# CHAPTER XVIII.

## ON THE ADVANTAGES AND DISADVANTAGES OF CHANGED CONDITIONS OF LIFE: STERILITY FROM VARIOUS CAUSES.

ON THE GOOD DERIVED FROM SLIGHT CHANGES IN THE CONDITIONS OF LIFE —STERILITY FROM CHANGED CONDITIONS, IN ANIMALS, IN THEIR NATIVE COUNTRY AND IN MENAGERIES—MAMMALS, BIRDS, AND INSECTS—LOSS OF SECONDARY SEXUAL CHARACTERS AND OF INSTINCTS—CAUSES OF STERILITY —STERILITY OF DOMESTICATED ANIMALS FROM CHANGED CONDITIONS— SEXUAL INCOMPATIBILITY OF INDIVIDUAL ANIMALS—STERILITY OF PLANTS FROM CHANGED CONDITIONS OF LIFE—CONTABESCENCE OF THE ANTHERS —MONSTROSITIES AS A CAUSE OF STERILITY—DOUBLE FLOWERS—SEEDLESS FRUIT—STERILITY FROM THE EXCESSIVE DEVELOPMENT OF THE ORGANS OF VEGETATION—FROM LONG-CONTINUED PROPAGATION BY BUDS—IN-CIPIENT STERILITY THE PRIMARY CAUSE OF DOUBLE FLOWERS AND SEEDLESS FRUIT.

*On the Good derived from slight Changes in the Conditions of Life.*—In considering whether any facts were known which might throw light on the conclusion arrived at in the last chapter, namely, that benefits ensue from crossing, and that it is a law of nature that all organic beings should occasionally cross, it appeared to me probable that the good derived from slight changes in the conditions of life, from being an analogous phenomenon, might serve this purpose. No two individuals, and still less no two varieties, are absolutely alike in constitution and structure; and when the germ of one is fertilised by the male element of another, we may believe that it is acted on in a somewhat similar manner as an individual when exposed to slightly changed conditions. Now, every one must have observed the remarkable influence on convalescents of a change of residence, and no medical man doubts the truth of this fact. Small farmers who hold but little land are convinced that their cattle derive great benefit from a change of pasture. In the case of plants, the evidence is strong that a great advantage is derived from exchanging seeds, tubers, bulbs, and cuttings from one soil or place to another as different as possible.

The belief that plants are thus benefited, whether or not well founded, has been firmly maintained from the time of Columella, who wrote shortly after the Christian era, to the present day; and it now prevails in England, France, and Germany.[1] A sagacious observer, Bradley, writing in 1724,[2] says, "When we once become "Masters of a good Sort of Seed, we should at least put it into "Two or Three Hands, where the Soils and Situations are as dif- "ferent as possible; and every Year the Parties should change "with one another; by which Means, I find the Goodness of the "Seed will be maintained for several Years. For Want of this "Use many Farmers have failed in their Crops and been great "Losers." He then gives his own practical experience on this head. A modern writer[3] asserts, "Nothing can be more clearly "established in agriculture than that the continual growth of any "one variety in the same district makes it liable to deterioration "either in quality or quantity." Another writer states that he sowed close together in the same field two lots of wheat-seed, the product of the same original stock, one of which had been grown on the same land and the other at a distance, and the difference in favour of the crop from the latter seed was remarkable. A gentleman in Surrey who has long made it his business to raise wheat to sell for seed, and who has constantly realised in the market higher prices than others, assures me that he finds it indispensable continually to change his seed; and that for this purpose he keeps two farms differing much in soil and elevation.

With respect to the tubers of the potato, I find that at the present day the practice of exchanging sets is almost everywhere followed. The great growers of potatoes in Lancashire formerly used to get tubers from Scotland, but they found that "a change from the moss-lands, and *vice versâ*, was generally sufficient." In former times in France the crop of potatoes in the Vosges had become reduced in the course of fifty or sixty years in the proportion from 120-150 to 30-40 bushels; and the famous Oberlin attributed the surprising good which he effected in large part to changing the sets.[4]

A well-known practical gardener, Mr. Robson,[5] positively states

[1] For England, *see* below. For Germany, *see* Metzger, 'Getreidearten,' 1841, s. 63. For France, Loiseleur-Deslongchamps ('Consid. sur les Céréales,' 1843, p. 200) gives numerous references on this subject. For Southern France, *see* Godron, 'Florula Juvenalis,' 1854, p. 28.

[2] 'A General Treatise of Husbandry,' vol. iii. p. 58.

[3] 'Gardener's Chronicle and Agricult. Gazette,' 1858, p. 247; and for the second statement, Ibid., 1850, p. 702. On this same subject, *see* also Rev. D. Walker's 'Prize Essay of Highland Agricult. Soc.,' vol. ii. p. 200. Also Marshall's 'Minutes of Agriculture,' November, 1775.

[4] Oberlin's 'Memoirs,' Eng. translat., p. 73. For Lancashire, *see* Marshall's 'Review of Reports,' 1808, p. 295.

[5] 'Cottage Gardener,' 1856, p. 186. For Mr. Robson's subsequent statements, *see* 'Journal of Horticulture,' Feb. 18, 1866, p. 121. For Mr Abbey's remarks on grafting, &c., Ibid., July 18, 1865, p. 44.

that he has himself witnessed decided advantage from obtaining bulbs of the onion, tubers of the potato, and various seeds, all of the same kind, from different soils and distant parts of England. He further states that with plants propagated by cuttings, as with the Pelargonium, and especially the Dahlia, manifest advantage is derived from getting plants of the same variety, which have been cultivated in another place; or, "where the extent of the place "allows, to take cuttings from one description of soil to plant on "another, so as to afford the change that seems so necessary to the "well-being of the plants." He maintains that after a time an exchange of this nature is "forced on the grower, whether he be "prepared for it or not." Similar remarks have been made by another excellent gardener, Mr. Fish, namely, that cuttings of the same variety of Calceolaria, which he obtained from a neighbour, "showed much greater vigour than some of his own that were "treated in exactly the same manner," and he attributed this solely to his own plants having become "to a certain extent worn "out or tired of their quarters." Something of this kind apparently occurs in grafting and budding fruit-trees; for, according to Mr. Abbey, grafts or buds generally take with greater facility on a distinct variety or even species, or on a stock previously grafted, than on stocks raised from seeds of the variety which is to be grafted; and he believes this cannot be altogether explained by the stocks in question being better adapted to the soil and climate of the place. It should, however, be added, that varieties grafted or budded on very distinct kinds, though they may take more readily and grow at first more vigorously than when grafted on closely allied stocks, afterwards often become unhealthy.

I have studied M. Tessier's careful and elaborate experiments,[6] made to disprove the common belief that good is derived from a change of seed; and he certainly shows that the same seed may with care be cultivated on the same farm (it is not stated whether on exactly the same soil) for ten consecutive years without loss. Another excellent observer, Colonel Le Couteur,[7] has come to the same conclusion; but then he expressly adds, if the same seed be used, "that which is grown on land manured from the mixen one "year becomes seed for land prepared with lime, and that again "becomes seed for land dressed with ashes, then for land dressed "with mixed manure, and so on." But this in effect is a systematic exchange of seed, within the limits of the same farm.

On the whole the belief, which has long been held by many cultivators, that good follows from exchanging seed, tubers, &c., seems to be fairly well founded. It seems hardly credible that the advantage thus derived can be due to the seeds, especially if very small ones, obtaining in one soil some

[6] 'Mém. de l'Acad. des Sciences,' 1790, p. 209.

[7] 'On the Varieties of Wheat,' p. 52.

chemical element deficient in the other and in sufficient quantity to influence the whole after-growth of the plant. As plants after once germinating are fixed to the same spot, it might have been anticipated that they would show the good effects of a change more plainly than do animals which continually wander about; and this apparently is the case. Life depending on, or consisting in, an incessant play of the most complex forces, it would appear that their action is in some way stimulated by slight changes in the circumstances to which each organism is exposed. All forces throughout nature, as Mr. Herbert Spencer[8] remarks, tend towards an equilibrium, and for the life of each organism it is necessary that this tendency should be checked. These views and the foregoing facts probably throw light, on the one hand, on the good effects of crossing the breed, for the germ will be thus slightly modified or acted on by new forces; and on the other hand, on the evil effects of close interbreeding prolonged during many generations, during which the germ will be acted on by a male having almost identically the same constitution.

*Sterility from Changed Conditions of Life.*

I will now attempt to show that animals and plants, when removed from their natural conditions, are often rendered in some degree infertile or completely barren; and this occurs even when the conditions have not been greatly changed. This conclusion is not necessarily opposed to that at which we have just arrived, namely, that lesser changes of other kinds are advantageous to organic beings. Our present subject is of some importance, from having an intimate connection with the causes of variability. Indirectly it perhaps bears on the sterility of species when crossed: for as, on the one hand, slight changes in the conditions of life are favourable to plants and animals, and the crossing of varieties adds

[8] Mr. Spencer has fully and ably discussed this whole subject in his 'Principles of Biology,' 1864, vol. ii. ch. x. In the first edition of my 'Origin of Species,' 1859, p. 267, I spoke of the good effects from slight changes in the conditions of life and from cross-breeding, and of the evil effects from great changes in the conditions and from crossing widely distinct forms, as a series of facts "connected together by some common but unknown bond, which is essentially related to the principle of life.

to the size, vigour, and fertility of their offspring; so, on the other hand, certain other changes in the conditions of life cause sterility; and as this likewise ensues from crossing much-modified forms or species, we have a parallel and double series of facts, which apparently stand in close relation to each other.

