

## CHAPTER XVI.

CAUSES WHICH INTERFERE WITH THE FREE CROSSING OF  
VARIETIES—INFLUENCE OF DOMESTICATION ON FERTILITY.

DIFFICULTIES IN JUDGING OF THE FERTILITY OF VARIETIES WHEN CROSSED—VARIOUS CAUSES WHICH KEEP VARIETIES DISTINCT, AS THE PERIOD OF BREEDING AND SEXUAL PREFERENCE—VARIETIES OF WHEAT SAID TO BE STERILE WHEN CROSSED—VARIETIES OF MAIZE, VERBASCUM, HOLLYHOCK, GOURDS, MELONS, AND TOBACCO, RENDERED IN SOME DEGREE MUTUALLY STERILE—DOMESTICATION ELIMINATES THE TENDENCY TO STERILITY NATURAL TO SPECIES WHEN CROSSED—ON THE INCREASED FERTILITY OF UNCROSSED ANIMALS AND PLANTS FROM DOMESTICATION AND CULTIVATION.

THE domesticated races of both animals and plants, when crossed, are, with extremely few exceptions, quite prolific,—in some cases even more so than the purely-bred parent-races. The offspring, also, raised from such crosses are likewise, as we shall see in the following chapter, generally more vigorous and fertile than their parents. On the other hand, species when crossed, and their hybrid offspring, are almost invariably in some degree sterile; and here there seems to exist a broad and insuperable distinction between races and species. The importance of this subject as bearing on the origin of species is obvious; and we shall hereafter recur to it.

It is unfortunate how few precise observations have been made on the fertility of mongrel animals and plants during several successive generations. Dr. Broca<sup>1</sup> has remarked that no one has observed whether, for instance, mongrel dogs, bred *inter se*, are indefinitely fertile; yet, if a shade of infertility be detected by careful observation in the offspring of natural forms when crossed, it is thought that their specific distinction is proved. But so many breeds of sheep, cattle, pigs, dogs, and poultry, have been crossed and recrossed in various ways, that any sterility, if it had existed, would from being injurious almost certainly have been observed. In

<sup>1</sup> 'Journal de Physiolog.,' tom. ii., 1859, p. 385.

investigating the fertility of crossed varieties many source of doubt occur. Whenever the least trace of sterility between two plants, however closely allied, was observed by Kölreuter, and more especially by Gärtner, who counted the exact number of seed in each capsule, the two forms were at once ranked as distinct species; and if this rule be followed, assuredly it will never be proved that varieties when crossed are in any degree sterile. We have formerly seen that certain breeds of dogs do not readily pair together; but no observations have been made whether, when paired, they produce the full number of young, and whether the latter are perfectly fertile *inter se*; but, supposing that some degree of sterility were found to exist, naturalists would simply infer that these breeds were descended from aboriginally distinct species; and it would be scarcely possible to ascertain whether or not this explanation was the true one.

The Sebright Bantam is much less prolific than any other breed of fowls, and is descended from a cross between two very distinct breeds, recrossed by a third sub-variety. But it would be extremely rash to infer that the loss of fertility was in any manner connected with its crossed origin, for it may with more probability be attributed either to long-continued close interbreeding, or to an innate tendency to sterility correlated with the absence of hackles and sickle tail-feathers.

Before giving the few recorded cases of forms, which must be ranked as varieties, being in some degree sterile when crossed, I may remark that other causes sometimes interfere with varieties freely intercrossing. Thus they may differ too greatly in size, as with some kinds of dogs and fowls: for instance, the editor of the 'Journal of Horticulture, &c.,'<sup>2</sup> says that he can keep Bantams with the larger breeds without much danger of their crossing, but not with the smaller breeds, such as Games, Hamburgs, &c. With plants a difference in the period of flowering serves to keep varieties distinct, as with the various kinds of maize and wheat: thus Colonel Le Couteur<sup>3</sup> remarks, "the Talavera wheat, from flowering much earlier than any other kind, is sure to

<sup>2</sup> Dec. 1863, p. 484.

<sup>3</sup> On 'The Varieties of Wheat,' p. 66.

continue pure." In different parts of the Falkland Islands the cattle are breaking up into herds of different colours; and those on the higher ground, which are generally white, usually breed, as I am informed by Sir J. Sullivan, three months earlier than those on the lowland; and this would manifestly tend to keep the herds from blending.

