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C. C. Nutting

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It is not necessary in this connection to detail more countings of treated and untreated plats. The results all show with unmistakable evidence that there were no beneficial results in treating corn for Corn Smut.

In No. I., 6 smutted plants against 8 in check.

In No. II., 6 smutted plants against 7 in check.

In No. III., 42 smutted plants against 38 in check.

In No. IV., 38 smutted plants against 32 in check.

From these results it seems to me that something more must be learned about Corn Smut before we shall be able to treat the disease. I should not, however, consider these experiments conclusive.

These experiments should not be considered as showing conclusively that smut does not enter the delicate tissues of corn by way of the seed. Incidentally he referred to some experiments now carried on at the College Farm, in which ammoniacal carbonate of copper, Bordeaux mixture, and other substances were mixed with soil, in which, afterward, corn was planted. Ammoniacal carbonate of copper in soil retards the germination of corn.

Dr. Erwin Smith has called my attention to the Brefeld's work, in which he shows that Corn Smut will enter any merismatic tissue.

SOME OF THE CAUSES AND RESULTS OF POLYGAMY AMONG THE PINNIPEDIA.¹

BY C. C. NUTTING.

Several years ago the writer was much struck by the great sexual differences met with among the Gallinæ, and had noted the fact that there was a relation between sexual disparity in size and polygamy.

During the last summer an opportunity was afforded to carefully observe one species of the Pinnipedia, and these observations led to a perusal of all the available literature for facts concerning the relation between sexual disparity and polygamy in this order. The results of this study had already been outlined for a paper to be read before the Iowa Academy of Sciences, when an article appeared in the November number of the *Naturalist* entitled "Probable Causes of Polygamy Among Birds," by Samuel N. Rhoads.

The above facts are mentioned to show that the conclusions as to the cause of polygamy among birds on the one hand, and Pinnipedia on the other, were the result of independent investigations, and hence will serve to strengthen each other in some important particulars.

True polygamy is something of a rarity among the Mammalia. It must not be confounded with mere promiscuous sexual intercourse, such as is

¹ Paper read before the Iowa Academy of Sciences, Jan. 1st, 1890.

often met with among the Herbivora. The term polygamy, in its strict sense, can properly apply only to those species in which a single male habitually copulates with several females, and jealously and persistently defends them from the approach of other males.

The most typical examples of this state of affairs are met with among the Pinnipedia, and ultra polygamy is exemplified by the northern fur seal (*Callorhinus ursinus*).

Two striking facts at once arrest the attention of even the most cursory observer of this species:

1st, The astonishing extent to which polygamy is carried. Mr. Elliott thinks "that it will be nearly correct to assign to each male from twelve to fifteen females, occupying the stations nearest the water, and those back in the rear from five to nine. I have counted forty-five cows all under one bull."²

2nd, The no less astonishing disparity in size between the sexes. The average length of the male is $7\frac{1}{2}$ feet, while that of the female is 4 feet. The male weighs 450 lbs., while the female weighs only 85 lbs. It will thus be seen that the male weighs nearly *six times* as much as the female.

Two questions arise in view of the above facts:

1st, Is there any relation between polygamy and sexual disparity in size?
2nd, If so, what is that relation?

The Pinnipedia are fortunately sufficiently numerous in species and individuals to furnish an ample field for the study of both of the above questions. They are all eminently gregarious in habit, a condition favorable to polygamy. The order furnishes examples of both monogamous and polygamous species, and almost every degree of sexual disparity in size to be found in the Mammalia. We can easily construct a series of species, ascending from those exhibiting the least sexual disparity to those exhibiting the greatest. We can then see what, if any, relation exists between sexual disparity and polygamy. We shall presently see that pugnacity on the part of the males plays a not unimportant *role* in our discussion, and for that reason the fighting proclivities of the males will also be noted.

The following arrangement, then, illustrates what might be termed the ascending series of sexual disparity. The relation of the sexes (monogamy, promiscuity, or polygamy) and the relative pugnacity of the males in relation to other males of the same species will also be noted in each case.

Odobenus rosmarus (Walrus). (a) Sexes nearly equal in size, the female not being notably smaller than the male. (b) Monogamous, according to the only information at the disposition of the writer.³ (c) Disposition not at all quarrelsome, the animals of both sexes being singularly good-natured and peaceable, "huddling together like so many swine," although they will fight fiercely in defense of their young.