It is notorious that many animals, though perfectly tamed, refuse to breed in captivity. Isidore Geoffroy St.-Hilaire[9] consequently has drawn a broad distinction between tamed animals which will not breed under captivity, and truly domesticated animals which breed freely — generally more freely, as shown in the sixteenth chapter, than in a state of nature. It is possible and generally easy to tame most animals; but experience has shown that it is difficult to get them to breed regularly, or even at all. I shall discuss this subject in detail; but will give only those cases which seem most illustrative. My materials are derived from notices scattered through various works, and especially from a Report, kindly drawn up for me by the officers of the Zoological Society of London, which has especial value, as it records all the cases, during nine years from 1838–46, in which the animals were seen to couple but produced no offspring, as well as the cases in which they never, as far as known, coupled. This MS. Report I have corrected by the annual Reports subsequently published up to the year 1865.[10] Many facts are given on the breeding of the animals in that magnificent work, 'Gleanings from the Menageries of Knowsley Hall,' by Dr. Gray. I made, also, particular inquiries from the experienced keeper of the birds in the old Surrey Zoological Gardens. I should premise that a slight change in the treatment of animals sometimes makes a great difference in their fertility; and it is probable that the results observed in

[9] 'Essais de Zoologie Générale,' 1841, p. 256.

[10] Since the appearance of the first edition of this work, Mr. Sclater has published ('Proc. Zoolog. Soc.,' 1868, p. 623) a list of the species of mammals which have bred in the gardens from 1848 to 1867 inclusive. Of the Artiodactyla 85 species have been kept, and of these 1 species in 1·9 have bred at least once during the 20 years; of 28 Marsupialia, 1 in 2·5 have bred; of 74 Carnivora, 1 in 3·0 have bred; of 52 Rodentia, 1 in 4·7 have bred; and of Quadrumana 75 species have been kept, and 1 in 6·2 have bred.

different menageries would differ. Indeed, some animals in our Zoological Gardens have become more productive since the year 1846. It is, also, manifest from F. Cuvier's account of the Jardin des Plantes,[11] that the animals formerly bred much less freely there than with us; for instance, in the Duck tribe, which is highly prolific, only one species had at that period produced young.

The most remarkable cases, however, are afforded by animals kept in their native country, which, though perfectly tamed, quite healthy, and allowed some freedom, are absolutely incapable of breeding. Rengger,[12] who in Paraguay particularly attended to this subject, specifies six quadrupeds in this condition; and he mentions two or three others which most rarely breed. Mr. Bates, in his admirable work on the Amazons, strongly insists on similar cases;[13] and he remarks, that the fact of thoroughly tamed native mammals and birds not breeding when kept by the Indians, cannot be wholly accounted for by their negligence or indifference, for the turkey and fowl are kept and bred by various remote tribes. In almost every part of the world—for instance, in the interior of Africa, and in several of the Polynesian islands—the natives are extremely fond of taming the indigenous quadrupeds and birds; but they rarely or never succeed in getting them to breed.

The most notorious case of an animal not breeding in captivity is that of the elephant. Elephants are kept in large numbers in their native Indian home, live to old age, and are vigorous enough for the severest labour; yet, with a very few exceptions, they have never been known even to couple, though both males and females have their proper periodical seasons. If, however, we proceed a little eastward to Ava, we hear from Mr. Crawfurd[14] that their "breeding in the domestic state, or at least in the half-domestic state in which the female elephants are generally kept, is of every-day occurrence;" and Mr. Crawfurd informs me that he believes that the difference must be attributed solely to the females being allowed to roam the forest with some degree of freedom. The captive rhinoceros, on the other hand, seems from Bishop Heber's account[15] to breed in India far more readily than the elephant. Four wild species of the horse genus have bred in Europe, though here exposed to a great change in their natural habits of life; but the species have generally been crossed one with another. Most of

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[11] Du Rut, 'Annales du Muséum,' 1807, tom. ix. p. 120.

[12] 'Säugethiere von Paraguay,' 1830, s. 49, 106, 118, 124, 201, 208, 249, 265, 327.

[13] 'The Naturalist on the Amazons,' 1863, vol. i. pp. 99, 193; vol. ii. p. 113.

[14] 'Embassy to the Court of Ava,' vol. i. p. 534.

[15] 'Journal,' vol. i. p. 213.

the members of the pig family breed readily in our menageries; even the Red River hog (*Potamochœrus penicillatus*), from the sweltering plains of West Africa, has bred twice in the Zoological Gardens. Here also the Peccary (*Dicotyles torquatus*) has bred several times; but another species, the *D. labiatus*, though rendered so tame as to be half-domesticated, is said to breed so rarely in its native country of Paraguay, that according to Rengger[16] the fact requires confirmation. Mr. Bates remarks that the tapir, though often kept tame in Amazonia by the Indians, never breeds.

Ruminants generally breed quite freely in England, though brought from widely different climates, as may be seen in the Annual Reports of the Zoological Gardens, and in the Gleanings from Lord Derby's menagerie.

The Carnivora, with the exception of the Plantigrade division, breed (though with capricious exceptions) about half as freely as ruminants. Many species of Felidæ have bred in various menageries, although imported from diverse climates and closely confined. Mr. Bartlett, the present superintendent of the Zoological Gardens,[17] remarks that the lion appears to breed more frequently and to bring forth more young at a birth than any other species of the family. He adds that the tiger has rarely bred; "but there are several well-authenticated instances of the female tiger breeding with the lion." Strange as the fact may appear, many animals under confinement unite with distinct species and produce hybrids quite as freely as, or even more freely than, with their own species. On inquiring from Dr. Falconer and others, it appears that the tiger when confined in India does not breed, though it has been known to couple. The chetah (*Felis jubata*) has never been known by Mr. Bartlett to breed in England, but it has bred at Frankfort; nor does it breed in India, where it is kept in large numbers for hunting; but no pains would be taken to make them breed, as only those animals which have hunted for themselves in a state of nature are serviceable and worth training.[18] According to Rengger, two species of wild cats in Paraguay, though thoroughly tamed, have never bred. Although so many of the Felidæ breed readily in the Zoological Gardens, yet conception by no means always follows union: in the nine-year Report, various species are specified which were observed to couple seventy-three times, and no doubt this must have passed many times unnoticed; yet from the seventy-three unions only fifteen births ensued. The Carnivora in the Zoological Gardens were formerly less freely exposed to the air and cold than at present, and this change of treatment, as I was assured by the former superintendent, Mr. Miller, greatly increased their fertility. Mr. Bartlett, and there cannot be a more capable

[16] 'Säugethiere,' s. 327.

[17] On the Breeding of the Larger Felidæ, 'Proc. Zoolog. Soc.,' 1861, p. 140.

[18] Sleeman's 'Rambles in India,' vol. ii. p. 10.

judge, says, "it is remarkable that lions breed more freely in "travelling collections than in the Zoological Gardens; probably "the constant excitement and irritation produced by moving from "place to place, or change of air, may have considerable influence "in the matter."

Many members of the Dog family breed readily when confined. The Dhole is one of the most untamable animals in India, yet a pair kept there by Dr. Falconer produced young. Foxes, on the other hand, rarely breed, and I have never heard of such an occurrence with the European fox: the silver fox of North America (*Canis argentatus*), however, has bred several times in the Zoological Gardens. Even the otter has bred there. Every one knows how readily the semi-domesticated ferret breeds, though shut up in miserably small cages; but other species of Viverra and Paradoxurus absolutely refuse to breed in the Zoological Gardens. The Genetta has bred both here and in the Jardin des Plantes, and produced hybrids. The *Herpestes fasciatus* has likewise bred; but I was formerly assured that the *H. griseus*, though many were kept in the Gardens, never bred.

The Plantigrade Carnivora breed under confinement much less freely than other Carnivora, although no reason can be assigned for this fact. In the nine-year Report it is stated that the bears had been seen in the Zoological Gardens to couple freely, but previously to 1848 had most rarely conceived. In the Reports published since this date three species have produced young (hybrids in one case), and, wonderful to relate, the white Polar bear has produced young. The badger (*Meles taxus*) has bred several times in the Gardens; but I have not heard of this occurring elsewhere in England, and the event must be very rare, for an instance in Germany has been thought worth recording.[19] In Paraguay the native Nasua, though kept in pairs during many years and perfectly tamed, has never been known, according to Rengger, to breed or show any sexual passion; nor, as I hear from Mr. Bates, does this animal, or the Cercoleptes, breed in Amazonia. Two other plantigrade genera, Procyon and Gulo, though often kept tame in Paraguay, never breed there. In the Zoological Gardens species of Nasua and Procyon have been seen to couple; but they did not produce young.