Certain domestic races seem to prefer breeding with their own kind; and this is a fact of some importance, for it is a step towards that instinctive feeling which helps to keep closely allied species in a state of nature distinct. We have now abundant evidence that, if it were not for this feeling, many more hybrids would be naturally produced than in this case. We have seen in the first chapter that the alco dog of Mexico dislikes dogs of other breeds; and the hairless dog of Paraguay mixes less readily with the European races, than the latter do with each other. In Germany the female Spitz-dog is said to receive the fox more readily than will other dogs; a female Australian Dingo in England attracted the wild male foxes. But these differences in the sexual instinct and attractive power of the various breeds may be wholly due to their descent from distinct species. In Paraguay the horses have much freedom, and an excellent observer<sup>4</sup> believes that the native horses of the same colour and size prefer associating with each other, and that the horses which have been imported from Entre Rios and Banda Oriental into Paraguay likewise prefer associating together. In Circassia six sub-races of the horse have received distinct names; and a native proprietor of rank<sup>5</sup> asserts that horses of three of these races, whilst living a free life, almost always refuse to mingle and cross, and will even attack one another.

It has been observed, in a district stocked with heavy Lincolnshire and light Norfolk sheep, that both kinds, though bred together, when turned out, "in a short time separate to a sheep;" the Lincolnshires drawing off to the rich soil, and the Norfolks to their own dry light soil; and as long as there is plenty of grass, "the two breeds keep themselves as

<sup>4</sup> Rengger, 'Säugethiere von Paraguay,' s. 336.

<sup>5</sup> See a memoir by MM. Lherbette

and De Quatrefages, in 'Bull. Soc. d'Acclimat.,' tom. viii., July, 1861, p. 312.

distinct as rooks and pigeons." In this case different habits of life tend to keep the races distinct. On one of the Faroe islands, not more than half a mile in diameter, the half-wild native black sheep are said not have readily mixed with the imported white sheep. It is a more curious fact that the semi-monstrous ancon sheep of modern origin "have been observed to keep together, separating themselves from the rest of the flock, when put into enclosures with other sheep."<sup>6</sup> With respect to fallow-deer, which live in a semi-domesticated condition, Mr. Bennett<sup>7</sup> states that the dark and pale coloured herds, which have long been kept together in the Forest of Dean, in High Meadow Woods, and in the New Forest, have never been known to mingle: the dark-coloured deer, it may be added, are believed to have been first brought by James I. from Norway, on account of their greater hardiness. I imported from the island of Porto Santo two of the feral rabbits, which differ, as described in the fourth chapter, from common rabbits; both proved to be males, and, though they lived during some years in the Zoological Gardens, the superintendent, Mr. Bartlett, in vain endeavoured to make them breed with various tame kinds; but whether this refusal to breed was due to any change in the instinct, or simply to their extreme wildness, or whether confinement had rendered them sterile, as often occurs, cannot be determined.

Whilst matching for the sake of experiment many of the most distinct breeds of pigeons, it frequently appeared to me that the birds, though faithful to their marriage vow, retained some desire after their own kind. Accordingly I asked Mr. Wicking, who has kept a larger stock of various breeds together than any man in England, whether he thought that they would prefer pairing with their own kind, supposing that there were males and females enough of each; and he without hesitation answered that he was convinced that

<sup>6</sup> For the Norfolk sheep, see Marshall's 'Rural Economy of Norfolk,' vol. ii. p. 136. See Rev. L. Landt's 'Description of Faroe,' p. 66. For the ancon sheep, see 'Phil. Transact.,' 1813, p. 90.

<sup>7</sup> White's 'Nat. Hist. of Selbourne,' edited by Bennett, p. 39. With respect to the origin of the dark-coloured deer, see 'Some Account of English Deer Parks,' by E. P. Shirley, Esq.

this was the case. It has often been noticed that the dovecot pigeon seems to have an actual aversion towards the several fancy breeds;<sup>8</sup> yet all have certainly sprung from a common progenitor. The Rev. W. D. Fox informs me that his flocks of white and common Chinese geese kept distinct.