Cystophoro cristata (Hooded Seal). (a) Considerable sexual disparity. The male is 8 feet long, and the female 7 feet. Weight of male, 450 lbs.; female, 200 lbs. (b) Probably monogamous, although there is no direct evidence at hand. There is at least nothing to indicate that they are polygamous in the

² Quoted from "Monograph of North American Pinnipeds" (Allen). Nearly all the material used in the above article has been taken from that work.

³ Monograph of North American Pinnipeds, p. 107.

sense used in this paper. (c) The males fight fiercely for the possession of the females.

Erignathus barbatus (Bearded Seal). (a) Considerable sexual disparity. Length of male, 10 feet; length of females, 7 feet 4 inches. Weight of males, two and one-half times that of females. (b) Strictly polygamous, according to the single authority found. (c) Males often have severe battles, the strongest males driving away the younger.

Macrorhinus angustirostris (Sea Elephant). (a) Great sexual disparity. The weight of the male is three and one-half times that of female. (b) Polygamous.⁴ Elliott says that they "resemble the sea lion in their breeding

Eumetopias stelleri (Steller's Sea Lion). (a) Great sexual disparity. Length of males, 12 feet; of females, 8½ feet. Weight of male, three times that of female. (b) Strictly polygamous. This species maintains a regular harem, but "does not maintain any such regular system in preparing for and attention to its harem as is illustrated on the breeding grounds of the fur seal" (Elliott). (c) "The bulls fight savagely among themselves, and turn off from the breeding ground all the younger and weak males."

Callorhinus ursinus (Northern Fur Seal). (a) Extreme sexual disparity. The males weigh three times as much as the females. (b) Ultra polygamous, the males maintaining a large harem, and guarding the females with the greatest vigilance and courage. In fact, this animal is the most polygamous of all the Mammalia. (c) Males fight with greatest desperation and persistence for females.⁵

A consideration of the above series will disclose the fact that there is a close and constant relation between polygamy and disparity in size among the Pinnipedia. It also indicates that this relation is a *direct* one, the disparity increasing *pari passu* with the polygamy throughout the series. Another fact is rendered evident by this series, and that is that the combativeness of the males increases *pari passu* with sexual disparity and polygamy.

These facts having been reasonably well established, it is possible to construct a hypothetical history of events which will illustrate the successive stages by which a species might pass from a simply gregarious habit, in which monogamy, or at least promiscuity, prevails, to the extreme of polygamy practiced by the northern fur seal. Such a transition may be conceived to take place by the following steps or gradations:

1st. An eminently gregarious species would offer more favorable conditions for the introduction of polygamy than a nongregarious species. Our point of departure in this part of the discussion would then be a gregarious, monogamous species. If the principles deduced from an examination of the series presented in the first part of this paper be correct, this species should also be one in which there is little sexual disparity, and little or no fighting among the males for the possession of the females. All of the

⁴ "The sea elephants appear to be exceptional among the Phocidæ in the great disparity of size between the sexes, in which, as well as in their breeding habits, they closely resemble the Otaries." Monograph of North American Pinnipeds (Allen), p. 755. The italics are mine.

habits." (c) The males "fight desperately for the females."

⁵ Elliott says he has seen one male fur seal fight fifty or sixty battles during a single season.

above conditions seem to be fulfilled in the case of the walrus (*Odobænus rosmarus*). This species will then stand for our point of departure.

2nd. The gregarious habit of the walrus offers a constant opportunity for a departure from the path of monogamous rectitude. This fact is well illustrated in human affairs by the great amount of social immorality found among the crowded tenements of our large cities. Constant opportunity offers the most powerful temptation to gratify desire, and this is doubtless as true among Pinnipedia as among men. The result of this is a departure from strict monogamy in the direction of promiscuity.⁶ The harbor seal (*Phoca vitulina*) illustrates this stage in the process. So far as I can ascertain, this species is simply promiscuous in sexual affairs, but does not attain to polygamy in the sense used here. The sexual disparity is slight, the males being somewhat heavier, and but little, if any, longer than the females.