As domesticated rabbits, guinea-pigs, and white mice breed so abundantly when closely confined under various climates, it might have been thought that most other members of the Rodent order would have bred in captivity, but this is not the case. It deserves notice, as showing how the capacity to breed sometimes goes by affinity, that the one native rodent of Paraguay, which there breeds *freely* and has yielded successive generations, is the *Cavia aperea;* and this animal is so closely allied to the guinea-pig,

[19] Wiegmann's 'Archiv für Naturgesch.,' 1837, s. 162.

that it has been erroneously thought to be the parent form.[20] In the Zoological Gardens, some rodents have coupled, but have never produced young; some have neither coupled nor bred; but a few have bred, as the porcupine more than once, the Barbary mouse, lemming, chinchilla, and agouti (*Dasyprocta aguti*) several times. This latter animal has also produced young in Paraguay, though they were born dead and ill-formed; but in Amazonia, according to Mr. Bates, it never breeds, though often kept tame about the houses. Nor does the paca (*Cœlogenys paca*) breed there. The common hare when confined has, I believe, never bred in Europe; though, according to a recent statement, it has crossed with the rabbit.[21] I have never heard of the dormouse breeding in confinement. But squirrels offer a more curious case: with one exception, no species has bred in the Zoological Gardens, yet as many as fourteen individuals of *S. palmarum* were kept together during several years. The *S. cinera* has been seen to couple, but it did not produce young; nor has this species, when rendered extremely tame in its native country, North America, been ever known to breed.[22] At Lord Derby's menagerie squirrels of many kinds were kept in numbers, but Mr. Thompson, the superintendent, told me that none had ever bred there, or elsewhere as far as he knew. I have never heard of the English squirrel breeding in confinement. But the species which has bred more than once in the Zoological Gardens is the one which perhaps might have been least expected, namely, the flying squirrel (*Sciuropterus volucella*): it has, also, bred several times near Birmingham; but the female never produced more than two young at a birth, whereas in its native American home she bears from three to six young.[23]

Monkeys, in the nine-year Report from the Zoological Gardens, are stated to unite most freely, but during this period, though many individuals were kept, there were only seven births. I have heard of only one American monkey, the Ouistiti, breeding in Europe.[24] A Macacus, according to Flourens, bred in Paris; and

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[20] Rengger, 'Säugethiere,' &c., s. 276. On the parentage of the guinea-pig, *see* also Isid. Geoffroy St.-Hilaire, 'Hist. Nat. Gén.' I sent to Mr. H. Denny of Leeds the lice which I collected from the wild aperea in La Plata, and he informs me that they belong to a genus distinct from those found on the guinea-pig. This is important evidence that the aperea is not the parent of the guinea-pig; and is worth giving, as some authors erroneously suppose that the guinea-pig since being domesticated has become sterile when crossed with the aperea.

[21] Although the existence of the *Leporides*, as described by Dr. Broca ('Journal de Phys.,' tom. ii. p. 370), has been positively denied, yet Dr. Pigeaux ('Annals and Mag. of Nat. Hist.' vol. xx., 1867, p. 75) affirms that the hare and rabbit have produced hybrids.

[22] 'Quadrupeds of North America, by Audubon and Bachman, 1846, p. 268.

[23] Loudon's 'Mag. of Nat. Hist.,' vol. ix., 1836, p. 571; Audubon and Bachman's 'Quadrupeds of North America,' p. 221.

[24] Flourens, 'De l'Instinct,' &c., 1845, p. 88.

more than one species of this genus has produced young in London, especially the *Macacus rhesus*, which everywhere shows a special capacity to breed under confinement. Hybrids have been produced both in Paris and London from this same genus. The Arabian baboon, or *Cynocephalus hamadryas*,[25] and a Cercopithecus have bred in the Zoological Gardens, and the latter species at the Duke of Northumberland's. Several members of the family of Lemurs have produced hybrids in the Zoological Gardens. It is much more remarkable that monkeys very rarely breed when confined in their native country; thus the Cay (*Cebus azaræ*) is frequently and completely tamed in Paraguay, but Rengger[26] says that it breeds so rarely, that he never saw more than two females which had produced young. A similar observation has been made with respect to the monkeys which are frequently tamed by the aborigines in Brazil.[27] In Amazonia, these animals are so often kept in a tame state, that Mr. Bates in walking through the streets of Parà counted thirteen species; but, as he asserts, they have never been known to breed in captivity.[28]

### *Birds.*

Birds offer in some respects better evidence than quadrupeds, from their breeding more rapidly and being kept in greater numbers.[29] We have seen that carnivorous animals are more fertile under confinement than most other mammals. The reverse holds good with carnivorous birds. It is said[30] that as many as eighteen species have been used in Europe for hawking, and several others in Persia and India;[31] they have been kept in their native country in the finest condition, and have been flown during six, eight, or nine years;[32] yet there is no record of their having ever produced young. As these birds were formerly caught whilst young, at great expense, being imported from Iceland, Norway,

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[25] *See* 'Annual Reports Zoolog. Soc.' 1855, 1858, 1863, 1864; 'Times' newspaper, Aug. 10th, 1847; Flourens, 'De l'Instinct,' p. 85.

[26] 'Säugethiere,' &c., s. 34, 49.

[27] Art. Brazil, 'Penny Cyclop.,' p. 363.

[28] 'The Naturalist on the Amazons,' vol. i. p. 99.

[29] A list of the species of birds which have bred in the Zoological Gardens from 1848 to 1867 inclusive has been published by Mr. Sclater in 'Proc. Zoolog. Soc.,' 1869, p. 626, since the first edition of this work appeared. Of Columbæ 51 species have been kept, and of Anseres 80 species, and in both these families, 1 species in 2·6 have bred at least once in the 20 years. Of Gallinæ, 83 species have been kept, and 1 in 2·7 have bred; of 57 Grallæ, 1 in 9 have bred; of 110 Prehensores, 1 in 22 have bred; of 178 Passeres, 1 in 25·4 have bred; of 94 Accipitres, 1 in 47 have bred; of 25 Picariæ, and of 35 Herodiones, not one species in either group has bred.

[30] 'Encyclop. of Rural Sports,' p. 691.

[31] According to Sir A. Burnes ('Cabool,' &c., p. 51), eight species are used for hawking in Sinde.

[32] Loudon's 'Mag. of Nat. Hist.,' vol. vi., 1833, p. 110.

and Sweden, there can be little doubt that, if possible, they would have been propagated. In the Jardin des Plantes, no bird of prey has been known to couple.[33] No hawk, vulture, or owl has ever produced fertile eggs in the Zoological Gardens, or in the old Surrey Gardens, with the exception, in the former place on one occasion, of a condor and a kite (*Milvus niger*). Yet several species, namely, the *Aquila fusca*, *Haliætus leucocephalus*, *Falco tinnunculus*, *F. subbuteo*, and *Buteo vulgaris*, have been seen to couple in the Zoological Gardens. Mr. Morris[34] mentions as a unique fact that a kestrel (*Falco tinnunculus*) bred in an aviary. The one kind of owl which has been known to couple in the Zoological Gardens was the Eagle Owl (*Bubo maximus*); and this species shows a special inclination to breed in captivity; for a pair at Arundel Castle, kept more nearly in a state of nature "than ever fell to the lot of an animal deprived of its liberty,"[35] actually reared their young. Mr. Gurney has given another instance of this same owl breeding in confinement; and he records the case of a second species of owl, the *Strix passerina*, breeding in captivity.[36]

Of the smaller graminivorous birds, many kinds have been kept tame in their native countries, and have lived long; yet, as the highest authority on cage-birds[37] remarks, their propagation is "uncommonly difficult." The canary-bird shows that there is no inherent difficulty in these birds breeding freely in confinement; and Audubon says[38] that the *Fringilla* (*Spiza*) *ciris* of North America breeds as perfectly as the canary. The difficulty with the many finches which have been kept in confinement is all the more remarkable as more than a dozen species could be named which have yielded hybrids with the canary; but hardly any of these, with the exception of the siskin (*Fringilla spinus*), have reproduced their own kind. Even the bullfinch (*Loxia pyrrhula*) has bred as frequently with the canary, though belonging to a distinct genus, as with its own species.[39] With respect to the skylark (*Alauda arvensis*), I have heard of birds living for seven years in an aviary, which never produced young; and a great London bird-fancier assured me that he had never known an instance of their breeding; nevertheless one case has been recorded.[40] In the nine-year Report from the Zoological Society, twenty-four

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[33] F. Cuvier, 'Annal. du Muséum,' tom. ix. p. 128.

[34] 'The Zoologist,' vol. vii.-viii., 1849-50, p. 2648.

[35] Knox, 'Ornithological Rambles in Sussex,' p. 91.

[36] 'The Zoologist,' vol. vii.-viii., 1849-50, p. 2566; vol. ix.-x., 1851-2, p. 3207.

[37] Bechstein, 'Naturgesch. der Stubenvögel,' 1840, s. 20.

[38] 'Ornithological Biography,' vol. v. p. 517.

[39] A case is recorded in 'The Zoologist,' vol. i.-ii., 1843-45, p. 453. For the siskin breeding, vol. iii.-iv., 1845-46, p. 1075. Bechstein, 'Stubenvögel,' s. 139, speaks of bullfinches making nests, but rarely producing young.

[40] Yarrell's 'Hist. British Birds,' 1839, vol. i. p. 412.

insessorial species are enumerated which had not bred, and of these only four were known to have coupled.

Parrots are singularly long-lived birds; and Humboldt mentions the curious fact of a parrot in South America, which spoke the language of an extinct Indian tribe, so that this bird preserved the sole relic of a lost language. Even in this country there is reason to believe[41] that parrots have lived to the age of nearly one hundred years; yet they breed so rarely, though many have been kept in Europe, that the event has been thought worth recording in the gravest publications.[42] Nevertheless, when Mr. Buxton turned out a large number of parrots in Norfolk, three pairs bred and reared ten young birds in the course of two seasons; and this success may be attributed to their free life.[43] According to Bechstein[44] the African *Psittacus erithacus* breeds oftener than any other species in Germany: the *P. macoa* occasionally lays fertile eggs, but rarely succeeds in hatching them; this bird, however, has the instinct of incubation sometimes so strongly developed, that it will hatch the eggs of fowls or pigeons. In the Zoological Gardens and in the old Surrey Gardens some few species have coupled, but, with the exception of three species of parrakeets, none have bred. It is a much more remarkable fact that in Guiana parrots of two kinds, as I am informed by Sir R. Schomburgk, are often taken from the nests by the Indians and reared in large numbers; they are so tame that they fly freely about the houses, and come when called to be fed, like pigeons; yet he has never heard of a single instance of their breeding.[45] In Jamaica, a resident naturalist, Mr. R. Hill,[46] says, "no birds more readily submit to human "dependence than the parrot-tribe, but no instance of a parrot "breeding in this tame life has been known yet." Mr. Hill specifies a number of other native birds kept tame in the West Indies, which never breed in this state.