These facts and statements, though some of them are incapable of proof, resting only on the opinion of experienced observers, show that some domestic races are led by different habits of life to keep to a certain extent separate, and that others prefer coupling with their own kind, in the same manner as species in a state of nature, though in a much less degree.

With respect to sterility from the crossing of domestic races, I know of no well-ascertained case with animals. This fact, seeing the great difference in structure between some breeds of pigeons, fowls, pigs, dogs, &c., is extraordinary, in contrast with the sterility of many closely allied natural species when crossed; but we shall hereafter attempt to show that it is not so extraordinary as it at first appears. And it may be well here to recall to mind that the amount of external difference between two species is not a safe guide for predicting whether or not they will breed together,—some closely allied species when crossed being utterly sterile, and others which are extremely unlike being moderately fertile. I have said that no case of sterility in crossed races rests on satisfactory evidence; but here is one which at first seems trustworthy. Mr. Youatt,<sup>9</sup> and a better authority cannot be quoted, states, that formerly in Lancashire crosses were frequently made between longhorn and shorthorn cattle; the first cross was excellent, but the produce was uncertain; in the third or fourth generation the cows were bad milkers; “in addition to which, there was much uncertainty whether the cows would conceive; and full one-third of the cows among some of these half-breds failed to be in calf.” This at first seems a good case: but Mr. Wilkinson states,<sup>10</sup> that a breed derived from this same cross was actually established in another part of England; and if it had failed in fertility, the fact would surely have been noticed. Moreover, supposing that Mr. Youatt had proved his case, it might be argued that the sterility was wholly due to the two parent-breeds being descended from primordially distinct species.

In the case of plants Gärtner states that he fertilised thirteen heads (and subsequently nine others) on a dwarf maize bearing

<sup>8</sup> ‘The Dovecote,’ by the Rev. E. S. Dixon, p. 155; Bechstein, ‘Naturgesch. Deutschlands,’ Band iv., 1795, s. 17.

<sup>9</sup> ‘Cattle,’ p. 202.

<sup>10</sup> Mr. J. Wilkinson, in ‘Remarks addressed to Sir J. Sebright,’ 1820, p. 38.

yellow seed<sup>11</sup> with pollen of a tall maize having red seed; and one head alone produced good seed, but only five in number. Though these plants are monœcious, and therefore do not require castration, yet I should have suspected some accident in the manipulation, had not Gärtner expressly stated that he had during many years grown these two varieties together, and they did not spontaneously cross; and this, considering that the plants are monœcious and abound with pollen, and are well known generally to cross freely, seems explicable only on the belief that these two varieties are in some degree mutually infertile. The hybrid plants raised from the above five seeds were intermediate in structure, extremely variable, and perfectly fertile.<sup>12</sup> In like manner Prof. Hildebrand<sup>13</sup> could not succeed in fertilising the female flowers of a plant bearing brown grains with pollen from a certain kind bearing yellow grains; although other flowers on the same plant, which were fertilised with their own pollen, yielded good seed. No one, I believe, even suspects that these varieties of maize are distinct species; but had the hybrids been in the least sterile, no doubt Gärtner would at once have so classed them. I may here remark, that with undoubted species there is not necessarily any close relation between the sterility of a first cross and that of the hybrid offspring. Some species can be crossed with facility, but produce utterly sterile hybrids; others can be crossed with extreme difficulty, but the hybrids when produced are moderately fertile. I am not aware, however, of any instance quite like this of the maize, namely, of a first cross made with difficulty, but yielding perfectly fertile hybrids.<sup>14</sup>

The following case is much more remarkable, and evidently perplexed Gärtner, whose strong wish it was to draw a broad line of distinction between species and varieties. In the genus *Verbascum*, he made, during eighteen years, a vast number of experiments, and crossed no less than 1085 flowers and counted their seeds. Many of these experiments consisted in crossing white and yellow varieties of both *V. lychnitis* and *V. blattaria* with nine other species and their hybrids. That the white and yellow flowered plants of these two species are really varieties, no one has doubted; and Gärtner actually raised in the case of both species one variety from the seed of the other. Now in two of his works<sup>15</sup> he distinctly asserts that crosses between similarly-coloured flowers yield more seed than between dissimilarly-coloured; so that the yellow-flowered variety of either species (and conversely with the white-flowered variety), when crossed with pollen of its own kind, yields more seed than when

<sup>11</sup> 'Bastarderzeugung,' s. 87, 169. See also the Table at the end of volume.

