

# INHERITANCE IN LADY BEETLES

## III—Crosses between variants of *Hippodamia quinquesignata* and between this species and *H. convergens*\*

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THE experiments here described started with a small collection (23 beetles) from the mountains near Logan, Utah, obtained through the courtesy of Professor G. F. Knowlton and Dr. Stephen L. Wood. They were all in one hibernating mass, belonged to the species *Hippodamia quinquesignata* Kby. (determined by Professor Wm. C. Stehr), and exhibited certain striking differences in pattern. As soon as virgin females of the most distinct variants could be obtained, they were crossed with one another and with the spotless form of *H. convergens* from California. After two or three generations wild spotless *H. convergens* was again introduced, and some of the descendants of this cross were mated with the spotted form of *H. convergens*.

### Phenotypes of *H. quinquesignata*

The elytral patterns of the original collection from Logan can be described in terms of the numerical scheme adopted by the author<sup>2</sup> for *H. convergens* with its six spots zigzagging from the anterior outer (humeral) spot (no. 1) back to the apical spot (no. 6). In the majority of individuals the first two spots were connected by a band extending across both elytra near the front margin. Sometimes this band was broad with smooth edges (Figure 11A), sometimes narrow (B) or irregular, or even completely interrupted (C). In a smaller number this band was lacking, leaving only the two spots on each elytron corresponding to spots 1 and 2 of *H. convergens*, spot 2 being regularly joined to the scutellar stripe (Figure 12A).

In nearly half of the Logan beetles there was a spot behind this band, near

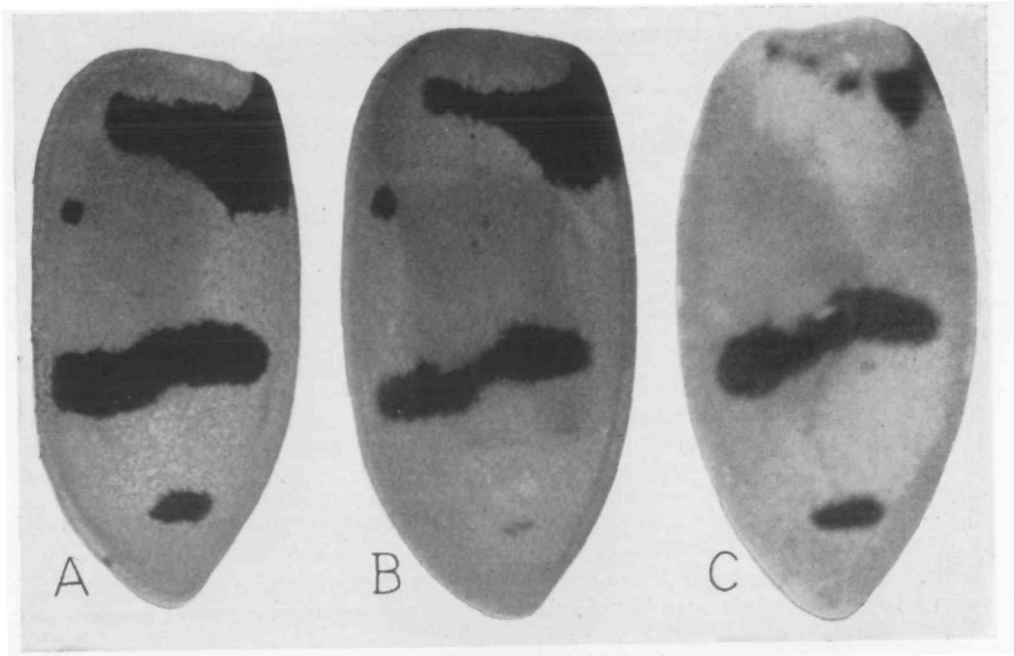
the lateral border of the elytron (Figure 11A, B), corresponding to spot 3 of *H. convergens*.

Just back of the middle of each elytron, in most of the beetles, was an oblique band (Figure 11A-C), usually having a jog or slight constriction near its middle which showed it to be a fusion of spots in the 4 and 5 positions of *H. convergens*. In three beetles of the original collections spots 4 and 5 were completely separate, with 1 and 2 still connected in a band; and in later generations deep constriction in this band (Figure 12B) and complete separation of the spots (C) were accompanied by the separation also of spots 1 and 2.