The great pigeon family offers a striking contrast with the parrots: in the nine-year Report thirteen species are recorded as having bred, and, what is more noticeable, only two were seen to couple without any result. Since the above date every annual Report gives many cases of various pigeons breeding. The two magnificent crowned pigeons (*Goura coronata* and *victoriæ*) produced hybrids;

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[41] Loudon's 'Mag. of Nat. History,' vol. xix., 1836, p. 347.

[42] 'Mémoires du Muséum d'Hist. Nat.,' tom. x. p. 314: five cases of parrots breeding in France are here recorded. *See* also 'Report Brit. Assoc. Zoolog.,' 1843.

[43] 'Annals and Mag. of Nat. Hist.,' Nov. 1868, p. 311.

[44] 'Stubenvögel,' s. 105, 83.

[45] Dr. Hancock remarks ('Charlesworth's Mag. of Nat. Hist.' vol. ii., 1838, p. 492), "it is singular that, amongst the numerous useful birds that are indigenous to Guiana, none are found to propagate among the Indians; yet the common fowl is reared in abundance throughout the country."

[46] 'A Week at Port Royal,' 1855, p. 7.

nevertheless, of the former species more than a dozen birds were kept, as I am informed by Mr. Crawfurd, in a park at Penang, under a perfectly well-adapted climate, but never once bred. The *Columba migratoria* in its native country, North America, invariably lays two eggs, but in Lord Derby's menagerie never more than one. The same fact has been observed with the *C. leucocephala*.[47]

Gallinaceous birds of many genera likewise show an eminent capacity for breeding under captivity. This is particularly the case with pheasants, yet our English species seldom lays more than ten eggs in confinement; whilst from eighteen to twenty is the usual number in the wild state.[48] With the Gallinaceæ, as with all other orders, there are marked and inexplicable exceptions in regard to the fertility of certain species and genera under confinement. Although many trials have been made with the common partridge, it has rarely bred, even when reared in large aviaries; and the hen will never hatch her own eggs.[49] The American tribe of Guans or Cracidæ are tamed with remarkable ease, but are very shy breeders in this country;[50] but with care various species were formerly made to breed rather freely in Holland.[51] Birds of this tribe are often kept in a perfectly tamed condition in their native country by the Indians, but they never breed.[52] It might have been expected that grouse from their habits of life would not have bred in captivity, more especially as they are said soon to languish and die.[53] But many cases are recorded of their breeding: the capercailzie (*Tetrao urogallus*) has bred in the Zoological Gardens; it breeds without much difficulty when confined in Norway, and in Russia five successive generations have been reared: *Tetrao tetrix* has likewise bred in Norway; *T. scoticus* in Ireland; *T. umbellus* at Lord Derby's; and *T. cupido* in North America.

It is scarcely possible to imagine a greater change in habits than that which the members of the ostrich family must suffer, when cooped up in small enclosures under a temperate climate, after freely roaming over desert and tropical plains or entangled forests;

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[47] Audubon, 'American Ornithology,' vol. v. pp. 552, 557.

[48] Moubray on Poultry, 7th edit., p. 133.

[49] Temminck, 'Hist. Nat. Gén. des Pigeons,' &c., 1813, tom. iii. pp. 288, 382; 'Annals and Mag. of Nat. Hist.,' vol xii., 1843, p. 453. Other species of partridge have occasionally bred; as the red-legged (*P. rubra*), when kept in a large court in France (*see* 'Journal de Physique,' tom. xxv. p. 294), and in the Zoological Gardens in 1856.

[50] Rev. E. S. Dixon, 'The Dovecote,' 1851, pp. 243-252.

[51] Temminck, 'Hist. Nat. Gén. des Pigeons,' &c., tom. ii. pp. 456, 458; tom. iii. pp. 2, 13, 47.

[52] Bates, 'The Naturalist on the Amazons,' vol. i. p. 193; vol. ii. p. 112.

[53] Temminck, 'Hist. Nat. Gén.,' &c., tom. ii. p. 125. For *Tetrao urogallus*, *see* L. Lloyd, 'Field Sports of North of Europe,' vol. i. pp. 287, 314; and 'Bull. de la Soc. d'Acclimat.,' tom. vii., 1860, p. 600. For *T. scoticus*, Thompson, 'Nat. Hist. of Ireland,' vol. ii. 1850, p. 49. For *T. cupido*. 'Boston Journal of Nat. Hist.,' vol. iii. p. 199.

yet almost all the kinds have frequently produced young in the various European menageries, even the mooruk (*Casuarius bennetii*) from New Ireland. The African ostrich, though perfectly healthy and living long in the South of France, never lays more than from twelve to fifteen eggs, though in its native country it lays from twenty-five to thirty.[54] Here we have another instance of fertility impaired, but not lost, under confinement, as with the flying squirrel, the hen-pheasant, and two species of American pigeons.

Most Waders can be tamed, as the Rev. E. S. Dixon informs me, with remarkable facility; but several of them are short-lived under confinement, so that their sterility in this state is not surprising. The cranes breed more readily than other genera: *Grus montigresia* has bred several times in Paris and in the Zoological Gardens, as has *G. cinerea* at the latter place, and *G. antigone* at Calcutta. Of other members of this great order, *Tetrapteryx paradisea* has bred at Knowsley, a Porphyrio in Sicily, and the *Gallinula chloropus* in the Zoological Gardens. On the other hand, several birds belonging to this order will not breed in their native country, Jamaica; and the Psophia, though often kept by the Indians of Guiana about their houses, "is seldom or never known to breed."[55]

The members of the great Duck family breed as readily in confinement as do the Columbæ and Gallinæ; and this, considering their aquatic and wandering habits, and the nature of their food, could not have been anticipated. Even some time ago above two dozen species had bred in the Zoological Gardens; and M. Selys-Longchamps has recorded the production of hybrids from forty-four different members of the family; and to these Professor Newton has added a few more cases.[56] "There is not," says Mr. Dixon,[57] "in the wide world, a goose which is not in the strict sense of the word domesticable;" that is, capable of breeding under confinement; but this statement is probably too bold. The capacity to breed sometimes varies in individuals of the same species; thus Audubon[58] kept for more than eight years some wild geese (*Anser canadensis*), but they would not mate; whilst other individuals of the same species produced young during the second year. I know of but one instance in the whole family of a species which absolutely refuses to breed in captivity, namely, the *Dendrocygna viduata*, although, according to Sir R. Schomburgk,[59] it is easily tamed, and is frequently kept by the Indians of Guiana. Lastly, with respect

[54] Marcel de Serres, 'Annales des Sci. Nat.,' 2nd series, Zoolog., tom. xiii. p. 175.

[55] Dr. Hancock, in 'Charlesworth's Mag. of Nat. Hist.,' vol. ii., 1838, p. 491; R. Hill, 'A Week at Port Royal,' p. 8; 'Guide to the Zoological Gardens,' by P. L. Sclater, 1859, pp. 11, 12; 'The Knowsley Menagerie,' by Dr. Gray, 1846, pl. xiv.; E. Blyth, 'Report Asiatic Soc. of Bengal,' May 1855.

[56] Prof. Newton, in 'Proc. Zoolog. Soc.,' 1860, p. 336.

[57] 'The Dovecote and Aviary,' p. 428.

[58] 'Ornithological Biography,' vol. iii. p. 9.

[59] 'Geograph. Journal,' vol. xiii., 1844, p. 32.

to Gulls, though many have been kept in the Zoological Gardens and in the old Surrey Gardens, no instance was known before the year 1848 of their coupling or breeding; but since that period the herring gull (*Larus argentatus*) has bred many times in the Zoological Gardens and at Knowsley.

There is reason to believe that insects are affected by confinement like the higher animals. It is well known that the Sphingidæ rarely breed when thus treated. An entomologist[60] in Paris kept twenty-five specimens of *Saturnia pyri*, but did not succeed in getting a single fertile egg. A number of females of *Orthosia munda* and of *Mamestra suasa* reared in confinement were unattractive to the males.[61] Mr. Newport kept nearly a hundred individuals of two species of Vanessa, but not one paired; this, however, might have been due to their habit of coupling on the wing.[62] Mr. Atkinson could never succeed in India in making the Tarroo silk-moth breed in confinement.[63] It appears that a number of moths, especially the Sphingidæ, when hatched in the autumn out of their proper season, are completely barren; but this latter case is still involved in some obscurity.[64]

Independently of the fact of many animals under confinement not coupling, or, if they couple, not producing young, there is evidence of another kind that their sexual functions are disturbed. For many cases have been recorded of the loss by male birds when confined of their characteristic plumage. Thus the common linnet (*Linota cannabina*) when caged does not acquire the fine crimson colour on its breast, and one of the buntings (*Emberiza passerina*) loses the black on its head. A Pyrrhula and an Oriolus have been observed to assume the quiet plumage of the hen-bird; and the *Falco albidus* returned to the dress of an earlier age.[65] Mr. Thompson, the superintendent of the Knowsley menagerie, informed me that he had often observed analogous facts. The horns of a male deer (*Cervus canadensis*) during the voyage from America were badly developed; but subsequently in Paris perfect horns were produced.

[60] Loudon's 'Mag. of Nat. Hist.,' vol. v., 1832, p. 153.