<sup>12</sup> 'Bastarderzeugung,' s. 87, 577.

<sup>13</sup> 'Bot. Zeitung,' 1868, p. 327.

<sup>14</sup> Mr. Shirreff formerly thought ('Gard. Chron.,' 1858, p. 771) that the offspring from a cross between certain

varieties of wheat became sterile in the fourth generation; but he now admits ('Improvement of the Cereals,' 1873) that this was an error.

<sup>15</sup> 'Kenntniß der Befruchtung,' s. 137; 'Bastarderzeugung,' s. 92, 181. On raising the two varieties from seed, see s. 307.

crossed with that of the white variety; and so it is when differently coloured species are crossed. The general results may be seen in the Table at the end of his volume. In one instance he gives<sup>16</sup> the following details; but I must premise that Gärtner, to avoid exaggerating the degree of sterility in his crosses, always compares the *maximum* number obtained from a cross with the *average* number naturally given by the pure mother-plant. The white variety of *V. lychnitis*, naturally fertilised by its own pollen, gave from an *average* of twelve capsules ninety-six good seeds in each; whilst twenty flowers fertilised with pollen from the yellow variety of this same species, gave as the *maximum* only eighty-nine good seeds; so that we have the proportion of 1000 to 908, according to Gärtner's usual scale. I should have thought it possible that so small a difference in fertility might have been accounted for by the evil effects of the necessary castration; but Gärtner shows that the white variety of *V. lychnitis*, when fertilised first by the white variety of *V. blattaria*, and then by the yellow variety of this species, yielded seed in the proportion of 622 to 438; and in both these cases castration was performed. Now the sterility which results from the crossing of the differently coloured varieties of the same species, is fully as great as that which occurs in many cases when distinct species are crossed. Unfortunately Gärtner compared the results of the first unions alone, and not the sterility of the two sets of hybrids produced from the white variety of *V. lychnitis* when fertilised by the white and yellow varieties of *V. blattaria*, for it is probable that they would have differed in this respect.

Mr. J. Scott has given me the results of a series of experiments on *Verbascum*, made by him in the Botanic Gardens of Edinburgh.<sup>17</sup> He repeated some of Gärtner's experiments on distinct species, but obtained only fluctuating results, some confirmatory, the greater number contradictory; nevertheless these seem hardly sufficient to overthrow the conclusion arrived at by Gärtner from experiments tried on a larger scale. Mr. Scott also experimented on the relative fertility of unions between similarly and dissimilarly-coloured varieties of the same species. Thus he fertilised six flowers of the yellow variety of *V. lychnitis* by its own pollen, and obtained six capsules; and calling, for the sake of comparison, the average number of good seed in each of their capsules one hundred, he found that this same yellow variety, when fertilised by the white variety, yielded from seven capsules an average of ninety-four seed. On the same principle, the white variety of *V. lychnitis* by its own pollen (from six capsules), and by the pollen of the yellow variety (eight capsules), yielded seed in the proportion of 100 to 82. The yellow variety of *V. thapsus* by its own pollen (eight capsules), and by that of the white variety (only two capsules), yielded seed in the proportion of 100 to 94. Lastly, the white variety of *V. blattaria*

<sup>16</sup> 'Bastarderzeugung,' s. 216.

published in 'Journ. Asiatic Soc. of Bengal,' 1867, p. 145.

<sup>17</sup> The results have since been

by its own pollen (eight capsules), and by that of the yellow variety (five capsules), yielded seed in the proportion of 100 to 79. So that in every case the unions of similarly-coloured varieties of the same species were more fertile than the unions of dissimilarly-coloured varieties; when all the cases are grouped together, the difference of fertility is as 100 to 86. Some additional trials were made, and altogether thirty-six similarly-coloured unions yielded thirty-five good capsules; whilst thirty-five dissimilarly-coloured unions yielded only twenty-six good capsules. Besides the foregoing experiments, the purple *V. phaniceum* was crossed by a rose-coloured and a white variety of the same species; these two varieties were also crossed together, and these several unions yielded less seed than *V. phaniceum* by its own pollen. Hence it follows from Mr. Scott's experiments, that in the genus *Verbascum* the similarly and dissimilarly-coloured varieties of the same species behave, when crossed, like closely allied but distinct species.<sup>18</sup>