It is possible that a fourth variable character could have been studied, for nearly a third of the Logan collection lacked spot no. 6, a condition almost realized in Figure 11B. However, in the limited numbers of pairs of parents which could be reared along with experiments already in progress when the collection was received, emphasis was placed on other contrasts. None of the parents chosen lacked the 6-spot, and it was rarely absent in later generations. This fact itself suggests strongly that presence or absence of this spot has a genetic basis, but offers little ground for judging the mode of its inheritance.

Another collection of beetles of this same species should be mentioned merely for a census of its phenotypes, though they did not contribute to any of the experiments. These beetles were collected in the active season, along with other species, at Caldwell, Idaho, by Dr. Harriet Smith. They showed the same general variations as did the Logan group, though spots 1 and 2 were a little

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### IRREGULARITIES OF PATTERNS

Figure 11

Variations of the pattern of *Hippodamia quinquesignata*, especially the anterior band, but also absence of lateral spot (C) and near absence of apical (B). The left elytron is shown in all figures.

more often separate (absence of the anterior band), spot 3 was a little less often absent, and spot 6 was a little more often absent. Spots 4 and 5 (of the postmedian band) were separate in almost exactly the same proportion of individuals as at Logan.

These two collections, though both small, coming from two adjoining states, indicate by their similarity that they probably represent rather well the wild population of that general region.

#### Numerical Rating of Patterns

All the results of the 63 different experiments are presented in Table I. The amount of detail there given is the result of a compromise between limitations of space and the need of a basis of judgment. To save many illustrations, the patterns are represented by numerical signs, now to be described.

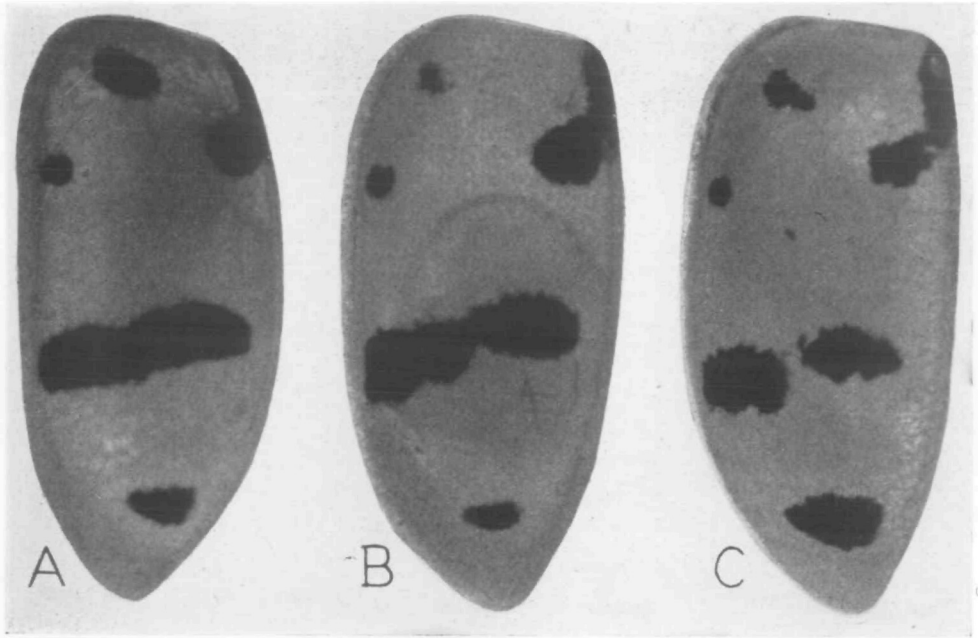
In the fourth and fifth columns of the table are given the phenotypic formulas

of the two parents. The six digits in these formulas refer to the six spots, according to the scheme devised<sup>2</sup> for *H. convergens*. Absence of a given spot is indicated by a zero in its position among the six spots. Size of the spots is indicated by the size of the number, up to a maximum which was originally 4 but now is 7.

A band connecting spots 1 and 2 is indicated by underscoring the digits in the first two positions. The size of the band is indicated by the size of the numbers thus underlined. The first two digits separated by a hyphen indicate that the band was narrow and quite irregular or even interrupted. The two numbers separated by an apostrophe mean that there was no anterior band at all.