[61] 'Zoologist,' vols. v.-vi., 1847-48, p. 1660.

[62] 'Transact. Entomolog. Soc.,' vol. iv., 1845, p. 60.

[63] 'Transact. Linn. Soc.,' vol. vii. p. 40.

[64] *See* an interesting paper by Mr. Newman, in the 'Zoologist,' 1857, p. 5764; and Dr. Wallace, in 'Proc. Entomolog. Soc.,' June 4th, 1860, p. 119.

[65] Yarrell's 'British Birds,' vol. i. p. 506; Bechstein, 'Stubenvögel,' s. 185; 'Philosoph. Transact.,' 1772, p. 271. Bronn ('Geschichte der Natur,' Band ii. s. 96) has collected a number of cases. For the case of the deer, *see* 'Penny Cyclop.,' vol. viii. p. 350.

When conception takes place under confinement, the young are often born dead, or die soon, or are ill-formed. This frequently occurs in the Zoological Gardens, and, according to Rengger, with native animals confined in Paraguay. The mother's milk often fails. We may also attribute to the disturbance of the sexual functions the frequent occurrence of that monstrous instinct which leads the mother to devour her own offspring,—a mysterious case of perversion, as it at first appears.

Sufficient evidence has now been advanced to prove that animals when first confined are eminently liable to suffer in their reproductive systems. We feel at first naturally inclined to attribute the result to loss of health, or at least to loss of vigour; but this view can hardly be admitted when we reflect how healthy, long-lived, and vigorous many animals are under captivity, such as parrots, and hawks when used for hawking, cheetahs when used for hunting, and elephants. The reproductive organs themselves are not diseased; and the diseases, from which animals in menageries usually perish, are not those which in any way affect their fertility. No domestic animal is more subject to disease than the sheep, yet it is remarkably prolific. The failure of animals to breed under confinement has been sometimes attributed exclusively to a failure in their sexual instincts: this may occasionally come into play, but there is no obvious reason why this instinct should be especially liable to be affected with perfectly tamed animals, except, indeed, indirectly through the reproductive system itself being disturbed. Moreover, numerous cases have been given of various animals which couple freely under confinement, but never conceive; or, if they conceive and produce young, these are fewer in number than is natural to the species. In the vegetable kingdom instinct of course can play no part; and we shall presently see that plants when removed from their natural conditions are affected in nearly the same manner as animals. Change of climate cannot be the cause of the loss of fertility, for, whilst many animals imported into Europe from extremely different climates breed freely, many others when confined in their native land are completely sterile. Change of food cannot be

the chief cause; for ostriches, ducks, and many other animals, which must have undergone a great change in this respect, breed freely. Carnivorous birds when confined are extremely sterile, whilst most carnivorous mammals, except plantigrades, are moderately fertile. Nor can the amount of food be the cause; for a sufficient supply will certainly be given to valuable animals; and there is no reason to suppose that much more food would be given to them than to our choice domestic productions which retain their full fertility. Lastly, we may infer from the case of the elephant, cheetah, various hawks, and of many animals which are allowed to lead an almost free life in their native land, that want of exercise is not the sole cause.

It would appear that any change in the habits of life, whatever these habits may be, if great enough, tends to affect in an inexplicable manner the powers of reproduction. The result depends more on the constitution of the species than on the nature of the change; for certain whole groups are affected more than others; but exceptions always occur, for some species in the most fertile groups refuse to breed, and some in the most sterile groups breed freely. Those animals which usually breed freely under confinement, rarely breed, as I was assured, in the Zoological Gardens, within a year or two after their first importation. When an animal which is generally sterile under confinement happens to breed, the young apparently do not inherit this power: for had this been the case, various quadrupeds and birds, which are valuable for exhibition, would have become common. Dr. Broca even affirms [66] that many animals in the Jardin des Plantes, after having produced young for three or four successive generations, become sterile; but this may be the result of too close interbreeding. It is a remarkable circumstance that many mammals and birds have produced hybrids under confinement quite as readily as, or even more readily than, they have procreated their own kind. Of this fact many instances have been given; [67] and we are thus reminded of those plants which when cultivated refuse to be fertilised by

[66] 'Journal de Physiologie,' tom. ii. p. 347.

[67] For additional evidence on this subject, *see* F. Cuvier, in 'Annales du Muséum,' tom. xii. p. 119.

their own pollen, but can easily be fertilised by that of a distinct species. Finally, we must conclude, limited as the conclusion is, that changed conditions of life have an especial power of acting injuriously on the reproductive system. The whole case is quite peculiar, for these organs, though not diseased, are thus rendered incapable of performing their proper functions, or perform them imperfectly.

*Sterility of Domesticated Animals from changed conditions.*—With respect to domesticated animals, as their domestication mainly depends on the accident of their breeding freely under captivity, we ought not to expect that their reproductive system would be affected by any moderate degree of change. Those orders of quadrupeds and birds, of which the wild species breed most readily in our menageries, have afforded us the greatest number of domesticated productions. Savages in most parts of the world are fond of taming animals;[68] and if any of these regularly produced young, and were at the same time useful, they would be at once domesticated. If, when their masters migrated into other countries, they were in addition found capable of withstanding various climates, they would be still more valuable; and it appears that the animals which breed readily in captivity can generally withstand different climates. Some few domesticated animals, such as the reindeer and camel, offer an exception to this rule. Many of our domesticated animals can bear with undiminished fertility the most unnatural conditions; for instance, rabbits, guinea-pigs, and ferrets breed in miserably confined hutches. Few European dogs of any kind withstand the climate of India without degenerating, but as long as they survive, they retain, as I hear from Dr. Falconer, their fertility; so it is, according to Dr. Daniell, with English dogs taken to Sierra Leone. The fowl, a native of the hot jungles of India, becomes more fertile than its parent-stock in every quarter of the world, until we advance as far north as Greenland and Northern Siberia, where this bird will not breed. Both fowls and pigeons, which I received during the autumn direct from Sierra Leone, were at once ready to couple.[69] I have, also, seen pigeons

[68] Numerous instances could be given. Thus Livingstone ('Travels,' p. 217) states that the King of the Barotse, an inland tribe which never had any communication with white men, was extremely fond of taming animals, and every young antelope was brought to him. Mr. Galton informs me that the Damaras are likewise fond of keeping pets. The Indians of South America follow the same habit. Capt. Wilkes states that the Polynesians of the Samoan Islands tamed pigeons; and the New Zealanders, as Mr. Mantell informs me, kept various kinds of birds.

[69] For analogous cases with the fowl, *see* Réaumur, 'L'Art de faire Eclore,' &c., 1749, p. 243; and Col. Sykes, in 'Proc. Zoolog. Soc.,' 1832, &c. With respect to the fowl not breeding in northern regions, *see* Latham's 'Hist. of Birds,' vol. viii., 1823, p. 169.

breeding as freely as the common kinds within a year after their importation from the upper Nile. The guinea-fowl, an aboriginal of the hot and dry deserts of Africa, whilst living under our damp and cool climate, produces a large supply of eggs.

Nevertheless, our domesticated animals under new conditions occasionally show signs of lessened fertility. Roulin asserts that in the hot valleys of the equatorial Cordillera sheep are not fully fecund;[70] and according to Lord Somerville,[71] the merino-sheep which he imported from Spain were not at first perfectly fertile. It is said[72] that mares brought up on dry food in the stable, and turned out to grass, do not at first breed. The peahen, as we have seen, is said not to lay so many eggs in England as in India. It was long before the canary-bird was fully fertile, and even now first-rate breeding birds are not common.[73] In the hot and dry province of Delhi, as I hear from Dr. Falconer, the eggs of the turkey, though placed under a hen, are extremely liable to fail. According to Roulin, geese taken to the lofty plateau of Bogota, at first laid seldom, and then only a few eggs; of these scarcely a fourth were hatched, and half the young birds died; in the second generation they were more fertile; and when Roulin wrote they were becoming as fertile as our geese in Europe. With respect to the valley of Quito, Mr. Orton says:[74] "the only geese in the valley are a few imported from Europe, and these refuse to propagate." In the Philippine Archipelago the goose, it is asserted, will not breed or even lay eggs.[75] A more curious case is that of the fowl, which, according to Roulin, when first introduced would not breed at Cusco in Bolivia, but subsequently became quite fertile; and the English Game fowl, lately introduced, had not as yet arrived at its full fertility, for to raise two or three chickens from a nest of eggs was thought fortunate. In Europe close confinement has a marked effect on the fertility of the fowl: it has been found in France that with fowls allowed considerable freedom only twenty per cent. of the eggs failed; when allowed less freedom forty per cent. failed; and in close confinement sixty out of the hundred were not hatched.[76] So we see that unnatural and changed conditions of life produce some effect on the fertility of our most thoroughly domesticated animals, in the same manner, though in a far less degree, as with captive wild animals.

It is by no means rare to find certain males and females which will not breed together, though both are known to be perfectly fertile with other males and females. We have no reason to suppose that this is caused by these animals having been subjected to any change in their habits of life; therefore such cases are hardly related to our present subject. The cause apparently lies in an innate sexual in-

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[70] "Mém. par divers Savans," 'Acad. des Sciences,' tom. vi., 1835, p. 347.

[71] Youatt on Sheep, p. 181.

[72] J. Mills, 'Treatise on Cattle,' 1776, p. 72.

[73] Bechstein, 'Stubenvögel,' s. 242.

[74] 'The Andes and the Amazon,' 1870, p. 107.

[75] Crawfurd's 'Descriptive Dict. of the Indian Islands,' 1856, p. 145.

