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THE INHERITANCE OF COAT COLOUR IN HORSES.

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XXVIII.

THE INHERITANCE OF COAT COLOUR IN HORSES.

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The data which this or any similar paper must rely upon are unfortunately not of the highest accuracy, and reasonably reliable results can be obtained only when the inaccuracies are appraised and fairly allowed for. The chief source of inaccuracy lies in the indefinite and varying notions of horse-breeders as to the colours of their stock. Many Thoroughbreds are described as "bay or brown," others as "brown or black"; and grey and roan are sometimes confused: the breeder's eye seeing perhaps what the mind would like it to see. Clydesdale breeders have tried to be more accurate with regard to bays and browns, for they enter "light" bays and "dark" bays, and "light," "dark," and even "very dark" browns; but it is doubtful whether this very attempt has not placed many bays among browns and browns among bays. At the same time they have an aversion to calling a roan a roan.

It may be long before the distinction between the rufous coat of the bay and the darker coat of the brown is clearly and generally known; but the other common colours should present no great difficulty. Unless when white "socks" or "stockings" have intruded, the legs of bays and browns are black towards the ground, but the body-colour of chestnuts, blacks, and greys is also the colour of the legs, excepting that in chestnuts and greys the legs are usually darker than the body. Most bays and all browns have a lighter-coloured patch at the nose—frequently sandy in the bay and tan in the brown—but blacks are black right down to the muzzle. The tan muzzle is the readiest means of distinguishing a very dark brown horse from a black. So far as can be made out at present roan is the intrusion of white hairs through a coat of any of the above-mentioned colours: the legs at the same time being unaffected, or nearly so. That is to say: a bay roan has black legs, a chestnut roan chestnut legs, and so on.

In order to make the conclusions of this paper clear, we shall follow the course of inquiry by which they were arrived at.

Little or no assistance can be got from history, for the reason that the migrations of the horse and the interactions of race upon race have not yet been clearly traced. Local and breed histories are very unsatisfactory. Large effects are attributed to very small beginnings, and importations of horses from parts of Europe to places in Britain and Ireland are presumed upon the flimsiest evidence. If a writer cannot find some foreign prince to send a present to his friend the King of England or Scotland, or some English or Scots nobleman to import half-a-dozen stallions from Holland or Flanders, he has always the Spanish Armada to fall back upon; and "*it is said*" has been the foundation-stone of many an essay in equine history. Professor Ridgeway's "Origin and Influence of the Thoroughbred Horse" is the outstanding exception; but some of its conclusions are weakened by the assumption that when two races of different colour unite a new colour may be produced.

For the present inquiry a jumping-off point had already been fixed by Mr. C. C. Hurst, whose paper "On the Inheritance of Coat Colour in Horses" was read before the Royal Society in December, 1905. Mr. Hurst showed chestnut to be recessive to bay and brown: bay and brown being taken together as one colour. A further hint as to the relationship subsisting between grey, bay, and black was afforded by the following communication published in *The Breeders' Gazette*, an American journal, on the 9th of June, 1909:—"In an experience of over thirty years in using Clydesdale stallions to all sorts of mares I have never known a mare drop a chestnut colt to one of them. One of my stallions sired some gray foals from gray mares, but these gray fillies, when mated with black Percherons, often had bay foals with white feet and stripes." The Clydesdale stallions referred to above were probably bays or browns, for few of any other colour have been imported to America. Thus grey seemed dominant to bay and brown; and, as these came in between grey and black, it was further probable that black was recessive to bay and brown. The absence of chestnuts, against the expectation raised by Mr. Hurst's conclusion, is not astonishing, since chestnuts have been unpopular among Clydesdales for many years. To test these tentatively-formed theories, an appeal was made to the Shire stud-book, because it contains a fair proportion of all the common colours. The Thoroughbred stud-book, for instance, contains plenty of chestnuts, but it is deficient in blacks, roans, and greys.

The first inquiry was confined to a tabulation of the colours of the foals entered in the first four volumes and of their sires and dams. After some working it became apparent, by observing how the colours did or did not "contain" each other, that our tentative theory was approximately correct.

It also became apparent that there was some possibility of separating the bays and the browns; and in all tables these are put in separate columns. There was, however, considerable difficulty about the roans, in regard to which we started with no definite theory. Several were tried, but none was found to answer. The one expected to fit best was that the roans were a hybrid between grey and one or more of the other colours, but it had to be given up. Eventually it was found that roans stand by themselves; and, for the present, they may be left out of consideration. We have thus five colours left to deal with: chestnut, black, bay, brown and grey.

The dominance of one colour over another is shown by—

(*a*) the dominant mated with the recessive producing sometimes the dominant sometimes the recessive;

(*b*) the recessive mated with itself producing always the recessive.

For example, Mr. Hurst showed that bays mated with chestnuts produced both bays and chestnuts, while chestnuts mated with chestnuts produced chestnuts only.

According to this criterion our figures from the first four volumes of the Shire stud-book indicate, although the numbers are small, that grey is dominant to the other four colours, and that black, in addition to chestnut, is also recessive to bay or brown. The relative positions of black and chestnut on the one hand and of bay and brown on the other are not clear. Black may be dominant to chestnut and brown to bay, but there are discrepancies in both cases.