This remarkable fact of the sexual affinity of similarly-coloured varieties, as observed by Gärtner and Mr. Scott, may not be of very rare occurrence; for the subject has not been attended to by others. The following case is worth giving, partly to show how difficult it is to avoid error. Dr. Herbert<sup>19</sup> has remarked that variously-coloured double varieties of the Hollyhock (*Althea rosea*) may be raised with certainty by seed from plants growing close together. I have been informed that nurserymen who raise seed for sale do not separate their plants; accordingly I procured seed of eighteen named varieties; of these, eleven varieties produced sixty-two plants all perfectly true to their kind; and seven produced forty-nine plants, half of which were true and half false. Mr. Masters of

<sup>18</sup> The following facts, given by Kölreuter in his 'Dritte Fortsetzung,' ss. 34, 39, appear at first sight strongly to confirm Mr. Scott's and Gärtner's statements; and to a certain limited extent they do so. Kölreuter asserts, from innumerable observations, that insects incessantly carry pollen from one species and variety of *Verbascum* to another; and I can confirm this assertion; yet he found that the white and yellow varieties of *Verbascum thymifolium* often grew wild mingled together: moreover, he cultivated these two varieties in considerable numbers during four years in his garden, and they kept true by seed; but when he crossed them, they produced flowers of an intermediate tint. Hence it might have been thought that both varieties must have a stronger elective affinity for the pollen

of their own variety than for that of the other; this elective affinity, I may add of each species for its own pollen (Kölreuter, 'Dritte Forts.' s. 39, and Gärtner, 'Bastarderz., passim') being a perfectly well-ascertained power. But the force of the foregoing facts is much lessened by Gärtner's numerous experiments, for, differently from Kölreuter, he never once got ('Bastarderz.,' s. 307) an intermediate tint when he crossed the yellow and white flowered varieties of *Verbascum*. So that the fact of the white and yellow varieties keeping true to their colour by seed does not prove that they were not mutually fertilised by the pollen carried by insects from one to the other.

<sup>19</sup> 'Amaryllidaceæ,' 1837, p. 366. Gärtner has made a similar observation.

Canterbury has given me a more striking case; he saved seed from a great bed of twenty-four named varieties planted in closely adjoining rows, and each variety reproduced itself truly with only sometimes a shade of difference in tint. Now in the hollyhock the pollen, which is abundant, is matured and nearly all shed before the stigma of the same flower is ready to receive it;<sup>20</sup> and as bees covered with pollen incessantly fly from plant to plant, it would appear that adjoining varieties could not escape being crossed. As, however, this does not occur, it appeared to me probable that the pollen of each variety was prepotent on its own stigma over that of all other varieties, but I have no evidence on this point. Mr. C. Turner of Slough, well known for his success in the cultivation of this plant, informs me that it is the doubleness of the flowers which prevents the bees gaining access to the pollen and stigma; and he finds that it is difficult even to cross them artificially. Whether this explanation will fully account for varieties in close proximity propagating themselves so truly by seed, I do not know.

The following cases are worth giving, as they relate to monœcious forms, which do not require, and consequently cannot have been injured by, castration. Girou de Buzareingues crossed what he designates three varieties of gourd,<sup>21</sup> and asserts that their mutual fertilisation is less easy in proportion to the difference which they present. I am aware how imperfectly the forms in this group were until recently known; but Sageret,<sup>22</sup> who ranked them according to their mutual fertility, considers the three forms above alluded to as varieties, as does a far higher authority, namely, M. Naudin.<sup>23</sup> Sageret<sup>24</sup> has observed that certain melons have a greater tendency, whatever the cause may be, to keep true than others; and M. Naudin, who has had such immense experience in this group, informs me that he believes that certain varieties intercross more readily than others of the same species; but he has not proved the truth of this conclusion; the frequent abortion of the pollen near Paris being one great difficulty. Nevertheless, he has grown close together, during seven years, certain forms of *Citrullus*, which, as they could be artificially crossed with perfect facility and produced fertile offspring, are ranked as varieties; but these forms when not artificially crossed kept true. Many other varieties, on the other hand, in the same group cross with such facility, as M. Naudin repeatedly insists, that without being grown far apart they cannot be kept in the least true.