[76] 'Bull. de la Soc. d'Acclimat.,' tom. ix., 1862, pp. 380, 384.

compatibility of the pair which are matched. Several instances have been communicated to me by Mr. W. C. Spooner (well known for his essay on Cross-breeding), by Mr. Eyton of Eyton, by Mr. Wicksted and other breeders, and especially by Mr. Waring of Chelsfield, in relation to horses, cattle, pigs, foxhounds, other dogs, and pigeons.[77] In these cases, females, which either previously or subsequently were proved to be fertile, failed to breed with certain males, with whom it was particularly desired to match them. A change in the constitution of the female may sometimes have occurred before she was put to the second male; but in other cases this explanation is hardly tenable, for a female, known not to be barren, has been unsuccessfully paired seven or eight times with the same male likewise known to be perfectly fertile. With cart-mares, which sometimes will not breed with stallions of pure blood, but subsequently have bred with cart-stallions, Mr. Spooner is inclined to attribute the failure to the lesser sexual power of the race-horse. But I have heard from the greatest breeder of race-horses at the present day, through Mr. Waring, that "it frequently occurs with a mare to be put several times during "one or two seasons to a particular stallion of acknowledged power, "and yet prove barren; the mare afterwards breeding at once with "some other horse." These facts are worth recording, as they show, like so many previous facts, on what slight constitutional differences the fertility of an animal often depends.

### *Sterility of Plants from changed Conditions of Life, and from other causes.*

In the vegetable kingdom cases of sterility frequently occur, analogous with those previously given in the animal kingdom. But the subject is obscured by several circumstances, presently to be discussed, namely, the contabescence of the anthers, as Gärtner has named a certain affection—monstrosities—doubleness of the flower—much-enlarged fruit—and long-continued or excessive propagation by buds.

It is notorious that many plants in our gardens and hot-houses, though preserved in the most perfect health, rarely or never produce seed. I do not allude to plants which run to leaves, from being kept too damp, or too warm, or too much manured; for these do not flower, and the case may be wholly different. Nor do I allude to fruit not ripening from want of heat or rotting from too much moisture. But many exotic plants, with their ovules and pollen appearing perfectly sound, will not set any seed. The sterility in many cases, as I know from my own observation, is simply due to the absence of the proper insects for carrying the pollen to the stigma. But after excluding the several cases just

[77] For pigeons, *see* Dr. Chapuis, 'Le Pigeon Voyageur Belge,' 1865, p. 66.

specified, there are many plants in which the reproductive system has been seriously affected by the altered conditions of life to which they have been subjected.

It would be tedious to enter on many details. Linnæus long ago observed[78] that Alpine plants, although naturally loaded with seed, produce either few or none when cultivated in gardens. But exceptions often occur: the *Draba sylvestris*, one of our most thoroughly Alpine plants, multiplies itself by seed in Mr. H. C. Watson's garden, near London; and Kerner, who has particularly attended to the cultivation of Alpine plants, found that various kinds, when cultivated, spontaneously sowed themselves.[79] Many plants which naturally grow in peat-earth are entirely sterile in our gardens. I have noticed the same fact with several liliaceous plants, which nevertheless grew vigorously.

Too much manure renders some kinds utterly sterile, as I have myself observed. The tendency to sterility from this cause runs in families; thus, according to Gärtner,[80] it is hardly possible to give too much manure to most Gramineæ, Cruciferæ, and Leguminosæ, whilst succulent and bulbous-rooted plants are easily affected. Extreme poverty of soil is less apt to induce sterility; but dwarfed plants of *Trifolium minus* and *repens*, growing on a lawn often mown and never manured, were found by me not to produce any seed. The temperature of the soil, and the season at which plants are watered, often have a marked effect on their fertility, as was observed by Kölreuter in the case of Mirabilis.[81] Mr. Scott, in the Botanic Gardens of Edinburgh, observed that *Oncidium divaricatum* would not set seed when grown in a basket in which it throve, but was capable of fertilisation in a pot where it was a little damper. *Pelargonium fulgidum*, for many years after its introduction, seeded freely; it then became sterile; now it is fertile[82] if kept in a dry stove during the winter. Other varieties of pelargonium are sterile and others fertile without our being able to assign any cause. Very slight changes in the position of a plant, whether planted on a bank or at its base, sometimes make all the difference in its producing seed. Temperature apparently has a much more powerful influence on the fertility of plants than on that of animals. Nevertheless it is wonderful what changes some few plants will withstand with undiminished fertility: thus the *Zephyranthes candida*, a native of the moderately warm banks of the Plata, sows itself in the hot dry country near Lima, and in Yorkshire

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[78] 'Swedish Acts,' vol. i., 1739, p. 3. Pallas makes the same remark in his 'Travels' (Eng. translat.), vol. i. p. 292.

[79] A. Kerner, 'Die Cultur der Alpenpflanzen,' 1864, s. 139; Watson's 'Cybele Britannica,' vol. i. p. 131; Mr. D. Cameron, also, has written on the culture of Alpine plants in 'Gard. Chronicle,' 1848, pp. 253, 268, and mentions a few which seed.

[80] 'Beiträge zur Kenntniss der Befruchtung,' 1844, s. 333.

[81] 'Nova Acta Petrop.,' 1793, p. 391.

[82] 'Cottage Gardener,' 1856, pp. 44, 109.

resists the severest frosts, and I have seen seeds gathered from pods which had been covered with snow during three weeks.[83] *Berberis wallichii*, from the hot Khasia range in India, is uninjured by our sharpest frosts, and ripens its fruit under our cool summers. Nevertheless, I presume we must attribute to change of climate the sterility of many foreign plants; thus, the Persian and Chinese lilacs (*Syringa persica* and *chinensis*), though perfectly hardy here, never produce a seed; the common lilac (*S. vulgaris*) seeds with us moderately well, but in parts of Germany the capsules never contain seed.[84] Some few of the cases, given in the last chapter, of self-impotent plants, might have been here introduced, as their state seems due to the conditions to which they have been subjected.

The liability of plants to be affected in their fertility by slightly changed conditions is the more remarkable, as the pollen when once in process of formation is not easily injured; a plant may be transplanted, or a branch with flower-buds be cut off and placed in water, and the pollen will be matured. Pollen, also, when once mature, may be kept for weeks or even months.[85] The female organs are more sensitive, for Gärtner[86] found that dicotyledonous plants, when carefully removed so that they did not in the least flag, could seldom be fertilised; this occurred even with potted plants if the roots had grown out of the hole at the bottom. In some few cases, however, as with Digitalis, transplantation did not prevent fertilisation; and according to the testimony of Mawz, *Brassica rapa*, when pulled up by its roots and placed in water, ripened its seed. Flower-stems of several monocotyledonous plants when cut off and placed in water likewise produce seed. But in these cases I presume that the flowers had been already fertilised, for Herbert[87] found with the Crocus that the plants might be removed or mutilated after the act of fertilisation, and would still perfect their seeds; but that, if transplanted before being fertilised, the application of pollen was powerless.

Plants which have been long cultivated can generally endure with undiminished fertility various and great changes; but not in most cases so great a change of climate as domesticated animals. It is remarkable that many plants under these circumstances are so much affected that the proportion and the nature of their chemical ingredients are modified, yet their fertility is unimpaired. Thus, as Dr. Falconer informs me, there is a great difference in the character of the fibre in hemp, in the quantity of oil in the seed of

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[83] Dr. Herbert, 'Amaryllidaceæ,' p. 176.

[84] Gärtner, 'Beiträge zur Kenntniss,' &c., s. 560, 564.

[85] 'Gardener's Chronicle,' 1844, p. 215; 1850, p. 470. Faivre gives a good résumé on this subject in his 'La Variabilité des Espèces,' 1868, p. 155.

[86] 'Beiträge zur Kenntniss,' &c., s. 252, 333.

[87] 'Journal of Hort. Soc.,' vol. ii., 1847, p. 83.

the Linum, in the proportion of narcotin to morphine in the poppy, in gluten to starch in wheat, when these plants are cultivated on the plains and on the mountains of India; nevertheless, they all remain fully fertile.

*Contabescence.*—Gärtner has designated by this term a peculiar condition of the anthers in certain plants, in which they are shrivelled, or become brown and tough, and contain no good pollen. When in this state they exactly resemble the anthers of the most sterile hybrids. Gärtner,[88] in his discussion on this subject, has shown that plants of many orders are occasionally thus affected; but the Caryophyllaceæ and Liliaceæ suffer most, and to these orders, I think, the Ericaceæ may be added. Contabescence varies in degree, but on the same plant all the flowers are generally affected to nearly the same extent. The anthers are affected at a very early period in the flower-bud, and remain in the same state (with one recorded exception) during the life of the plant. The affection cannot be cured by any change of treatment, and is propagated by layers, cuttings, &c., and perhaps even by seed. In contabescent plants the female organs are seldom affected, or merely become precocious in their development. The cause of this affection is doubtful, and is different in different cases. Until I read Gärtner's discussion I attributed it, as apparently did Herbert, to the unnatural treatment of the plants; but its permanence under changed conditions, and the female organs not being affected, seem incompatible with this view. The fact of several endemic plants becoming contabescent in our gardens seems, at first sight, equally incompatible with this view; but Kölreuter believes that this is the result of their transplantation. The contabescent plants of Dianthus and Verbascum, found wild by Wiegmann, grew on a dry and sterile bank. The fact that exotic plants are eminently liable to this affection also seems to show that it is in some manner caused by their unnatural treatment. In some instances, as with Silene, Gärtner's view seems the most probable, namely, that it is caused by an inherent tendency in the species to become dicœcious. I can add another cause, namely, the illegitimate unions of heterostyled plants, for I have observed seedlings of three species of Primula and of *Lythrum salicaria*, which had been raised from plants illegitimately fertilised by their own-form pollen, with some or all their anthers in a contabescent state. There is perhaps an additional cause, namely, self-fertilisation; for many plants of Dianthus and Lobelia, which had been raised from self-fertilised seeds, had their anthers in this state; but these instances are not conclusive, as both genera are liable from other causes to this affection.