MATINGS IN VOLS. I. TO IV. OF THE SHIRE STUD-BOOK.

Colours of Parents.	Chestnut.					Black.					Bay.					Brown.					Grey.					
	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Colours of foals.
Chestnut, .	27	–	1	1	–	23	22	12	4	1	48	23	93	8	–	13	13	44	11	–	7	7	3	3	11	
Black, .	–	–	–	–	–	2	17	–	–	1	19	34	76	42	–	2	28	28	35	–	2	6	3	5	11	
Bay, . .	–	–	–	–	–	–	–	–	–	–	21	11	248	23	–	11	18	158	77	–	6	6	36	6	46	
Brown, .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	8	19	37	–	–	6	16	12	20	
Grey, . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	9	

Another set of figures was collected, but this time foals of the more eminent sires were taken. It was thought thus to include more valuable and therefore more carefully registered animals. And the search was continued

to the tenth volume, in the hope that errors incidental to the earlier volumes of stud-books might be eliminated. The results are as follows:—

SELECTED MATINGS IN VOLS. I. TO X. OF THE SHIRE STUD-BOOK.

Colours of Parents.	Chestnut.					Black.					Bay.					Brown.					Grey.					Colours of foals.
	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	
Chestnut, .	44	1	5	1	–	19	26	27	7	–	67	19	113	7	1	14	15	43	21	–	5	13	14	3	18	
Black, . .	–	–	–	–	–	2	39	3	–	–	19	39	125	43	–	4	39	19	36	–	2	6	9	13	24	
Bay, . .	–	–	–	–	–	–	–	–	–	–	28	13	287	18	–	5	23	133	56	1	4	6	60	11	56	
Brown, . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	7	20	27	–	–	5	31	21	36	
Grey, . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	–	12	

It will be seen that the figures in this Table are practically a re-echo of those in the former. The relations of black to chestnut and brown to bay are no clearer. Remembering the errors of description to which stud-books are liable, black, brown, and bay, when bred to their own colours, seem to breed with regularity; but black is disturbed by the intrusion of chestnut, bay by black, and brown by black and chestnut.

A similar and larger collection of data from the Clydesdale stud-book, which was next resorted to, gave almost identical results and left us no farther forward.

But a deeper search into this book showed a possible cause of the disturbances referred to a few lines back. Among Clydesdales, breeding stock are usually entered in the stud-book twice: first as foals and afterwards when they themselves have foals to be entered; and their colours are usually mentioned both times. It was found that the colours of a good many animals were not the same at the second as at the first entering. The changes were not only from bay to brown or from brown to bay; but almost as many were from brown to black or black to brown. There was also a considerable number of changes involving chestnut and brown and chestnut and bay.

We were thus driven to the Thoroughbred stud-book, which had been avoided so far because of the large amount of tedious labour involved in ascertaining sires' and dams' colours. Thoroughbred colts are not entered a second time unless to make corrections; and the colours of fillies when they re-appear with their progeny have been given only in the last three volumes. For our purpose, Thoroughbreds have an advantage over Clydesdales and

Shires in that their colours are not usually stated till they are beyond foal age, and thus some possible errors are avoided.

In dealing with Thoroughbreds a number of the more important sires was selected, and the colours of the dams with which they were mated and of the foals produced noted down. It was hoped that in this way the gametic composition of the sires might be ascertained and assistance gained therefrom. One drawback was that, while there were plenty of chestnut, bay, and brown sires, only two grey sires (Grey Friars and Grey Leg) and one black (Desmond) having a fairly large number of foals in the latest volumes could be found. Another drawback was the large number of stock entered as "bay or brown" and "brown or black." These doubtful colours were omitted, although it was found necessary to consider them afterwards. The following are the figures got in this way from vols. XIX. and XX. of the Thoroughbred stud-book :—

MATINGS IN VOLS. XIX. AND XX. OF THE THOROUGHBRED STUD-BOOK.

Colours of Sires.	Colours of Dams.																					Colours of foals.
	Chestnut.					Black.					Bay.					Brown.					Grey.					
	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	
Chestnut, .	508	–	8	–	–	9	4	18	11	–	297	2	480	59	1	106	7	174	72	–	1	–	1	–	4	
Black, . .	1	2	8	4	–	–	–	–	–	–	–	–	8	6	–	–	1	2	5	–	–	–	–	–	–	
Bay, . .	459	–	586	48	–	14	1	33	27	–	270	1	1295	125	–	71	3	359	151	–	–	–	2	–	4	
Brown, . .	99	10	278	100	–	–	8	12	20	–	52	7	385	205	–	11	6	78	114	–	–	–	1	–	–	
Grey, . .	15	–	3	1	25	1	–	–	–	4	12	–	26	6	27	2	–	8	7	8	–	–	–	–	1	

These figures are, if anything, more confusing than those got from Shires and Clydesdales; but a very pertinent discovery was made during the course of their compilation. It became apparent that the only black sire of the lot, Desmond, was breeding in a very peculiar manner for a black. It was against all experience that a sire should reproduce his own colour only three times in thirty-seven. Besides, the colours of his foals suggested that he was not a black at all, but a brown. Desmond stands in Ireland, and several gentlemen likely to know him maintained, when appealed to, that he was a brown. When the question was put to one of these, "Is Desmond a black or a brown?" he replied, "He is brown: he has a tan muzzle." Finally his owner's Lord Dunraven's secretary wrote "Desmond is a brown horse." Desmond was entered "brown or black" as a foal, but this designation was subsequently changed to black.