Spot no. 3 follows, between two virgules; absence is indicated by zero. Size by the digits 1 to 4.

The digits in fourth and fifth position



### BANDS BECOME SPOTS

Figure 12

Separation of anterior band into two distinct spots, resembling *H. lecontei*; also separation of postmedian band into two spots, as in *H. convergens*.

represent the postmedian band. If underlined, these spots were distinctly joined; if separated by a hyphen, the merger was slight or doubtful; if separated by an apostrophe, the spots were distinct, though they were mostly rather close together until about Experiment 319, when the *H. convergens* influence (of no postmedian band) was becoming dominant.

The presence and size of the apical spot are indicated by the digit in sixth position, following the third virgule.

When a parent was not available for rating, and records were inadequate to indicate sizes of spots, the six positions are represented by the letters *a-f*. Spotless beetles could not be represented by the above scheme, but merely by six digits indicating the size of the spots which were present. A question mark after a phenotypic formula means that the beetle has been lost and the ratings of the spots are taken from records.

### Course of the Experiments

From the original Utah collection four matings were made, two pairs possessing anterior bands (spots 1 and 2 joined), two pairs with these spots separate. The females in these four matings may not have been virgin; indeed, in one of them she certainly was not.

The course of the experiments after these first four matings is indicated in the second and third columns of Table I by the numbers of experiments from whose offspring the parents were selected. The abbreviated words in these columns indicate that parents were taken from wild collections obtained in Yosemite Valley, California, and in Colorado, respectively. The genealogy is not an ideal one; it is the series of experiments which succeeded. To the difficulty created by declining vigor resulting perhaps from inbreeding, to which attention was called in an earlier paper,<sup>2</sup> must be added a peculiarity of this particular



investigation, namely, the absence of one sex from many of the progenies. This feature made it impossible to obtain an  $F_2$  or other inbred generation in a number of crucial situations.

Certain experiment numbers in the columns of parents do not appear in the first column as a part of the main line of descent. Experiment 264 was a mating of two spotless beetles of the species *H. convergens* from Placerville, California. Experiments 329, 330 and 331 were matings of wild *H. convergens* from Colorado. These experiments were designed to provide a stock of spotless and spotted members of that species.

### Phenotypes of Offspring

In classifying the progeny of the various crosses, in the last fourteen columns of the table, space is saved by assuming that no two of the characters are linked. There is no obvious indication of linkage, since the various recombinations of characters are found. Owing to the obstacles described in the preceding section, matings to test linkage would have been difficult. Though certain combinations are more frequent in the progenies as a group, this excess is readily traceable to the combinations that happened to be present in the parents used. To list all the combinations separately would require a table many times as large, with probably less resulting clarity concerning the main genetic features. Each of the four phenotypic characters is therefore classified independently.

In the first two of the last 14 columns (phenotypes) are indicated the numbers of progeny which were spotless (*S*) and spotted (*s*). It should be remembered that "spotless" beetles may have spots.<sup>2</sup> The beetles appearing in the spotted columns are then classified further with respect to each of the other features of their pattern. The next three columns are devoted to the anterior band; the meaning of the headings of these columns has already been explained in the section on "Numerical Rating of Patterns." The next six columns relate to the presence and size of spot no. 3; the

symbol  $3^0$  means that this spot was missing, while the symbols  $3^1$  to  $3^5$  indicate that spot 3 was present and of sizes 1 to 5. The last three columns classify the offspring with respect to the postmedian band (spots 4 and 5), under headings which were explained earlier.

### The Genetic Explanation

Because of the difficulty of making certain desirable crosses, and because of the decline in vigor over a series of generations, it has not been possible to determine the heredity of each character in the usual fashion by the use of homozygous material. Nevertheless, a scheme has been devised which furnishes a rather satisfactory explanation of the bulk of the data. The great majority of the results can be explained by assuming four main pairs of genes, along with supplementary genes which modify the dominance or otherwise affect the expression of some of these four. One of the principal pairs of genes relates to the spotless or spotted pattern, on which earlier results have been published for one of the species.<sup>2</sup> A second pair concerns the anterior band connecting spots 1 and 2; a third determines the presence or absence of spot 3; and a fourth relates to the merger of spots 4 and 5 into the postmedian band.