Another case, though somewhat different, may be here given, as

<sup>20</sup> Kölreuter first observed this fact, 'Mém. de l'Acad. de St. Petersburg,' vol. iii. p. 127. See also C. K. Sprengel, 'Das Entdeckte Geheimniss,' s. 345.

<sup>21</sup> Namely, Barbarines, Pastissons, Giraumous: 'Annal. des Sc. Nat.' tom. xxx., 1833, pp. 398 and 405.

<sup>22</sup> 'Mémoire sur les Cucurbitacæ,' 1826, pp. 46, 55.

<sup>23</sup> 'Annales des Sc. Nat.,' 4th series, tom. vi. M. Naudin considers these forms as undoubtedly varieties of *Cucurbita pepo*.

<sup>24</sup> 'Mém. Cucurb.,' p. 8.

it is highly remarkable, and is established on excellent evidence. Kölreuter minutely describes five varieties of the common tobacco,<sup>25</sup> which were reciprocally crossed, and the offspring were intermediate in character and as fertile as their parents: from this fact Kölreuter inferred that they are really varieties; and no one, as far as I can discover, seems to have doubted that such is the case. He also crossed reciprocally these five varieties with *N. glutinosa*, and they yielded very sterile hybrids; but those raised from the *var. perennis*, whether used as the father or mother plant, were not so sterile as the hybrids from the four other varieties.<sup>26</sup> So that the sexual capacity of this one variety has certainly been in some degree modified, so as to approach in nature that of *N. glutinosa*.<sup>27</sup>

These facts with respect to plants show that in some few cases certain varieties have had their sexual powers so far modified, that they cross together less readily and yield less seed than other varieties of the same species. We shall presently see that the sexual functions of most animals and plants are eminently liable to be affected by the conditions of life to which they are exposed; and hereafter we shall

<sup>25</sup> 'Zweite Forts.' s. 53, namely, *Nicotiana major vulgaris*; (2) *perennis*; (3) *transylvanica*; (4) a subvar. of the last; (5) *major latifol. fl. alb.*

<sup>26</sup> Kölreuter was so much struck with this fact that he suspected that a little pollen of *N. glutinosa* in one of his experiments might have accidentally got mingled with that of *var. perennis*, and thus aided its fertilising power. But we now know conclusively from Gärtner ('Bastardierz,' s. 34, 43) that the pollen of two species never acts *conjunctly* on a third species; still less will the pollen of a distinct species, mingled with a plant's own pollen, if the latter be present in sufficient quantity, have any effect. The sole effect of mingling two kinds of pollen is to produce in the same capsule seeds which yield plants, some taking after the one and some after the other parent.

<sup>27</sup> Mr. Scott has made some observations on the absolute sterility of a purple and white primrose (*Primula vulgaris*) when fertilised by pollen from the common primrose ('Journal

of Proc. of Linn. Soc.,' vol. viii., 1864, p. 98); but these observations require confirmation. I raised a number of purple-flowered long-styled seedlings from seed kindly sent me by Mr. Scott, and, though they were all in some degree sterile, they were much more fertile with pollen taken from the common primrose than with their own pollen. Mr. Scott has likewise described a red equal-styled cowslip (*P. veris*, *ibid.* p. 106), which was found by him to be highly sterile when crossed with the common cowslip; but this was not the case with several equal-styled red seedlings raised by me from his plant. This variety of the cowslip presents the remarkable peculiarity of combining male organs in every respect like those of the short-styled form, with female organs resembling in function and partly in structure those of the long-styled form; so that we have the singular anomaly of the two forms combined in the same flower. Hence it is not surprising that these flowers should be spontaneously self-fertile in a high degree.

briefly discuss the conjoint bearing of this fact, and others, on the difference in fertility between crossed varieties and crossed species.