This discovery with regard to Desmond suggested that inquiries should also be made about the black mares involved in the Thoroughbred table. It will be noticed that they breed very like Desmond when mated with chestnut, bay, and brown stallions. Presumably therefore they are also browns. Inquiry was made about a number of these mares, especially those having several foals, and in every case where a definite reply was received the mare turned out to be a brown. This led to inquiries further afield—to horses not concerned in our tables—and the conclusion arrived at is that most, if not all, throughbred "black" horses are really browns.[1] The authorities of the Trakehnen stud-farm in Germany desired at one time a black thoroughbred stallion to cross with their black mares, and they only found such an animal, or, at any rate, what they took to be such, with the greatest difficulty.

There being thus a lack of blacks among Thoroughbreds, it became necessary to return again for such animals to the Clydesdales, among which, in their early days and in recent years, a fair number can be found. By avoiding sires whose blackness is doubtful, the following statistics were collected :—

PROGENY OF TWENTY-TWO BLACK CLYDESDALE SIRES.

	Ch.	Bl.	By.	Br.	Gr.
From Chestnut Mares, ...	2	5	3	6	–
„ Black Mares, ...	–	36	–	2	–
„ Bay Mares, ...	6	29	90	44	–
„ Brown Mares, ...	1	51	32	102	–
„ Grey Mares, ...	2	2	1	3	5

The bays and browns from chestnut mares, the browns from black mares, and the browns from bay mares were disturbing; but their numbers did not seem outside the error that might be expected in view of the proportion of brown and black mares and foals wrongly described by their breeders.

A corresponding set of figures was compiled from the Shire Stud Book :—

PROGENY OF TEN BLACK SHIRE HORSES.

	Ch.	Bl.	By.	Br.	Gr.
From Chestnut Mares, . . .	7	12	11	1	–
„ Black Mares, ...	2	39	–	–	–
„ Bay Mares, ...	13	19	56	18	–
„ Brown Mares, ...	3	23	10	22	–
„ Grey Mares, ...	1	1	2	2	9

[1] Since this paper was read diligent search has been made for undoubted black Thoroughbreds, but without success.

Assuming the discrepancies referred to above are the result of confusion among blacks and browns, the appearance of so many chestnut foals from undoubted black sires makes it obvious that black contains chestnut; that is that chestnut is recessive to black, which, as we have already shown, is recessive to bay and brown.

We should next have had to inquire closely into the true colours of the mares and foals involved in the last two tables—an inquiry that could not have been satisfactory because of many of the mares and foals being now dead and forgotten—but we were saved this by the discovery of a note on the point at issue in the English translation of Herr von Œttingen's recently published work on "Horse Breeding." Herr von Œttingen is director of the royal stud at Trakehnen in Germany. He tells us (p. 329) that for over a hundred years blacks have been bred in one special stud (Gurdszen, 90 to 100 brood mares), browns in another (Dranzkehmen, 70 to 80 brood mares), and chestnuts in another (Jonasthal, 50 to 60 brood mares); while "in two studs (in Trakehnen 80 to 100 brood mares, and in Bajohrgallen 60 to 70 brood mares) all colours are represented and mixed with each other." Then having pointed out that at Trakehnen they have thus "plenty of material at hand from which to construct laws as to the transmission of coat colour," he proceeds:—

"There exists a distinct regularity with grays, chestnuts, and blacks as regards transmission. This regularity is as follows: grays and chestnuts mated only to their own colour, produce either chestnuts or grays, and black with black about 8 per cent. chestnuts (often dark chestnuts), the rest always blacks, never black-brown or dark brown."

This statement confirms our conclusion that black is dominant to chestnut, and also the other that it is recessive to brown. It also confirms the opinion already expressed that most if not all "black" Thoroughbreds are browns. Herr von Œtmann's observation that greys with greys breed only greys and chestnuts is no doubt correct; but in two mixed studs containing in all from 140 to 170 mares there could not have been enough grey mares and sires from which to draw a general conclusion.

The relative positions of bay and brown remain to be settled; and although there is evidence in favour of brown being dominant to bay, this conclusion is not clearly established. It must be remembered these are the colours breeders have the greatest difficulty in discriminating; and errors affect sires and dams and foals. In regard to sires it has been possible to correct the registered colours in several cases; and while every correction has increased the evidence in favour of brown being dominant, it is still

possible there may be some other explanation, as, for instance, that bay is a diluted brown. Unfortunately we cannot experiment with horses as we could with smaller animals.

