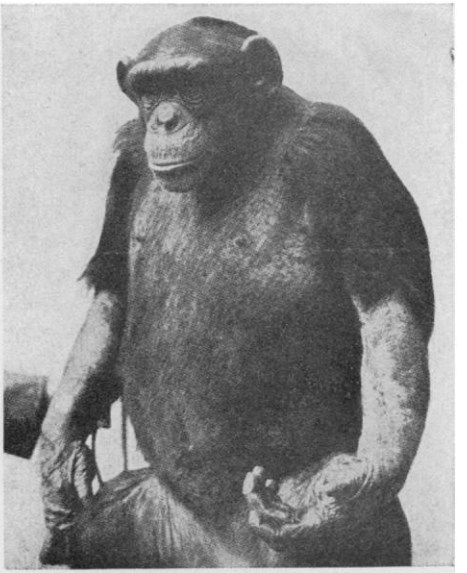
It would be an experiment both interesting and valuable to test the relative strength of the Felidae and the chimpanzee and orang, in order to determine which is entitled to the rank of greatest strength in the animal world per unit area of muscle cross-section. The author has thought of doing so himself, but the practical difficulties are immense in the case of the Felidae. Milo Hasting's statement is a true one that: "The cat tribe and man seldom if ever test their powers save in a manner in which weapons and not strength decide the issue."

The power of blow of the paw of a lion or tiger might perhaps be measured with a specially constructed apparatus and the power of spring by an arrangement of a net attached to a dynamometer dropped over the beast in the act of springing, but, difficult as this would probably prove to do, homologizing of the result with those of tests on the Primates bids fair to be a greater problem.

The last question raised by the strength of the chimpanzee seems to have been *completely* overlooked in the past. All anatomists place reliance upon the relative development of the various muscle attachment ridges and pits on the bones as a trustworthy indication of the strength of the owner.

Yet anyone who will take the trouble to compare carefully the crest of the ilium of the chimpanzee with that of the human being will notice that the muscle attachment roughnesses are very markedly less prominent in the former than in the latter, yet Suzette's pulls have clearly demonstrated an immense superiority in strength of the lumbar region in the ape. Also with regard to long sustained action, a short time spent in the anthropoidal posture will convince any person that this pos-





CHIMPANZEES UPON WHICH STRENGTH TESTS WERE MADE

Upper left figure: "Johanna," Philadelphia Zoological Garden. Upper right figure: "Suzette," New York Zoological Park. Lower figure: "Boma," photographed by E. R. Sanborn, New York Zoological Park.

ture calls for more taxing long sustained action of the lumbar muscles than does the erect posture of the human being.

We certainly can not look to man's erect posture for an explanation of the smooth sharp rim of the hip bone in the anthropoid ape, why then do the usually so reliable muscle attachments fail here to correctly indicate relative strength? The discrepancy is an extremely pronounced, not a trifling one, moreover.

And finally, how about those interesting Neanderthal men? We customarily base our estimate of their probable strength upon the degree of prominence of their muscle attachments as observed in the fossil bones—but should not the above consideration incline us toward caution in this class of inferences, particularly when the subjects are an ancient race known to have approximated closely to the anthropoidal type in their anatomy—as well as impel the comparative anatomist to a thorough investigation into the reason for this strange discrepancy.

Allentown, Pennsylvania.

NOTES ON THE MAMMALS OF NORTHWESTERN ALASKA

By Alfred M. Bailey and Russell W. Hendee

[*Plates 2–4*]

The expedition of the Colorado Museum of Natural History of 1921 and 1922 to northwestern Alaska was for the purpose of securing habitat groups of the birds and mammals of that interesting region. The large mammals of the Arctic coast of Alaska seem to be poorly represented in North American museums, and as it has been the policy of Mr. J. D. Figgins, the director of the Colorado Museum of Natural History, to represent "America First" in museum exhibits, we were sent north fully equipped for sixteen month's work beyond the Arctic Circle.

We left Seattle June 9, 1921, on the S. S. Victoria, and returned in October of the following year. Through the courtesy of Captain C. S. Cochran of the Coast Guard Cutter "Bear" we were able to visit King and St. Lawrence Islands in Bering Sea, and various points along the Siberian shore, and finally we were carried with our outfit to Wainwright, the town selected for our winter base. This little Eskimo village of some thirty igloos lies within one hundred miles of Point Barrow, the northern-