*Domestication eliminates the tendency to Sterility which is general with Species when crossed.*

This hypothesis was first propounded by Pallas,<sup>28</sup> and has been adopted by several authors. I can find hardly any direct facts in its support; but unfortunately no one has compared, in the case of either animals or plants, the fertility of anciently domesticated varieties, when crossed with a distinct species, with that of the wild parent-species when similarly crossed. No one has compared, for instance, the fertility of *Gallus bankiva* and of the domesticated fowl, when crossed with a distinct species of Gallus or Phasianus; and the experiment would in all cases be surrounded by many difficulties. Dureau de la Malle, who has so closely studied classical literature, states<sup>29</sup> that in the time of the Romans the common mule was produced with more difficulty than at the present day; but whether this statement may be trusted I know not. A much more important, though somewhat different, case is given by M. Groenland,<sup>30</sup> namely, that plants, known from their intermediate character and sterility to be hybrids between *Ægilops* and wheat, have perpetuated themselves under culture since 1857, *with a rapid but varying increase of fertility in each generation*. In the fourth generation the plants, still retaining their intermediate character, had become as fertile as common cultivated wheat.

The indirect evidence in favour of the Pallasian doctrine appears to me to be extremely strong. In the earlier chapters I have shown that our various breeds of the dog are descended from several wild species; and this probably is the case with sheep. There can be no doubt that the Zebu or humped Indian ox belongs to a distinct species from European cattle: the latter, moreover, are descended from two forms, which may be called either species or races. We have good evidence

<sup>28</sup> 'Act. Acad. St. Petersburg,' (1st series), p. 61.  
1780, part ii. pp. 84, 100.

<sup>30</sup> 'Bull. Bot. Soc. de France,' Dec.  
<sup>29</sup> 'Annales des Sc. Nat.' tom. xxi. 27th, 1861, tom. viii. p. 612.

that our domesticated pigs belong to at least two specific types, *S. scrofa* and *indicus*. Now a widely extended analogy leads to the belief that if these several allied species, when first reclaimed, had been crossed, they would have exhibited, both in their first unions and in their hybrid offspring, some degree of sterility. Nevertheless, the several domesticated races descended from them are now all, as far as can be ascertained, perfectly fertile together. If this reasoning be trustworthy, and it is apparently sound, we must admit the Pallasian doctrine that long-continued domestication tends to eliminate that sterility which is natural to species when crossed in their aboriginal state.

*On increased Fertility from Domestication and Cultivation.*

Increased fertility from domestication, without any reference to crossing, may be here briefly considered. This subject bears indirectly on two or three points connected with the modification of organic beings. As Buffon long ago remarked,<sup>31</sup> domestic animals breed oftener in the year and produce more young at a birth than wild animals of the same species; they, also, sometimes breed at an earlier age. The case would hardly have deserved further notice, had not some authors lately attempted to show that fertility increases and decreases in an inverse ratio with the amount of food. This strange doctrine has apparently arisen from individual animals when supplied with an inordinate quantity of food, and from plants of many kinds when grown on excessively rich soil, as on a dunghill, becoming sterile: but to this latter point I shall have occasion presently to return. With hardly an exception, our domesticated animals, which have been long habituated to a regular and copious supply of food, without the labour of searching for it, are more fertile than the corresponding wild animals. It is notorious how frequently cats and dogs breed, and how many young they produce at a birth. The wild rabbit is said generally to

<sup>31</sup> Quoted by Isid. Geoffroy St. Hilaire, 'Hist. Naturelle Générale,' tom. iii. p. 476. Since this MS. has been sent to press a full discussion on

the present subject has appeared in Mr. Herbert Spencer's 'Principles of Biology,' vol. ii., 1867, p. 457 *et seq.*

breed four times yearly, and to produce each time at most six young; the tame rabbit breeds six or seven times yearly, producing each time from four to eleven young; and Mr. Harrison Weir tells me of a case of eighteen young having been produced at a birth, all of which survived. The ferret, though generally so closely confined, is more prolific than its supposed wild prototype. The wild sow is remarkably prolific; she often breeds twice in the year, and bears from four to eight and sometimes even twelve young; but the domestic sow regularly breeds twice a year, and would breed oftener if permitted; and a sow that produces less than eight at a birth "is worth little, and the sooner she is fattened for the butcher the better." The amount of food affects the fertility of the same individual: thus sheep, which on mountains never produce more than one lamb at a birth, when brought down to lowland pastures frequently bear twins. This difference apparently is not due to the cold of the higher land, for sheep and other domestic animals are said to be extremely prolific in Lapland. Hard living, also, retards the period at which animals conceive; for it has been found disadvantageous in the northern islands of Scotland to allow cows to bear calves before they are four years old.<sup>32</sup>