Extracting them from the three tables already given, the data in reference to the bay and brown matings are as follows, greys being neglected :—

—	Colours of Parents.	Chestnut.				Black.				Bay.				Brown.			
		Ch.	Bl.	By.	Br.	Ch.	Bl.	By.	Br.	Ch.	Bl.	By.	Br.	Ch.	Bl.	By.	Br.
Shires, vols. I. to IV., ...	Bay, . .	48	23	93	8	19	34	76	42	21	11	248	23	11	18	158	77
Shires, vols. I. to X., ...	,, . .	67	19	113	7	19	39	125	43	28	13	287	18	5	23	133	56
Thoroughbreds, vols. XIX. and XX.,	,, . .	756	2	1066	107	14	1	41	33	270	1	1295	125	123	10	744	356
Shires, vols. I. to IV., ...	Brown, . .	13	13	44	11	2	28	28	35	11	18	158	77	1	8	19	37
Shires, vols. I. to X., ...	,, . .	14	15	43	21	4	39	19	36	5	23	133	56	2	7	20	27
Thoroughbreds, vols. XIX. and XX.,	,, . .	205	17	452	172	–	8	12	20	123	10	744	356	11	6	78	114

With regard to this table, it must be remembered that probably all the black Thoroughbreds are brown, and also that some black Shires are probably brown and some browns black.

When thoroughbred bays are mated with bays there are 270 chestnut foals, 1 black, 1295 bays, and 125 browns. Assuming no misdescriptions, this suggests that bay is dominant to both chestnut and brown. This would place brown between bay and chestnut. But in that case, in a mixed population of browns, bays, and chestnuts, there ought to be a larger number of brown foals than 125. The same remark applies to the Shire figures. Again, when thoroughbred browns are mated with browns there are 11 chestnut foals, 6 blacks, 78 bays, and 114 browns. This, on the other hand, suggests that brown is dominant to both bay and chestnut. But one of these suggestions must be wrong. The latter has the greater semblance of correctness: that is that brown is dominant. Apart from the suggestion that a diluting or saturating factor may connect bay and brown, the figures in the table suggest the possibility that some bays may be hybrids between chestnuts and browns: a suggestion which is upheld by the breeding of brown with chestnut, viz., 205 chestnut, 17 black, 452 bay, and 172 brown foals among Thoroughbreds. But again, if this be the explanation, the bays when bred together ought to produce more than 125 browns, even assuming that a larger proportion of them are pure and not impure bays.

The explanation seems rather to lie in the error of misdescription; and the point will be brought out by an examination of the table on the three following pages, which shows the results of the matings of a number of individual sires with mares of their own and the other four colours. The Thoroughbreds are taken from volume XIX. of the stud-book, the Shires from volumes I. to X., and the Clydesdales from volumes I. to XXXI. Among the Thoroughbreds the foals entered as "bay or brown" are given under the bays and enclosed within brackets, those entered as "black or brown" under the browns. The probability is that many bays are browns and browns bays—the wish to have them one or other occasioning some doubt—and most, if not all, of the thoroughbred "blacks or browns" are really browns. The registered colour of every sire is given, and, where it has been obtained, the corrected colour is noted below. At the same time the probable gametic composition of the sire is indicated.

On looking at the cases of Florizel II., Baron's Pride, and Baron of Buchlyvie, whose colours, according to authorities, are not those given in the stud-books, the effect of a misdescription in weighting one colour at the expense of another will be seen.

[TABLES.

—	Registered Colours of Sires.	Probable Gametic Composition.	Registered Colours of Dams.																							
			Chestnut.					Black.					Bay.					Brown.					Grey.				
			Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.
Amphion, (T)[1] . .	ch.	ch. ch.	17	–	–	–	–	1	–	–	–	–	10	–	15	2	–	7	1	4	2	–	–	–	–	–	–
Cyllene, (T) . . .	ch.	ch. ch.	14	–	1	–	–	–	–	–	–	–	11	–	28	–	–	3	–	11	–	–	–	–	–	–	–
Gallinule, (T) . . .	ch.	ch. ch.	30	–	–	–	–	–	1	–	–	–	14	–	23 (2)	9 (2)	–	9	1	5	10 (2)	–	–	–	–	–	–
Islington, (T) . . .	ch.	ch. ch.	21	–	–	–	–	–	–	–	–	–	8	–	18 (1)	4 (1)	–	3	–	5	3	–	–	–	–	–	–
Love Wisely, (T) . .	ch.	ch. ch.	21	–	–	–	–	–	–	–	–	–	16	–	15 (1)	5 (1)	–	2	–	4	5	–	–	–	–	–	–
Red Prince II., (T) .	ch.	ch. ch.	17	–	–	–	–	–	–	1 (1)	–	–	7	–	10 (1)	–	–	6	–	2	1	–	–	–	–	–	–
Victor Wild, (T) . .	ch.	ch. ch.	26	–	–	–	–	2	–	–	–	–	7	–	8	1	–	4	1	7 (4)	7	–	–	–	–	–	–
Winkfield, (T) . .	ch.	ch. ch.	25	–	1	–	–	–	1	1	–	–	15	1	18 (1)	3	–	1	–	6 (1)	1 (2)	–	–	–	–	–	–
Wonder of the West, (S) .	ch.	ch. ch.	11	–	–	–	–	–	1	1	1	–	7	3	18	–	–	1	3	6	3	–	1	–	1	–	1
Spark, (S) . . .	bl.	bl. ch.	–	–	–	–	–	1	3	–	–	–	4	2	20	5	–	2	8	1	6	–	–	–	–	2	1
The Maister, (C) . .	bl.	bl. ch.	–	–	–	–	–	–	5	–	–	–	2	1	15	3	–	–	2	2	7	–	1	1	1	–	–
Petrucio, (C) . . .	bl.	bl. bl.	–	–	–	–	–	–	2	–	1	–	–	5	7	3	–	–	2	2	4	–	–	–	–	–	–
Sir Everest, (C) . .	bl.	bl. bl.	–	–	–	–	–	–	5	–	–	–	–	2	9	–	–	–	1	6	3	–	–	–	–	–	–
Avington, (T) . .	by.	by. ch.	16	–	14	–	–	–	–	–	–	–	12	–	29	–	–	1	–	4	–	–	–	–	–	–	–
Bread Knife, (T) . .	by.	by. ch.	1	–	9	2	–	1	–	(1) – (1)	2	–	5	–	23 (3)	4	–	1	–	(4) 7 (1)	4	–	–	–	–	–	–
Bushey Park, (T) . .	by.	by. ch.	4	–	20 (2)	1	–	–	–	–	–	–	1	–	32 (3)	–	–	–	–	17 (5)	8	–	–	–	–	–	–
Donovan, (T) . .	by.	by. ch.	9	–	10 (1)	2	–	–	–	1	–	–	7	–	24 (3)	8	–	2	–	3	5	–	–	–	–	–	–
Florizel II., (T)[2] . .	by.	by. ch.	13	–	14 (2)	2	–	–	–	–	3	–	7	–	31	7	–	1	–	4 (5)	5	–	–	–	–	–	–