### Spotless versus Spotted

The results concerning the spotless pattern as contrasted with the spotted are rather clear. The spotless pattern (gene *S*) is dominant over the spotted (*s*). The nearest approach to a contradiction of this conclusion is found in Experiment 293 in which the parents must, from their source, be regarded as heterozygous (*Ss*), yet all their 16 offspring are spotless. The one-fourth recessive class could be absent by accident; also a mutation to spotless could have made one of the parents a homozygote; or a recessive lethal might have accompanied the spotted pattern in this instance. The other results with spotless and spotted are quite regular. In forty matings of spotted with spotted, only spotted progeny were produced (this

character is recessive). In twelve matings of spotted with spotless the progeny are 105 spotless and 122 spotted (a 1:1 ratio). In four crosses of spotless by spotless the offspring are 73 spotless and 14 spotted (a 3:1 ratio).

Certain other results indicate that a nearly spotless condition may be attained without gene *S*. From earlier work with Michigan and California beetles<sup>2</sup> it had been concluded that a "spotless" beetle (a possessor of gene *S*) might have posterior spots about three-fourths as great as the maximum spots of the spotted pattern. It was possible to fix that point as the statistical boundary between the two patterns, though it was recognized as probable that spotted beetles might have smaller spots, and spotless ones have larger spots, than this dividing point indicated. The present work shows that some beetles from Colorado far transcend this limit in one direction. The fathers in Experiment 333 to 337 were all considered spotless when used in matings; but since none of their offspring was necessarily regarded as spotless, and only about three of them could have been regarded as spotless on the Michigan-California basis, they are considered spotted and their phenotypes and genotypes are formulated in accord with that conclusion. In another instance one of the offspring of Experiment 366, largely descended from the Colorado strain, was given a phenotypic rating of 033010, and would have been classified as spotless were it not that both of its parents were spotted. This one beetle could be the result of a mutation; otherwise it indicates that a nearly spotless pattern may result in the absence of gene *S*. It was not possible to breed this beetle further to settle this point.

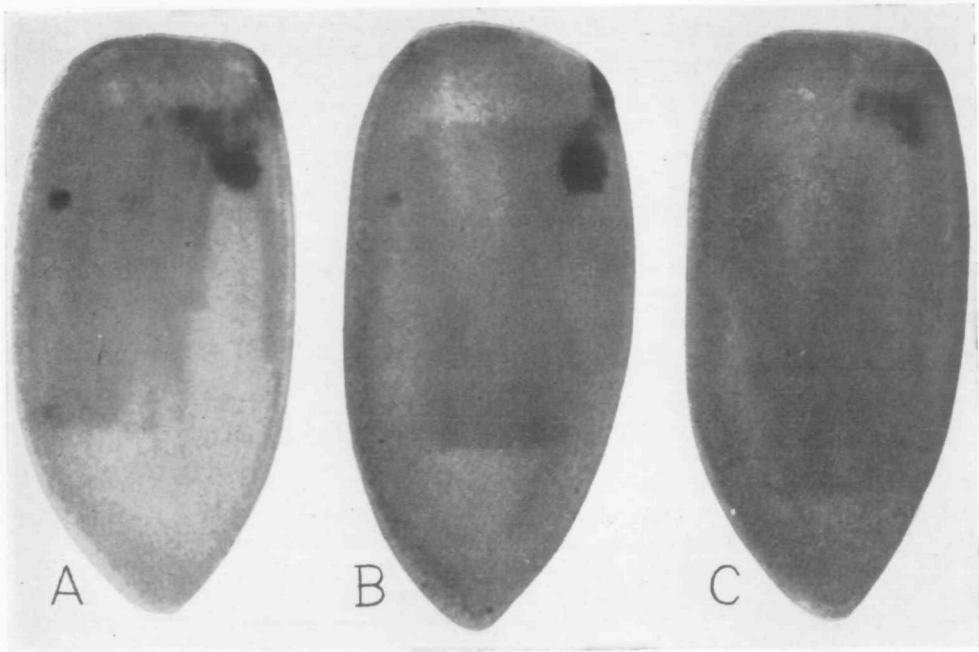
An additional point of interest is that the spotless gene suppresses the spots of *H. quinquesignata* to about the same extent as those of *H. convergens*. Most "spotless" individuals had some spots, particularly the anterior ones. For the most part these spots were rounded and reduced, without any indication of their specific form. In several specimens, however, spot no. 2 had diffuse extensions

which were interpreted as the characteristic contributions of that spot to the anterior band. In Figure 13A the second spot is spread lightly toward both spot no. 1 and the scutellar stripe; in *B* it expands only toward the scutellar stripe; and in *C* the whole spot is diffuse but of a shape indicating an approach to the stripe. These beetles are from Experiments 311, 314 and 312, respectively, in which the anterior band might be either present or absent. One mating was made in an attempt to prove whether these extensions did actually represent the anterior band, but no offspring were obtained.