Cases of an opposite nature likewise occur, namely, plants with

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[88] 'Beiträge zur Kenntniss,' &c., s. 117 *et seq.*; Kölreuter, 'Zweite Fortsetzung,' s. 10, 121; 'Dritte Fortsetzung,' s. 57. Herbert, 'Amaryllidaceæ,' p. 355. Wiegmann, 'Ueber die Bastarderzeugung,' s. 27.

the female organs struck with sterility, whilst the male organs remain perfect. *Dianthus japonicus*, a Passiflora, and Nicotiana, have been described by Gärtner[89] as being in this unusual condition.

*Monstrosities as a cause of sterility.*—Great deviations of structure, even when the reproductive organs themselves are not seriously affected, sometimes cause plants to become sterile. But in other cases plants may become monstrous to an extreme degree and yet retain their full fertility. Gallesio, who certainly had great experience,[90] often attributes sterility to this cause; but it may be suspected that in some of his cases sterility was the cause, and not the result, of the monstrous growths. The curious St. Valery apple, although it bears fruit, rarely produces seed. The wonderfully anomalous flowers of *Begonia frigida*, formerly described, though, they appear fit for fructification, are sterile.[91] Species of Primula in which the calyx is brightly coloured are said[92] to be often sterile, though I have known them to be fertile. On the other hand, Verlot gives several cases of proliferous flowers which can be propagated by seed. This was the case with a poppy, which had become monopetalous by the union of its petals.[93] Another extraordinary poppy, with the stamens replaced by numerous small supplementary capsules, likewise reproduces itself by seed. This has also occurred with a plant of *Saxifraga geum*, in which a series of adventitious carpels, bearing ovules on their margins, had been developed between the stamens and the normal carpels.[94] Lastly, with respect to peloric flowers, which depart wonderfully from the natural structure,—those of *Linaria vulgaris* seem generally to be more or less sterile, whilst those before described of *Antirrhinum majus*, when artificially fertilised with their own pollen, are perfectly fertile, though sterile when left to themselves, for bees are unable to crawl into the narrow tubular flower. The peloric flowers of *Corydalis solida*, according to Godron,[95] are sometimes barren and sometimes fertile; whilst those of Gloxinia are well known to yield plenty of seed. In our greenhouse Pelargoniums, the central flower of the truss is often peloric, and Mr. Masters informs me that he tried in vain during several years to get seed from these flowers. I likewise made many vain attempts, but sometimes succeeded in fertilising them with pollen from a normal

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[89] 'Bastarderzeugung,' s. 356.

[90] 'Teoria della Riproduzione,' 1816, p. 84; 'Traité du Citrus,' 1811, p. 67.

[91] Mr. C. W. Crocker, in 'Gard. Chronicle,' 1861, p. 1092.

[92] Verlot, 'Des Variétés,' 1865, p. 80.

[93] Verlot, ibid., p. 88.

[94] Prof. Allman, Brit. Assoc., quoted in the 'Phytologist,' vol. ii. p. 483. Prof. Harvey, on the authority of Mr. Andrews, who discovered the plant, informed me that this monstrosity could be propagated by seed. With respect to the poppy, see Prof. Goeppert, as quoted in 'Journal of Horticulture,' July 1st, 1863, p. 171.

[95] 'Comptes Rendus,' Dec. 19th, 1864, p. 1039.

flower of another variety; and conversely I several times fertilised ordinary flowers with peloric pollen. Only once I succeeded in raising a plant from a peloric flower fertilised by pollen from a peloric flower borne by another variety; but the plant, it may be added, presented nothing particular in its structure. Hence we may conclude that no general rule can be laid down; but any great deviation from the normal structure, even when the reproductive organs themselves are not seriously affected, certainly often leads to sexual impotence.

*Double Flowers.*—When the stamens are converted into petals, the plant becomes on the male side sterile; when both stamens and pistils are thus changed, the plant becomes completely barren. Symmetrical flowers having numerous stamens and petals are the most liable to become double, as perhaps follows from all multiple organs being the most subject to variability. But flowers furnished with only a few stamens, and others which are asymmetrical in structure, sometimes become double, as we see with the double gorse or Ulex, and Antirrhinum. The Compositæ bear what are called double flowers by the abnormal development of the corolla of their central florets. Doubleness is sometimes connected with prolification,[96] or the continued growth of the axis of the flower. Doubleness is strongly inherited. No one has produced, as Lindley remarks,[97] double flowers by promoting the perfect health of the plant. On the contrary, unnatural conditions of life favour their production. There is some reason to believe that seeds kept during many years, and seeds believed to be imperfectly fertilised, yield double flowers more freely than fresh and perfectly fertilised seed.[98] Long-continued cultivation in rich soil seems to be the commonest exciting cause. A double narcissus and a double *Anthemis nobilis*, transplanted into very poor soil, has been observed to become single;[99] and I have seen a completely double white primrose rendered permanently single by being divided and transplanted whilst in full flower. It has been observed by Professor E. Morren that doubleness of the flowers and variegation of the leaves are antagonistic states; but so many exceptions to the rule have lately been recorded,[100] that, though general, it cannot be looked at as invariable. Variegation seems generally to result from a feeble or atrophied condition of the plant, and a large proportion of the seedlings raised from parents, if both are variegated, usually perish at an early age; hence we may perhaps infer that doubleness, which is

[96] 'Gardener's Chronicle,' 1866, p. 681.

[97] 'Theory of Horticulture,' p. 333.

[98] Mr. Fairweather, in 'Transact. Hort. Soc.,' vol. iii. p. 406: Bosse, quoted by Bronn, 'Geschichte der Natur,' B. ii. s. 77. On the effects of the removal of the anthers, *see* Mr. Leitner, in Silliman's 'North American Journ. of Science,' vol. xxiii. p. 47; and Verlot, 'Des Variétés,' 1865, p. 84.

[99] Lindley's 'Theory of Horticulture,' p. 333.

[100] 'Gardener's Chronicle,' 1865, p. 626; 1866, pp. 290, 730; and Verlot, 'Des Variétés,' p. 75.

the antagonistic state, commonly arises from a plethoric condition. On the other hand, extremely poor soil sometimes, though rarely, appears to cause doubleness: I formerly described[101] some completely double, bud-like, flowers produced in large numbers by stunted wild plants of *Gentiana amarella* growing on a poor chalky bank. I have also noticed a distinct tendency to doubleness in the flowers of a Ranunculus, Horse-chestnut, and Bladder-nut (*Ranunculus repens*, *Æsculus pavia*, and *Staphylea*), growing under very unfavourable conditions. Professor Lehmann[102] found several wild plants growing near a hot spring with double flowers. With respect to the cause of doubleness, which arises, as we see, under widely different circumstances, I shall presently attempt to show that the most probable view is that unnatural conditions first give a tendency to sterility, and that then, on the principle of compensation, as the reproductive organs do not perform their proper functions, they either become developed into petals, or additional petals are formed. This view has lately been supported by Mr. Laxton,[103] who advances the case of some common peas, which, after long-continued heavy rain, flowered a second time, and produced double flowers.

*Seedless Fruit.*—Many of our most valuable fruits, although consisting in a homological sense of widely different organs, are either quite sterile, or produce extremely few seeds. This is notoriously the case with our best pears, grapes, and figs, with the pine-apple, banana, bread-fruit, pomegranate, azarole, date-palms, and some members of the orange-tribe. Poorer varieties of these same fruits either habitually or occasionally yield seed.[104] Most horticulturists look at the great size and anomalous development of the fruit as the cause, and sterility as the result; but the opposite view, as we shall presently see, is more probable.

*Sterility from the excessive development of the organs of Growth or Vegetation.*—Plants which from any cause grow too luxuriantly, and produce leaves, stems, runners, suckers, tubers, bulbs, &c., in excess, sometimes do not flower, or if they flower do not yield seed. To make European vegetables under the hot climate of India yield seed, it is necessary to check their growth; and, when one-third grown, they are taken up, and their stems and tap-roots are cut or

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[101] 'Gardener's Chronicle,' 1843, p. 628. In this article I suggested the theory above given on the doubleness of flowers. This view is adopted by Carrière, 'Production et Fix. des Variétés,' 1865, p. 67.

[102] Quoted by Gärtner, 'Bastarderzeugung,' s. 567.

[103] 'Gardener's Chronicle,' 1866, p. 901.