[1] (T) stands for Thoroughbred, (S) for Shire, (C) for Clydesdale.

[2] Mr. James Daly says Florizel II. and his two brothers Persimmon and Diamond Jubilee were all bays.

—	Registered Colours of Sires.	Probable Gametic Composition.	Registered Colours of Dams.																					
			Chestnut.					Black.					Bay.					Brown.					Grey.				
			Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.
Galloping Lad, (T)	by.	by. ch.	17	–	10	2	–	–	–	1	1	–	10	–	22	6	–		–	3	9	–	–	–	–	–	–
Isinglass, (T)	by.	by. ch.	19	–	(1) 14	1	–	–	–	–	–	–	15	–	(1) 43	–	–	4	–	(4) 20	2	–	–	–	–	–	–
Laveno, (T)	by.	by. ch.	22	–	19	1	–	–	–	–	–	–	9	–	31	–	–	4	1	(1) 14	3	–	–	–	–	–	2
Melton, (T)	by.	by. ch.	9	–	(1) 9	–	–	2	–	1	–	–	7	–	(2) 25	–	–	4	–	(4) 9	2	–	–	–	–	–	–
Orme, (T)	by.	by. ch.	14	–	11	–	–	1	–	(1) –	–	–	10	–	(6) 35	3	–	1	–	(2) 14	2	–	–	–	–	–	1
Persimmon, (T)	by.	by. ch.	19	–	(1) 15	3	–	–	–	–	3	–	12	–	(1) 39	8	–	4	–	(1) 2	6	–	–	–	–	–	–
Queen's Birthday, (T)	by.	by. ch.	14	–	7	3	–	–	–	(1) 3	1	–	5	–	(1) 29	11	–	1	–	(2) 6	10	–	–	–	–	–	–
Right Away, (T)	by.	by. ch.	10	–	15	1	–	–	–	–	2	–	4	–	25	–	–	6	–	(5) 4	(1) 6	–	–	–	–	–	–
St. Angelo, (T)	by.	by. ch.	15	–	(1) 12	–	–	–	–	–	–	–	9	–	22	3	–	1	–	(2) 5	5	–	–	–	–	–	–
Tarporley, (T)	by.	by. ch.	10	–	11	–	–	–	–	2	1	–	7	–	29	5	–	–	–	(1) 6	5	–	–	–	–	–	–
Pride of Blacon, (C)	by.	by. ch.	2	–	(1) –	1	–	–	1	5	5	–	2	1	25	7	–	2	2	(1) 18	28	–	–	–	–	1	1
Baron of Buchlyvie, (C)	br.[1]	by. bl.	–	–	–	–	–	–	–	–	2	–	–	3	28	9	–	–	8	6	20	–	–	–	–	–	–
Baron's Pride, (C)	br.[2]	by. bl.	–	1	1	–	–	–	5	1	2	–	–	3	77	8	–	–	9	26	55	–	–	–	–	–	–
Prince of Carruchan, (C)	by.	by. ch. or bl.	1	–	1	–	–	1	4	2	–	–	2	2	28	10	–	3	8	17	19	–	–	–	2	–	–
Hackler, (T)	by.	by. by.	1	–	19	–	–	–	1	2	1	–	–	–	30	1	–	–	–	21	3	–	–	–	–	–	–
Matchmaker, (T)	by.	by. by.	–	–	(3) 29	3	–	–	–	(1) 1	–	–	–	1	(4) 40	11	–	–	–	(8) 12	16	–	–	–	–	–	–
Missel Thrush, (T)	by.	by. by.	–	–	(3) 11	1	–	–	–	2	– (1)	–	1	–	(7) 25 (1)	7	–	–	–	(2) 5 (1)	3	–	–	–	–	–	–

[1] Mr. MacNeilage, the Secretary of the Clydesdale Horse Society, says this horse is a "dark bay or brown."

