

WAVED—A NEW COAT TYPE IN RABBITS

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(With Plate 15)

1st mating.

In the autumn of 1932 a number of fine-coated Rex rabbits were purchased from a breeder, the majority of these rabbits being brown (Havana-Rex). As they were primarily required for studies relating to the possibilities of producing a sound strain of exhibition Rexes these rabbits were well up to show standard. Whilst the does were all normal plush-coated Rexes of exceedingly fine texture, two of the brown bucks had a slight waviness in their coat, especially on the back. This was not very marked until after a moult the following summer when the waviness was seen to be distributed throughout the coat (Pl. 15, fig. 1). None of the original does showed this character, nor in later tests did any of the other original rabbits appear to carry it. A number of litters were produced sired by one or other of these two bucks mated to normal-coated Rex does. These produced 23 youngsters, none of which could be classed as markedly waved, although three of them showed a very slight tendency to a waved condition on the back at some time or other in their early life. This was, however, simply due to the normal process of moult, and after the age of one year, no waves were perceptible in any of the animals. They were therefore classified as normal-coated Rexes.

2nd mating.

An F_2 generation consisting of 22 individuals was bred, of which 17 were classed as normal Rexes and 5 as waved, a very close approximation to the Mendelian expectation of 16.5 : 5.5, if the waved condition is a simple autosomal recessive character. F_1 does mated to their wavy sire produced three litters including 8 normal Rexes and 7 waved Rexes. Four litters of waved \times waved produced 17 waved and no normal youngsters. From these preliminary crosses it could therefore be safely concluded that the waved condition of the coat is a simple recessive to normal coat as it appears in the Rex. In these and in all subsequent matings it was not found possible to distinguish between normals heterozygous for the waved condition and those which were homozygous.

3rd mating.

A litter bred from brown waved \times albino shorthair produced all shorthairs. These bred *inter se* gave 28 shorthairs and 6 waved Rexes, all of the fine-coated type. In this and most subsequent matings it is interesting to note that the ratio of normals to Rexes is wider than the Mendelian expectation, but this supports previous figures where the production of Rexes is less than anticipated. None of the shorthaired individuals appeared to vary from the normal. It was, however, remarkable that no normal Rexes had been produced in this cross. Two possible explanations were suggested, either that these three characters of normal shorthair, normal Rex, and waved formed an allelomorphous series, or that the original shorthair was in fact a "disguised waved", this character not being able to manifest itself unless combined with Rex.

4th mating.

In order to investigate further these possibilities, an entirely unrelated shorthair (blue) was crossed to a brown waved buck. The F_1 consisted of four normal shorthairs, whilst the F_2 gave 58 shorthairs and 15 Rexes of which only three were waved. It appeared, therefore, that the second explanation was correct and that the shorthair used in the original cross had, in fact, been a disguised waved.

In the course of correspondence with a breeder who owned a strain of similar waved Rexes, the suggestion was made that this characteristic might in some way be related to the Angora. This postulation received some support by the fact that the albino shorthaired doe used in the first shorthair and waved cross had as her grandsire an Angora, and although she was not herself heterozygous for the Angora character, it had been shown that she was, in fact, a disguised waved.

5th and 6th matings.

To investigate this matter further, waved Rex were twice crossed to an Angora Rex doe, and all the resulting nine youngsters proved to be waved. A further cross was made between an exhibition type normal Angora and a waved Rex. The resulting litter of five consisted of four shorthairs and one Angora, showing that in this case the waved Rex used had been heterozygous for Angora. The shorthairs from this cross when bred *inter se* produced an F_2 of 18, of which ten were shorthairs, three were Angoras, and five were waved Rexes. Unless it died in the nest at too early an age for identification, the expected Angora Rex did not appear, but the numbers were small. It should be noted that no

normal Rexes were produced, which shows that the Angora used in the experiment must again have been a disguised waved.

7th mating.

A waved buck was mated to an exceedingly coarse coated, French type Angora doe. Owing to unfortunate circumstances that season, however, an F_2 of only ten individuals was secured and of these only one Rex was reared. This proved to be a non-waved, which suggests that the waved characteristic is *not* carried by all Angoras, but may be confined to the finest exhibition British type of that variety.