[104] Lindley, 'Theory of Horticulture,' pp. 175–179; Godron, 'De l'Espèce,' tom. ii. p. 106; Pickering, 'Races of Man;' Gallesio, 'Teoria della Riproduzione,' 1816, pp. 101–110. Meyen ('Reise um Erde,' Th. ii. s. 214) states that at Manilla one variety of the banana is full of seeds: and Chamisso (Hooker's 'Bot. Misc.,' vol. i. p. 310) describes a variety of the bread-fruit in the Mariana Islands with small fruit, containing seeds which are frequently perfect. Burnes, in his 'Travels in Bokhara,' remarks on the pomegranate seeding in Mazenderan, as a remarkable peculiarity.

mutilated.[105] So it is with hybrids; for instance, Prof. Lecoq[106] had three plants of Mirabilis, which, though they grew luxuriantly and flowered, were quite sterile; but after beating one with a stick until a few branches alone were left, these at once yielded good seed. The sugar-cane, which grows vigorously and produces a large supply of succulent stems, never, according to various observers, bears seed in the West Indies, Malaga, India, Cochin China, Mauritius, or the Malay Archipelago.[107] Plants which produce a large number of tubers are apt to be sterile, as occurs, to a certain extent, with the common potato; and Mr. Fortune informs me that the sweet potato (*Convolvulus batatas*) in China never, as far as he has seen, yields seed. Dr. Royle remarks[108] that in India the *Agave vivipara*, when grown in rich soil, invariably produces bulbs, but no seeds; whilst a poor soil and dry climate lead to an opposite result. In China, according to Mr. Fortune, an extraordinary number of little bulbs are developed in the axils of the leaves of the yam, and this plant does not bear seed. Whether in these cases, as in those of double flowers and seedless fruit, sexual sterility from changed conditions of life is the primary cause which leads to the excessive development of the organs of vegetation, is doubtful; though some evidence might be advanced in favour of this view. It is perhaps a more probable view that plants which propagate themselves largely by one method, namely by buds, have not sufficient vital power or organised matter for the other method of sexual generation.

Several distinguished botanists and good practical judges believe that long-continued propagation by cuttings, runners, tubers, bulbs, &c., independently of any excessive development of these parts, is the cause of many plants failing to produce flowers, or producing only barren flowers,—it is as if they had lost the habit of sexual generation.[109] That many plants when thus propagated are sterile there can be no doubt, but as to whether the long continuance of this form of propagation is the actual cause of their sterility, I will not venture, from the want of sufficient evidence, to express an opinion.

That plants may be propagated for long periods by buds, without the aid of sexual generation, we may safely infer from this being the case with many plants which must have long survived in a state of nature. As I have had occasion before to allude to this subject, I will here give such cases as I have collected. Many alpine plants

[105] Ingledew, in 'Transact. of Agricult. and Hort. Soc. of India,' vol. ii.

[106] 'De la Fécondation,' 1862, p. 308.

[107] Hooker's 'Bot. Misc.,' vol. i. p. 99; Gallesio, 'Teoria della Riproduzione,' p. 110. Dr. J. de Cordemoy, in 'Transact. of the R. Soc. of Mauritius' (new series), vol. vi. 1873, pp. 60–67, gives a large number of cases of plants which never seed, including several species indigenous in Mauritius.

[108] 'Transact. Linn. Soc.,' vol. xvii. p. 563.

[109] Godron, 'De l'Espèce,' tom. ii. p. 106; Herbert on Crocus, in 'Journal of Hort. Soc.,' vol. i., 1846, p. 254: Dr. Wight, from what he has seen in India, believes in this view; 'Madras Journal of Lit. and Science,' vol. iv., 1836, p. 61.

ascend mountains beyond the height at which they can produce seed.[110] Certain species of Poa and Festuca, when growing on mountain-pastures, propagate themselves, as I hear from Mr. Bentham, almost exclusively by bulblets. Kalm gives a more curious instance[111] of several American trees, which grow so plentifully in marshes or in thick woods, that they are certainly well adapted for these stations, yet scarcely ever produce seeds; but when accidentally growing on the outside of the marsh or wood, are loaded with seed. The common ivy is found in Northern Sweden and Russia, but flowers and fruits only in the southern provinces. The *Acorus calamus* extends over a large portion of the globe, but so rarely perfects fruit that this has been seen only by a few botanists; according to Caspary, all its pollen-grains are in a worthless condition.[112] The *Hypericum calycinum*, which propagates itself so freely in our shrubberies by rhizomes, and is naturalised in Ireland, blossoms profusely, but rarely sets any seed, and this only during certain years; nor did it set any when fertilised in my garden by pollen from plants growing at a distance. The *Lysimachia nummularia*, which is furnished with long runners, so seldom produces seed-capsules, that Prof. Decaisne,[113] who has especially attended to this plant, has never seen it in fruit. The *Carex rigida* often fails to perfect its seed in Scotland, Lapland, Greenland, Germany, and New Hampshire in the United States.[114] The periwinkle (*Vinca minor*), which spreads largely by runners, is said scarcely ever to produce fruit in England;[115] but this plant requires insect-aid for its fertilisation, and the proper insects may be absent or rare. The *Jussiæa grandiflora* has become naturalised in Southern France, and has spread by its rhizomes so extensively as to impede the navigation of the waters, but never produces fertile seed.[116] The horse-radish (*Cochlearia armoracia*) spreads pertinaciously and is naturalised in various parts of Europe; though it bears flowers, these rarely produce capsules: Professor Caspary informs me that he has watched this plant since 1851, but has never seen its fruit; 65 per cent. of its pollen-grains are bad. The common *Ranunculus ficaria* rarely bears seed in England, France, or Switzerland; but in 1863 I observed seeds on several plants growing near my house.[117] Other

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[110] Wahlenberg specifies eight species in this state on the Lapland Alps: *see* Appendix to Linnæus' 'Tour in Lapland,' translated by Sir J. E. Smith, vol. ii. pp. 274–280.

[111] 'Travels in North America,' Eng. translat., vol. iii. p. 175.

[112] With respect to the ivy and Acorus, *see* Dr. Bromfield in the 'Phytologist,' vol. iii. p. 376. Also Lindley and Vaucher on the Acorus, and *see* Caspary as below.

[113] 'Annal. des Sc. Nat.,' 3rd series, Zool., tom. iv. p. 280. Prof. Decaisne refers also to analogous cases with mosses and lichens near Paris.

[114] Mr. Tuckermann, in Silliman's 'American Journal of Science,' vol. xlv. p. 1.

[115] Sir J. E. Smith, 'English Flora,' vol. i. p. 339.

[116] G. Planchon, 'Flora de Montpellier,' 1864, p. 20.

[117] On the non-production of seeds in England, *see* Mr. Crocker, in 'Gardener's Weekly Magazine,' 1852, p.

cases analogous with the foregoing could be given; for instance, some kinds of mosses and lichens have never been seen to fructify in France.

Some of these endemic and naturalised plants are probably rendered sterile from excessive multiplication by buds, and their consequent incapacity to produce and nourish seed. But the sterility of others more probably depends on the peculiar conditions under which they live, as in the case of the ivy in the northern parts of Europe, and of the trees in the swamps of the United States; yet these plants must be in some respects eminently well adapted for the stations which they occupy, for they hold their places against a host of competitors.

Finally, the high degree of sterility which often accompanies the doubling of flowers, or an excessive development of fruit, seldom supervenes at once. An incipient tendency is observed, and continued selection completes the result. The view which seems the most probable, and which connects together all the foregoing facts and brings them within our present subject, is, that changed and unnatural conditions of life first give a tendency to sterility; and in consequence of this, the organs of reproduction being no longer able fully to perform their proper functions, a supply of organised matter, not required for the development of the seed, flows either into these organs and renders them foliaceous, or into the fruit, stems, tubers, &c., increasing their size and succulency. But it is probable that there exists, independently of any incipient sterility, an antagonism between the two forms of reproduction, namely, by seed and buds, when either is carried to an extreme degree. That incipient sterility plays an important part in the doubling of flowers, and in the other cases just specified, I infer chiefly from the following facts. When fertility is lost from a wholly different cause, namely, from hybridism, there is a strong tendency, as Gärtner[118] affirms,

70; Vaucher, 'Hist. Phys. Plantes d'Europe,' tom. i. p. 33; Lecoq, 'Géograph. Bot. d'Europe,' tom. iv. p. 466; Dr. D. Clos, in 'Annal. des Sc. Nat.,' 3rd series, Bot., tom. xvii., 1852, p. 129: this latter author refers to other analogous cases. See more especially on this plant, and on other allied cases, Prof. Caspary, "Die Nuphar," 'Abhand. Naturw. Gesellsch. zu Halle,' B. xi. 1870, p. 40, 78.

[118] 'Bastarderzeugung,' s. 565 Kölreuter (Dritte Fortsetzung, s. 73, 87, 119) also shows that when two species, one single and the other double, are crossed, the hybrids are apt to be extremely double.

for flowers to become double, and this tendency is inherited. Moreover, it is notorious that with hybrids the male organs become sterile before the female organs, and with double flowers the stamens first become foliaceous. This latter fact is well shown by the male flowers of dicœcious plants, which, according to Gallesio,[119] first become double. Again, Gärtner [120] often insists that the flowers of even utterly sterile hybrids, which do not produce any seed, generally yield perfect capsules or fruit,—a fact which has likewise been repeatedly observed by Naudin with the Cucurbitaceæ; so that the production of fruit by plants rendered sterile through any cause is intelligible. Kölreuter has also expressed his unbounded astonishment at the size and development of the tubers in certain hybrids; and all experimentalists [121] have remarked on the strong tendency in hybrids to increase by roots, runners, and suckers. Seeing that hybrid plants, which from their nature are more or less sterile, thus tend to produce double flowers; that they have the parts including the seed, that is the fruit, perfectly developed, even when containing no seed; that they sometimes yield gigantic roots; that they almost invariably tend to increase largely by suckers and other such means;—seeing this, and knowing, from the many facts given in the earlier parts of this chapter, that almost all organic beings when exposed to unnatural conditions tend to become more or less sterile, it seems much the most probable view that with cultivated plants sterility is the exciting cause, and double flowers, rich seedless fruit, and in some cases largely-developed organs of vegetation, &c., are the indirect results—these results having been in most cases largely increased through continued selection by man.

[119] 'Teoria della Riproduzione Veg.,' 1816, p. 73.

[120] 'Bastarderzeugung,' s. 573.

[121] Ibid., s. 527.