[2] Mr. MacNeilage says this horse is "a good solid bay, inclined to be dark bay."

—	Registered Colours of Sires.	Probable Gametic Composition.	Registered Colours of Dams.																					
			Chestnut.					Black.					Bay.					Brown.					Grey.				
			Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.	Ch.	Bl.	By.	Br.	Gr.
Perigord, (T) . . .	by.	by. by.	–	–	19 (1)	3	–	–	–	1	–	–	–	1	34 (2)	8	–	–	–	5 (1)	4	–	–	–	–	–	–
Honest Tom, (S) . .	by.	by. by.	–	–	8	–	–	–	2	11	–	–	–	–	41	1	–	–	–	4	2	–	1	–	6	–	7
Premier, (S) . . .	by.	by. by.	–	–	3	–	–	–	–	3	6	–	–	–	18	2	–	–	–	1	8	–	–	–	1	2	4
Darnley, (C) . . .	by.	by. by.	–	–	1	4	–	–	1	3	6	–	1	–	50	18	–	–	–	24	42	–	–	–	2	2	2
MacGregor, (C) . .	by.	by. by.	–	–	3	–	–	–	–	3	3	–	–	–	63	16	–	–	1	45	48	–	–	–	1	3	1
Ayrshire, (T) . . .	by. or br.	br. ch.	10	–	5	4	–	–	–	–	–	–	13	–	32 (2)	6	–	1	–	2 (3)	12	–	–	–	1	–	–
St. Frusquin, (T) . .	br.	br. ch.	10	–	11	10 (1)	–	–	–	2	1 (1)	–	11	1	25 (3)	7	–	–	–	5 (1)	8 (2)	–	–	–	–	–	1
Baron Ruby, (C) . .	br.	br. bl.	–	–	3	1	–	–	3	2	1	–	–	–	6	11	–	–	2	2	16	–	–	–	–	–	2
Prince of Wales, (C) .	br.	br. bl.	–	3	3	2	–	–	–	–	–	–	–	3	31	16	1	–	7	26	70	–	–	–	1	1	2
Revelanta, (C) . .	br.	br. bl.	–	–	–	–	–	–	4	–	2	–	–	1	3	7	–	–	3	4	24	–	–	–	–	–	–
Sir Everard, (C) . .	br.	br. bl.	–	–	4	1	–	–	1	–	1	–	–	–	30	18	–	–	14	2	44	–	–	–	–	–	1
Woodend Gartly, (C) .	br.	br. bl.	–	–	1	1	–	–	2	–	–	–	–	1	6	10	–	–	6	–	11	–	–	–	–	–	–
Desmond, (T) . .	blk.	br. by.	1	2	8 (4)	4	–	–	–	–	–	–	–	–	8 (3)	6 (2)	–	–	1	2 (2)	5	–	–	–	–	–	–
Ladas, (T) . . .	br.	br. by.	–	–	23 (2)	5	–	–	–	–	2	–	–	–	30 (5)	8 (1)	–	–	1	7 (2)	11	–	–	–	–	–	–
St. Simon, (T) . .	br.	br. by.	–	–	15 (2)	6	–	–	–	1	2	–	–	–	43 (4)	12 (1)	–	–	–	– (2)	6	–	–	–	–	–	–
Wolf's Crag, (T) . .	br.	br. by.	–	3	29 (2)	2 (1)	–	–	1	1	–	–	–	2	36 (2)	6	–	–	1	7 (1)	1	–	–	–	–	–	–
Grey Friars, (T) . .	gr.	gr. ch.	4	–	–	–	8	–	–	–	–	1	–	–	8	1	3	–	–	2	–	1	–	–	–	–	–
Grey Leg, (T) . .	gr.	gr. ch.	6	–	–	–	3	1	–	–	–	2	8	–	6	1	4	–	–	1	1	2	–	–	–	–	–
Lincolnshire Lad II., (S) .	gr.	gr. by. or br.	–	–	1	1	3	–	1	1	7	6	–	–	10	3	11	–	–	7	6	4	–	–	–	–	–

Perhaps the most interesting colour of all is the one set aside earlier in the paper for separate consideration, viz., roan. There are only a few entries of roans in the Thoroughbred and Clydesdale stud-books; but inquiry brought out the fact that there are more horses of this colour in both breeds than the stud-books would make out. It is an unpopular colour among Thoroughbreds and Clydesdales, and when a breeder sees, say, a bay foal "with a grey hair through" its coat, it is easy for him to believe the foal to be a bay and not a roan.

On the other hand, roans are not altogether unpopular among Shires; and a good many are to be found in the stud-book, especially in the earlier volumes. We were therefore driven back upon the data collected from the first ten volumes of the Shire stud-book for examples of the behaviour of roan. It has been stated already that, in collecting these data, several theories suggested themselves; and the one that roans are hybrids between grey and some one of the other colours seemed *a priori* the most likely. But greys never, or at any rate very seldom, and then doubtfully, produced roans with those other colours; and the crossing of roan with roan was too infrequent to give any guidance. Eventually it became evident that roan was separate from grey, but that its behaviour towards the other colours was similar, while at the same time it had a peculiarity of its own.