3d. The departure from monogamy in the direction of promiscuity results in constant rivalry on the part of the males to possess the most attractive, or the greatest number, of the females. Rivalry begets warfare, the world over. This purely individual and personal rivalry among the male Pinnipedia results in individual combats, in which courage, ferocity, and size are the controlling factors. We thus have instituted the most rigorous kind of sexual selection, by means of which the above desirable qualities are secured, propagated, and intensified on the part of the males. The females, on the contrary, seem to be practically passive. The writer has been unable to find any evidence that the female Pinnipedia exercise any choice in the matter of accepting or rejecting individual successful males. The sexual selection thus instituted is true sexual selection as defined by Darwin as follows: "This [sexual selection] depends on the advantage which certain individuals have over other individuals of the same sex or species, in *exclusive relation to reproduction*."⁷ It differs, however, from a vast majority of instances of sexual selection in apparent absence of choice on the part of the female.

This stage in the development of polygamy is illustrated by the hooded seal (*Cystophora cristata*), which appears to be promiscuous in sexual matters, and in which the males fight fiercely for the possession of the females. The divergence in sex has become considerable, as already indicated, the males being more than twice as heavy as the females.

4th. The struggle for the possession of the females having become a fixed and intensified habit, and the sexual disparity continuing to grow more pronounced, the following results might be expected:

(a) The larger and lustier males would have their desire greatly intensified and their sexual powers appreciably increased.

(b) The smaller and weaker males would be crowded to the wall, and, in many instances, entirely deprived of all conjugal rights, which would be usurped by the larger and stronger animals.

As a result of these conditions, certain males would obtain possession of several females, and deprive all other males of access to them. This would be *polygamy* in the sense used in this paper. The whiskered seal (*Erignathus*

⁶This word, although questionable, is the only one known to the writer by which the meaning, indiscriminate intercourse, can be tersely expressed.

⁷The Descent of Man, p. 248. The italics are mine.

barbatus), in which the male weighs two and one-half times as much as the female, and polygamy prevails, would illustrate this stage in the process.

5th. Polygamy having become a fixed habit, all the conditions would tend to accelerate the divergence in size between the sexes. The selection by which the bulkiest and most pugnacious males would succeed in obtaining the females would be as rigorous as could well be conceived, and would result in very great sexual disparity. The males would become remarkably fierce and aggressive. The females, on the contrary, would become less and less disposed to offer any resistance to the males, and hence a remarkable difference in temperament would eventually separate the sexes. The males would be intensely pugnacious, jealous, and aggressive, while the females would be gentle, indifferent, and passive.⁸

Polygamy having become established, the causes or conditions which aided in its establishment would tend to its intensification to such an extent that some males would have scores of females in their harems, while others, indeed the majority, would be entirely deprived of marital rights. Such, in brief, is the state of affairs among the sea lions, of which the fur seal (*Calorhinus ursinus*) is the best example.

The above hypothetical history of events will serve to convey the writer's opinion as to what may have been the stages by which polygamy has arisen and become intensified among Pinnipedia. For the sake of the nonscientific reader, it may be well to say that there is no intention to convey the idea that the fur seal was first a walrus, then a seal, and finally evolved into a sea lion or fur seal.

Two other points deserve mention in connection with this highly interesting animal.

The question naturally arises, why do not the females increase in size by inheriting the increased bulk of the male? There are few more interesting and perplexing laws than those of inheritance, and among these one of the most elusive is the inheritance of certain characteristics by one sex alone. Darwin attempts to explain these facts by the hypothesis of pangeneses,—a theory which seems to have few, if any, supporters at present. Whatever may be the cause of the transmission of certain characters to one sex only, there are two facts that may help us to understand the disparity between the sexes of the fur seals:

1st. The great size of the male is purely a *secondary sexual character*, and as such would not be expected to be inherited by the female, whatever may be the reason or cause ultimately found to explain the fact.

2d. Small size is of direct advantage to the female in this case, and hence a *natural selection*⁹ would tend to intensify this feature, or what is prac-

⁸Curiously enough, Darwin quotes Captain Bryant to the effect that the females of the fur seal "appear desirous of returning to some particular male" (*Descent of Man*, p. 257). A careful perusal of the detailed accounts of the habits of this animal collated by Allen, in his *Monograph of North American Pinnipeds*, fails to discover any exercise of choice whatever on the part of the female. It may further be said that even if she had a choice there would be no chance to exercise it, as she is immediately pounced upon by the nearest male upon landing, and usually handed about by the scruff of the neck by several males before finding her ultimate resting place.

⁹The selection here spoken of can hardly be termed a *sexual selection*, as the advantage accrues directly to the mother, and does not have the direct and exclusive bearing upon the reproductive act which is the essence of sexual selection. It is, of course, true that one sex alone is affected; but this fact alone is not sufficient to stamp it as sexual selection as set forth by Darwin.

tically the same thing, to keep the females from sharing in the increased size of the males.