Since three distinct strains of exhibition Angoras were used in these waved rabbit experiments, it seems probable that many if not all of these Angoras bear the waved characteristic in their genetical constitution. The Castorrex when first imported into this country was very generally mated to existing fur breeds in order to produce new Rex colours, and as these fur breeds had already in many instances been freely crossed to Angoras in order to improve the fur properties, it is not surprising that "disguised waveds" were used with the result that the waved coat made its appearance in several different strains of Rexes.

1st and 8th matings.

From the earliest matings one unexpected point appeared, the waved condition generally, but not always, appeared to be confined to the brown coat. In the first test of waved Rex \times normal Rex the latter does were homozygous black Rexes, the F_1 all being black. In the F_2 , however, all the 5 waved Rexes were brown, and the 17 normals were 15 blacks and 2 browns. In the original backcross, 6 brown waved Rexes and 1 black waved Rex were produced to 5 black and 3 brown normal Rexes, whilst one litter of black (heterozygous for brown) waved \times brown waved, produced 2 black waved and 3 brown waved.

3rd mating.

An albino doe which was known genetically to be a homozygous black was used as the normal shorthair in the first of those crosses whilst the waved Rex buck was brown. The F_1 were all blacks, and the 6 waved Rexes of the F_2 were 4 brown and 2 black. The F_2 shorthairs were 18 blacks, 8 albino and 2 browns. Whilst the waved condition did not appear to be entirely confined to the brown colour it seemed to appear more readily in it than in any other, and the possibility of linkage could not be overlooked.

4th mating.

In the second cross of normal shorthair to waved, the latter was brown whilst the shorthair was blue. As was expected the four F_1 rabbits were all blacks, and the F_2 of 73 animals were classified as follows:

	Black	Brown	Blue	Lilac	Actual total	Expectation
Shorthair	31	12	12	3	58	54.8
Normal Rex	6	3	2	1	12	13.7
Waved	2	0	0	1	3	4.6
Actual totals	39	15	14	5	73	
Expectation	41.1	13.7	13.7	4.6		

9th mating.

In order to study further the possibility of linkage between either brown or blue and the waved condition, a brown waved buck was mated to a blue Rex doe, which was known not to be heterozygous for the waved factor. The resulting F_1 , none of which were waved, were interbred and produced 72 youngsters, of these 21 were waved, and 51 normal Rexes, classified as follows:

	Black	Blue	Brown	Lilac	Total	Expectation
Normal Rexes	27	11	9	4	51	54
Expectation	30.4	10.1	10.1	3.4	54	—
Waved Rexes	13	2	4	2	21	18
Expectation	10.1	3.4	3.4	1.1	18	—
Totals	40	13	13	6	72	
Expectation	40.5	13.5	13.5	4.5		

This approximation to expectation is sufficiently close to show that when larger numbers of records were available, no evidence was forthcoming of possible linkage between the waved condition and either brown or blue colour. As brown has been shown to be linked with albinism, it is unlikely that the waved condition is in any way associated with albinism.

In a large proportion of the waved Rexes from the earlier matings the first moult, which begins when the rabbit is about 6 weeks old, appeared to be exceedingly rapid, sometimes being completed in as little as 15 days. In these cases the rabbit was generally absolutely naked for some days and needed especial care in housing and bedding to keep it sufficiently warm. Moults in later life appeared to follow the normal course.

The age at which the waved specimens can be distinguished from the normal varies. Generally, waved youngsters bred from waved parents can be distinguished as soon as their coat shows, at about 8–12 days. The majority of these were found in the early tests to have the complete (“naked”) moult, but later on in many matings youngsters, distinguished at an early age as waved by a “matt-like” appearance of their coats,

did not have the naked moult. In other cases, and especially those bred from crosses in which one or both parents were normal Rexes heterozygous for the waved condition, the youngsters may not be distinguishable from normals until 4 months or even older. The wave in all cases becomes more marked after each successive moult, reaching the maximum development at the age of 18 months or 2 years. By selection an early development of the wave can be fixed in a strain.

Waviness in the coat appears to be strictly confined to the finest coated exhibition types. It does not appear in the German type of Rex, nor in the coarser types of Gillet Rex, and experimental crosses have not been successful in producing a waved coarse-type Rex, but it would seem that they may be in some cases disguised waveds.

The losses in the waved Rexes have not been outstanding, but have been slightly above those of normal rabbits. In earlier experiments a number were lost during the first naked moult, but later litters in which these occurred were saved through methods of improved husbandry.