Grey, as we have already found, is dominant in the other colours—brown, bay, black, and chestnut. This means that, in a population of the above colours, there can be no grey foal without, at least, one grey parent, and that, if the pedigree of a grey foal be followed backwards as far as it is known, a grey ancestor will be found in every generation. The following examples might be given :—

A THOROUGHBRED EXAMPLE.[1]

The Drone, *grey* (foaled 1823), × Kiss (foaled 1827).

Irish Birdcatcher, *chestnut.* × Whim, *grey.*

Chanticleer, *grey*, × Birthday, *bay or brown.*

Newminster, *bay*, × Souvenir, *grey.*

Strathconan, *grey*, × Sweet Violet, *bay.*

Linnaeus, *grey*, × Dulcie Agnes, *brown.*

Linny, *grey*, × Lady Blue, *brown.*

Sidestrand, *grey* (foaled 1903).

A CLYDESDALE EXAMPLE.

Blyth, *grey* (foaled 1836 or 1837).

Clydesdale Jock, *grey.*

Donald Blue, *grey*, × Mare, *brown.*

The Duke, *chestnut.* × Mare, *grey.*

Sultan, *black.* × Mare, *grey.*

Glengarry, *bay.* × Belle of Burnside, *colour not stated.*

Mains of Airies, *brown* × Rose of Meikle Folla, *grey.*

Rozelle, *bay.* × Blue Bell of Meikle Folla, *grey.*

Rozabelle, *grey* (foaled 1907).

[1] Sires are placed to the left, dams to the right.

The following pedigrees, similarly followed out, of the first three fillies and the first three colts met with in the last published volume (xxx) of the Shire stud-book will show that the roan has at least one roan ancestor in every generation,[1] and that therefore roan behaves as a dominant to the other colours:—

Tory, *red roan*, × Bounce.
|
Roan Jumbo, *roan*.
|
Muckton Nonsuch, *bay*, × Muckton Violet, *roan*.
|
Blythwood Conqueror, *bay*, × North Cotes Primrose, *red roan*.
|
Ashwell Conquering Prince, *bay*, × Garston's Lady, *blue roan*.
|
Filly, *bay or red roan* (foaled 1908).

Flower, *roan*.
|
King of Keele, *bay*, × Darling, *roan*.
|
Knottingley Royal, *bay*, × Bankone Darling, *roan*.
|
Filly, *roan* (foaled 1907).

Horse, *roan*.
|
Samson, *brown*, × Mare (*colour not recorded*).
|
Emperor, *roan*.
|
England's Wonder, *roan*, × Mare, *roan*.
|
Carbon, *brown*, × Bonny, *roan*.
|
Monaco, *bay*, × Trim, *roan*.
|
Baroness, *roan*.

Harold, *brown*, × Blue Bell, *blue roan*.
|
Horbling Harold, *blue roan*, × Primula, *brown*.
|
Hitchin Magnet, *bay*, × Silver Tail, *blue roan*.
|
Anglian Harold, *roan*.

[1] The Shire stud-book is comparatively young, and so the pedigrees are not long.

Vulcan, *black*, × Kit (Capes'), *red roan*.
|
Prince Harold, *black*, × Dunsmore Fashion II, *roan*.
|
Dunsmore Iron Duke, *roan*, × Lemington Royal Heroine, *bay*.
|
Forage Iron Duke, *roan*.

Hereward, *bay*, × Willow Lady, *roan*.
|
Pratt's Wallflower, *black*, × Willow Bounce, *blue roan*.
|
Blue Duke, *blue roan*.

The comparison between roan and grey might be carried further. Grey is dominant to the other four ordinary colours. This means that when grey is crossed with these colours the number of grey foals ought to equal all the other colours together; excepting that, grey being somewhat unpopular among Shires, a higher proportion of grey foals than of the other colours may not be entered at all, and thus the numbers for grey may be depressed. The numbers from selected sires in the first ten volumes of the Shire stud-book are as follows:—

	Ch.	Bl.	By.	Br.		Total of these 4 colours.	Gr
Grey × chestnut gives	5	13	14	3	=	35	18
Grey × black ,,	2	6	9	13	=	30	24
Grey × bay ,,	4	6	60	11	=	81	56
Grey × brown ,,	–	5	31	21	=	57	36

The figures for roans—iron-grey being counted among the roans—the progeny of roan mares in vols. XI. to XV. are as follows:—

	Ch.	Bl.	By.	Br.		Total of these 4 colours.	Roan.
Roan × chestnut gives	7	2	7	2	=	18	8
Roan × black ,,	–	5	–	2	=	7	12
Roan × bay ,,	4	2	30	11	=	47	41
Roan × brown ,,	1	2	14	7	=	25	20

Roan behaves therefore to these other colours very much like grey, their

dominant. But there is a very peculiar difference. The grey colour dominates the other colours below it entirely; roan does not. The grey foal of a bay dam and a grey sire is grey; but the roan foal of, say, a bay dam and a roan sire will have the body a mixture of white or grey hairs in a back-ground of bay or any of the other usual colours, while, so far as can be seen as yet, the leg-markings will be those usually associated with the back-ground. A bay or brown roan will have black "points," the legs of a chestnut-roan will be chestnut, and so on.