The advantage referred to arises from the manner in which the females are handled by the males upon the landing of the former, which is described as follows by Elliott:

"The little cows have a rough-and-tumble time of it when they begin to arrive; for no sooner is the pretty animal fairly established on the station of bull number one, when bull number two, seeing bull number one off his guard, reaches out with his long, strong neck and picks the unhappy but passive creature up by the scruff of hers, just as a cat does a kitten, and deposits her on his seraglio ground; then bulls numbers three, four, etc., in the vicinity, seeing this high-handed operation, all assail one another, and especially bull number two, and have a tremendous fight, perhaps for half a minute or so, and during this commotion the cow generally is moved or moves farther back from the water, two or three stations more, where, when all gets quiet, she usually remains in peace."

Allen also quotes Captain Bryant as follows: "Frequently a struggle ensues between the two males for the possession of the same female, and, both seizing her at once, pull her in two or terribly lacerate her with their teeth."

It is evident that the more easily and quickly the females can be moved the better for them, as they are thus more likely to avoid being lacerated by the males, either in being stolen from one by another, or in being fought over as described in the last quotation. If this is true, the lighter females would be less likely to be injured by the savage males, and hence the heavier ones would be weeded out by a natural selection, which by its constant action would go far toward accounting for the great sexual disparity exhibited by these animals.

The remaining fact demanding explanation is the wonderful ability of the male sea lions to endure long-protracted fasts. On this point Mr. Elliott says that they "abstain entirely from food of any kind or water for three months at least, and a few of them stay four months before going into the water for the first time since hauling up in May."

"This alone is remarkable enough, but it is simply wonderful when we associate the condition with the increasing activity, restlessness, and duty devolving upon the bulls as heads and fathers of large families. They do not stagnate, like bears in caves."

It seems highly probable that this astonishing ability to endure protracted fasts is one of the results of the ultra polygamy practiced by these animals. A marked intensification of desire seems to be one of the immediate concomitants of polygamy among animals. A writer in a recent number of the *Naturalist*, says, in speaking of monogamous birds adopting a polygamous habit: "We may infer, therefore, that sexual power and high sexual characters go hand in hand, and that in proportion to the advance toward organic perfection virility increases."

The virility of the sea lion is probably more excessively developed than that of any other mammal. The sexual organization is of the most highly

* *American Naturalist*, November, 1890, p. 1030.

specialized type and differs in some important particulars (e. g., external scrotum) from most other pinnipeds.†

This excessive virility might lead to the habit of abstaining from food in order to secure and then guard the females. This abstinence in its incipency would not be of very great duration, but the period might be lengthened by almost imperceptible increments throughout hundreds of generations until the surprising results noted above would be reached. The animals live on their own blubber during their long fast, and it is reasonable to suppose that the male progenitors of the sea lions which were the strongest and lustiest and possessed the most blubber, would be able to out stay their rivals, and hence obtain possession of a greater number of females and beget a greater number of offspring than those having less strength and blubber. Thus a process of selection would be instituted whereby animals would eventually be produced possessed of sufficient blubber and endurance to survive the effects of even such phenomenal fasts as are endured by the fur seal of the present day.

In the preceding pages the writer has endeavored to account for the following peculiarities met with among the pinnipeds:

1. The relation between great sexual disparity in size and polygamy.
2. The manner in which polygamy may have originated.
3. The origin and effect of excessive pugnacity.
4. The origin and advantage of great sexual disparity.
5. The origin and advantage of the ability to endure long protracted fasts.

The sexual disparity, excessive pugnacity and ability to endure protracted fasts, are all intimately related to polygamy either as *cause* or *effect*.

Up to a certain point pugnacity and disparity seem to have acted as causes of polygamy. Beyond that point they seem to be effects of polygamy, or at least, are accelerated or intensified by it. The ability to endure long fasts would seem to be purely an effect of polygamy.

SYSTEMATIC ZOOLOGY IN COLLEGES.

BY C. C. NUTTING.

A few months ago one of the curators of the Smithsonian Institution took occasion, in private conversation, to complain of the fact that our universities and colleges did not turn out men capable of taking hold of a collection of zoological specimens and working it up systematically. He said: "We can find plenty of students from Johns Hopkins, Harvard, the University of Penn-

† For further interesting particulars, see Monograph of North American Pinnipeds, pp. 382-405