### The Anterior Band

Though the band connecting spots 1 and 2 is very variable in expression, a large part of its determination may be attributed to one pair of genes. In general, it is concluded that the gene for this band (designated *q* from *quinquesignata*) is recessive to separate spots (*Q*). As explained before, the experiments could not always be performed in such a way as to decide which gene is dominant. Many of the crosses between unlike parents produced divided progenies, indicating that one parent was heterozygous, but not showing which parent this was. Nevertheless, among the many pertinent tests were the following. In five experiments in which both parents had the anterior band, all the offspring (27 of them) had the band; at least one of the parents must have been homozygous. In four experiments between a banded and a bandless beetle, 15 offspring had the band, 14 lacked it; one parent must have been heterozygous. In one cross between a banded and a bandless, the four offspring were all bandless. While this last result would be possible on the assumption that the band is dominant, it is improbable. Since the above results are compatible with dominance of bandlessness, it is concluded that in general the band connecting spots 1 and 2 is recessive.

Some assumptions have to be made to fit certain results not included in the above clear-cut statement. Dominance



#### BAND CONCEALED UNDER SPOTLESSNESS

Figure 13

Diffuse 2-spot, interpreted as trace of anterior band underlying the not-quite-dominant spotless gene.

of  $Q$  (separate spots) is not always complete; it seems necessary to regard the mother of 305 as heterozygous, though she has an irregular or broken band. The father of 259, also necessarily considered a heterozygote, likewise had an interrupted band; but since in this cross the mother may not have been virgin, the father is not surely known. The offspring of Experiment 290 are in like manner better explained on the basis of a nondominant  $Q$ , since none of them has strictly separate 1- and 2-spots, though half of them would be expected to do so on the alternative assumptions.

The occasional or frequent lack of dominance in this pair of genes may be caused by other genes, so that dominance would be of different grades in different progenies.

#### Spot Number Three

That presence of the lateral spot behind the anterior band is due to a gene

( $T$ ) dominant over absence of the spot (gene  $t$ ) is concluded from the following evidence. Three early matings between beetles with and without the 3-spot (Exps. 280, 285, 287) yielded only offspring having this spot. Two other matings from the same source, between beetles with and without the 3-spot (Exps. 281, 290), and two similar matings from other sources (Exps. 278, 299) yielded divided progenies, some having 3, others lacking it. None of the matings of this kind yielded only offspring lacking the third spot.

Furthermore, one mating between beetles having the 3-spot produced, among the eight offspring, one which lacked it (Exp. 289). The ratio here is not too great a modification of 3:1, and certainly it does not fit the opposite assumption. It seems necessary to regard presence of spot no. 3 as dominant over its absence.

Some irregularities in the behavior of the  $Tt$  alleles must be assumed. Thus,

the mother in Experiment 300 is considered to have the genotype  $tt$  despite her small third spot, to account for a progeny exclusively without spot 3. If gene  $t$  be thought of as a suppressor of this spot, even the homozygote—so the assumption goes—has not quite suppressed it in this instance.

The father in Experiment 358 raises a question affecting either the choice of his genotype or the adequacy of gene  $T$  to produce the spot. If this father is  $tt$ , all the offspring are  $Tt$  (one nevertheless lacking spot 3), and the next three experiments should yield both types of offspring in the ratio of 3:1 (the one-fourth class being, however, missing). If, to avoid the expectation of beetles lacking the third spot in the progenies of these last three experiments, the father of Experiment 358 be assigned the genotype  $Tt$ , then gene  $T$  is not dominant in him. The former alternative has been doubtfully adopted for the table.