And still further: the back-ground colours seem to behave to each other, so far as dominance is concerned, as they do when no grey hairs are present to make them roans. That is to say: two chestnut-roans seem to produce only chestnuts and chestnut-roans, while two brown-roans seem to produce brown-roans, bay-roans, black-roans (perhaps also blue-roans), chestnut-roans, and another colour, strawberry-roan, which seems to depend rather upon the quantity of grey hairs present than upon the colour of the back-ground. It would almost seem as if the grey hairs in roan parents allowed the back-ground colours to work as they do ordinarily, but that they introduced themselves to the coat of about every second foal. These ideas have been suggested while tabulating the results of roan matings, but the data are still too few to say they are proved.

The source of roan, that is of the white hairs that make other coats roan, has not been found. Nor are the relative positions of roan and grey clear. Roan behaves like grey with the other colours below grey; but the crossings between grey and roan are too few for any inference.

Meantime let us set down a table showing the results of crossings with roans (vol. xi. to xv.), in which the roans are subdivided into roans, blue-roans, and iron-greys (which are probably grey-roans):—

Colours of Parents.	Roan.								Blue-Roan.								Iron-Grey.							
	Ch.	Bl.	By.	Br.	Gr.	Ir. Gr.	Bl. Rn.	Rn	Ch.	Bl.	By.	Br.	Gr.	Ir. Gr.	Bl. Rn.	Rn.	Ch.	Bl.	By.	Br.	Gr.	Ir. Gr.	Bl. Rn.	Rn.
Chestnut, . .	7	2	7	2	1	–	–	8	–	–	1	–	–	–	1	–	2	–	–	–	–	2	–	–
Black, . . .	–	5	–	2	–	–	3	9	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Bay, . . .	4	2	30	11	1	1	1	39	1	1	4	1	–	4	1	–	3	1	5	–	–	1	–	1
Brown, . .	1	2	14	7	1	–	1	19	–	2	1	2	–	–	5	2	–	–	1	–	1	–	–	–
Grey, . . .	–	–	–	1	5	–	1	6	–	–	–	2	–	–	–	–	–	–	1	–	1	–	–	–
Iron-Grey, .	–	–	1	–	2	1	–	4	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Blue-Roan, .	–	–	2	–	2	–	–	2	–	–	–	–	–	–	2	1	–	–	–	–	–	–	–	
Roan, . . .	–	–	1	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	1

It will be seen from the above table that a few greys are produced when roans are mated with ordinary colours. If we could be assured that these are really greys, and that the parents are correctly described, the problem of the relative positions of roan and grey would be solved; but such assurance is impossible with colours so liable to confusion as roan and grey. If a similar table of grey matings with ordinary colours were made out, it would show the contrary phenomenon of roans being produced by the greys, and so would suggest that grey is dominant to roan. For the present, therefore, the relative positions of grey and roan must remain undecided.

One other colour, dun, remains; but although some dun entries were seen in each of the three stud-books drawn upon, they were far too few for our purpose, and were not noted.

But from statements published by Weldon and Cossar Ewart, and from information given by Mr. P. Macginnis as to foals produced by dun sires in county Londonderry, the following small table can be formed:—

	Ch.	Bl.	By.	Br.	Gr.	Rn.	Dun.
1 dun × 1 chestnut gives	–	–	1	–	–	–	1
1 dun × 1 black ,,	–	1	–	–	–	–	2
1 dun × 2 bays ,,	1	1	1	–	–	1	1
1 dun × 1 dun ,,	1	–	1	–	–	–	2[1]
2 dun × 6 grey mares ,,	–	–	–	2	2	–	4

It is apparent from the first two and the last of these matings that dun contains, i.e., is dominant to, chestnut, black, and bay. The matings of dun and grey give no indication. But from information received on Clare Island last July it seems certain that dun is dominant to brown also. Some time ago a dun Norse sire which was brought to the island left a number of dun foals from a population consisting chiefly of bay and brown mares; and these dun foals when themselves put to a brown sire threw some dun foals again. This places dun dominant to brown, bay, black, and chestnut; but leaves its position with regard to grey and roan unknown.[2]

It may be well to reiterate the statement made at the beginning of this paper, that stud-book data are far from being absolutely accurate, and that the validity of our conclusions must depend upon the success with which the inaccuracies of the stud-book have been smoothed out. It is hoped

[1] One of these is called yellow.

[2] Since this paper was read a case has been found, in Professor Cossar Ewart's paper on "The Multiple Origin of Horses and Ponies," of two greys producing a dun. This would show that dun is recessive to grey.

such data may become more accurate in the future. Meantime this paper may lead to further observation and elucidation of the subject.

In addition to those mentioned in the text, the following gentlemen have very kindly furnished information on the subject in question :—

Mr. H. R. Rose, Chantilly Stud Farm ; Mr. Andrew Robertson, Dublin ; Mr. James Barrie, Balmedie, Aberdeen ; Captain Greer, Curragh Grange ; the Rt. Hon. Frederick Wrench ; Lord Rossmore ; Lord Bradford ; and Lord Derby.

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