Birds offer still better evidence of increased fertility from domestication: the hen of the wild *Gallus bankiva* lays from six to ten eggs, a number which would be thought nothing of with the domestic hen. The wild duck lays from five to ten eggs; the tame one in the course of the year from eighty to one hundred. The wild grey-lag goose lays from five to eight eggs; the tame from thirteen to eighteen, and she lays a second time; as Mr. Dixon has remarked, "high-feeding, care, and moderate warmth induce a habit of prolificacy which becomes in some measure hereditary." Whether the semi-domesticated dovecot pigeon is more fertile than the wild rock-pigeon, *C. livia*, I know not; but the more thoroughly domesti-

<sup>32</sup> For cats and dogs, &c., see Bellingieri, in 'Annal. des Sc. Nat.,' 2nd series, Zoolog., tom. xii. p. 155. For ferrets, Bechstein, 'Naturgeschichte Deutschlands,' Band i., 1801, s. 786, 795. For rabbits, ditto, s. 1123, 1131; and Bronn's 'Geschichte der Natur,' B. ii. s. 99. For mountain sheep, ditto, s. 102. For the fertility of the

wild sow, see Bechstein's 'Naturgesch. Deutschlands,' B. i., 1801, s. 534; for the domestic pig, Sidney's edit. of Youatt on the Pig, 1860, p. 62. With respect to Lapland, see Acerbi's 'Travels to the North Cape,' Eng. transl., vol. ii. p. 222. About the Highland cows, see Hogg on Sheep, p. 263.

cated breeds are nearly twice as fertile as doves: the latter, however, when caged and highly fed, become equally fertile with house pigeons. I hear from Judge Caton that the wild turkey in the United States does not breed when a year old, as the domesticated turkeys there invariably do. The peahen alone of domesticated birds is rather more fertile, according to some accounts, when wild in its native Indian home, than in Europe when exposed to our much colder climate.<sup>33</sup>

With respect to plants, no one would expect wheat to tiller more, and each ear to produce more grain, in poor than in rich soil; or to get in poor soil a heavy crop of peas or beans. Seeds vary so much in number that it is difficult to estimate them; but on comparing beds of carrots in a nursery garden with wild plants, the former seemed to produce about twice as much seed. Cultivated cabbages yielded thrice as many pods by measure as wild cabbages from the rocks of South Wales. The excess of berries produced by the cultivated asparagus in comparison with the wild plant is enormous. No doubt many highly cultivated plants, such as pears, pineapples, bananas, sugar-cane, &c., are nearly or quite sterile; and I am inclined to attribute this sterility to excess of food and to other unnatural conditions; but to this subject I shall recur.

In some cases, as with the pig, rabbit, &c., and with those plants which are valued for their seed, the direct selection of the more fertile individuals has probably much increased their fertility; and in all cases this may have occurred indirectly, from the better chance of some of the numerous offspring from the more fertile individuals having been preserved. But with cats, ferrets, and dogs, and with plants like carrots, cabbages, and asparagus, which are not valued for their prolificacy, selection can have played only a subordinate part; and their increased fertility must be attributed to the more favourable conditions of life under which they have long existed.

<sup>33</sup> For the eggs of *Gallus bankiva*, see Blyth, in 'Annals and Mag. of Nat. Hist.' 2nd series, vol. i., 1848, p. 456. For wild and tame ducks, Macgillivray, 'British Birds,' vol. v. p. 37; and 'Die Enten,' s. 87. For wild geese, L. Lloyd, 'Scandinavian Adventures,' vol. ii. 1854, P. 413; and for tame geese, 'Ornamental Poultry,' by Rev. E. S. Dixon, p. 139. On the breeding of Pigeons, Pistor, 'Das Ganze der Taubenzucht,' 1831, s. 46; and Boitard and Corbié 'Les

Pigeons,' p. 158. With respect to peacocks, according to Temminck ('Hist. Nat. Gén. des Pigeons,' &c., 1813, tom. ii. p. 41), the hen lays in India even as many as twenty eggs; but according to Jerdon and another writer (quoted in Tegetmeier's 'Poultry Book,' 1866, pp. 280, 282), she there lays only from four to nine or ten eggs: in England she is said, in the 'Poultry Book,' to lay five or six, but another writer says from eight to twelve eggs.