Whilst waved Rexes are not common, at least three breeders are in possession of types similar to those first bred at the Institute. It appears that data drawn from these studs would produce very similar conclusions to those stated above. An exception, however, is reported in one stud where the proportion of waved Rexes from normal \times waved Rex is approximately 3 : 1. This is higher than would be expected, even allowing for the majority of the normal Rexes being heterozygous for this type of coat. Possibly some of the litters recorded as from normals are really from young waveds which were late in developing their curl, or alternately from harsher coated animals which were actually masked waves. Recently stock has been secured of this waved strain and at the Institute the behaviour of its inheritance has been identical to that of the original stock reported upon in this paper.

The amount of wave in the coat varies considerably and appears without doubt to be affected by modifying factors. One breeder who has concentrated on the type has, by means of careful selection, produced a type that is exceedingly well waved, the coat being almost a mass of curls very similar to astrakan. This is now recognized as a variety, the *Astrex* (Pl. 15, fig. 2).

At the other extreme, some exhibition Rexes show a slight wave which is obviously due to the character, and is not desirable in the ordinary Rex. In view of the conclusions drawn in this paper, it should be a fairly simple matter for breeders either to perpetuate or to eliminate this character from their stock.

Nothing remarkable was noted in the sex-ratios of the rabbits produced under this experiment, but the numbers in any case were insufficient. Reciprocal crosses had similar results, and no evidence of sex-linkage was found.

This character of wave in rabbits appears to be similar to that reported by Crew (1933) in mice in that it is a simple autosomal monogenic recessive. Unlike the mutation in the mouse, the waved coat in the rabbit appears to become more marked with increasing age. This is similar to the dominant character shown in the curly-coated rat exhibited by Dr Helen King at the Sixth International Congress of Genetics at Ithaca in 1932.

SUMMARY

1. A waved coat condition in rabbits is described.
2. Evidence is produced to show that this character is a simple autosomal monogenic recessive.
3. No evidence of linkage with either blue or brown coat colour was found.
4. The character can only be manifested in the fine coated Rex type of rabbit, but it is commonly found in a masked form in other types, especially in exhibition Angoras, and in fur breeds descended from them.
5. The extent of the wave appears to be controlled by modifying factors.
6. In waved youngsters the moult is frequently exceedingly rapid, sometimes producing a naked condition.
7. The type has been discovered in several different strains of Rexes, but in all cases investigated the mode of inheritance has been similar.
8. The waved character is compared with somewhat similar mutations in the mouse and rat.

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Summary of matings

1st F	Waved Rex (brown) × 23 Normal Rex (black)	Normal Rex (black) × 5 waved Rex (all brown)	Waved Rex (brown) 8 normal Rex (5 black 3 brown)	Backcross 7 waved Rex (6 brown 1 black)
2nd	Waved Rex × Waved Rex 17 waved Rex			
3rd	Brown waved Rex × Albino shorthair (black) (disguised waved) All shorthairs (black) (disguised waveds) 28 shorthairs (2 brown, 8 albino, 18 black) (disguised waveds)			
4th	Brown waved Rex × Blue shorthair 4 black shorthair 58 shorthairs (including disguised waveds) 31 black 12 brown 12 blue 3 lilac			
	12 normal Rex	3 waved Rexes		
	6 black 3 brown 2 blue 1 lilac	2 black 1 lilac		
5th	Waved Rex × Angora Rex (disguised waved) 9 waved Rexes			
6th	Waved Rex × Exhibition Angora (disguised waved) 4 shorthairs and 1 Angora (disguised waveds) 10 shorthairs (disguised waved)			
	3 Angoras (disguised waved)	5 waved Rexes	0 Angora Rex	
7th	Waved Rex × French Angora Shorthairs 9 shorthairs and Angoras			
		1 Rex	0 waved Rexes	
8th	Black waved Rex × Brown waved Rex (Het. brown) 5 waved Rexes (3 black 3 brown)			
9th	Brown waved Rex × Blue Rex Black Rexes 51 normal Rexes (27 black, 9 brown, 11 blue, 4 lilac)			
		21 waved Rexes (13 black, 4 brown, 2 blue, 2 lilac)		

REFERENCE

- CREW, F. A. E. (1933). 'Waved', an autosomal recessive coat form character in the mouse. *J. Genet.* **27**, 95-6.

EXPLANATION OF PLATE 15

Fig. 1. Waved Rex pelt, from the Institute's stock.

Fig. 2. Astrex rabbit, showing effect of a concentration of modifiers.



Fig. 1.