Lack of dominance of  $T$  is hinted at in assigning the genotype  $Tt$  to the mother in Experiment 347, with her small 3-spot, as if a single  $t$  could nearly suppress that spot. The divided progeny calls for heterozygosis in both parents. A still greater failure of dominance of  $T$  is found in the one offspring of Experiment 358 which had no 3-spot. It can not very well be held to be  $tt$ , for the mother came very largely from recent wild sources and most probably was  $TT$ . If despite this argument, the mother be regarded as a heterozygote, then half (not just one) of the 66 offspring should lack spot no. 3. The ability of a single  $t$  occasionally to suppress this spot seems to be distinctly the more likely of the alternative assumptions.

### The Postmedian Band

The union or separation of spots 4 and 5 is subject to enough irregularity to call for probably a number of genes. These genes cannot, however, be equal in their effects. There is abundant reason to assume that one of them is far the most important—a principal gene, to which the others are related as modifiers or accessories.

There is some reason to regard the one main gene effecting a fusion of spots 4 and 5 as recessive (gene  $f$ ). In Experiment 307, on this basis, the cross is  $ff \times FF$  (the spotless father being regarded, because of the wild population from which he came, as almost necessarily homozygous for genes which would separate spots 4 and 5). The progeny would then be alike, with separate spots, as they are observed to be. If fusion of spots 4 and 5 were dominant, the cross in Experiment 307 would be at best  $Ff \times ff$  (with progeny of two kinds) and at worst  $FF \times ff$  (with progeny all having the postmedian band). Neither of these requirements is met.

Most other experiments could be brought into conformity by postulating that fusion of spots 4 and 5 is controlled by a dominant gene. On the basis of the evidence outlined in the preceding paragraph, the postmedian band is regarded as recessive ( $ff$ ), while separation is dominant ( $FF$  or  $Ff$ ). Which ever assumption is made as to dominance, many irregularities are found which require presumably the action of other genes. Some of these difficulties will be pointed out.

After making the best possible set of assumptions for the experiments as a whole, it seems necessary to conclude that the genotype  $ff$  does not always entail the firm fusion of spots 4 and 5. One of the offspring of Experiment 286 has the two spots barely touching on one side, a little more closely joined on the other; and in one of the offspring of Experiment 289 spots 4 and 5 are completely separate. Nor is  $F$  always dominant. To account for two kinds of offspring in Experiment 288 it seems necessary to assign the genotype  $Ff$  to one of the parents, yet both of them have spots 4 and 5 broadly fused. There are other places in the experiments where partial dominance of  $F$ , or lack of dominance, needs to be assumed.

In Experiments 319-325 and 327, a small number of the offspring have the postmedian band, which could be explained by regarding their fathers as



heterozygous ( $Ff$ ); but were that done, these postmedian bands should be much more numerous. Moreover, these fathers were wild beetles of the species *H. convergens* from California; and if so many individuals chosen at random should be heterozygous, then postmedian bands should appear in natural populations. Spots 4 and 5 are occasionally closer together, and rarely touch, in these populations, but gene  $f$  if present at all must be rare. The fathers in Experiments 326 and 339 (the latter wild *H. convergens* from Colorado) have been assigned the genotype  $Ff$ , partly to indicate the general possibility that exists for this whole group of experiments, and partly (in Exp. 339) because of the relatively large number of individuals having joined 4- and 5-spots. Even in this latter experiment, however, the spots were not broadly joined, as in the wild *H. quinquesignata* from which they partly descended; the postmedian band was deeply constricted at its middle.

This latter point—that union of spots 4 and 5 in the hybrids often scarcely produces a band—may suggest one of the explanations of the greater irregularity of this fusion as compared with the spotless condition, the anterior band, and spot No. 3. It is possible that other genes besides  $f$ —probably a number of them—cause an approach of spots 4 and 5 to one another. *Hippodamia convergens* might possess enough of these to account for the occasional nearness or slight fusion of these spots, but not possess gene  $f$  at all. The species *H. quinquesignata* could also possess these genes, perhaps as abundantly as does *H. convergens*. If these genes were accessory to genes  $F$  and  $f$ , in the sense that they added to or subtracted from the phenotypic effects of these genes, much variation of the band would be accounted for. Another effect of these genes might be modification of the dominance of  $F$ , but it is hardly necessary to devise any further complications to account for the observed irregularities.

### Genotypes of Parents and Offspring

In accord with the foregoing discus-

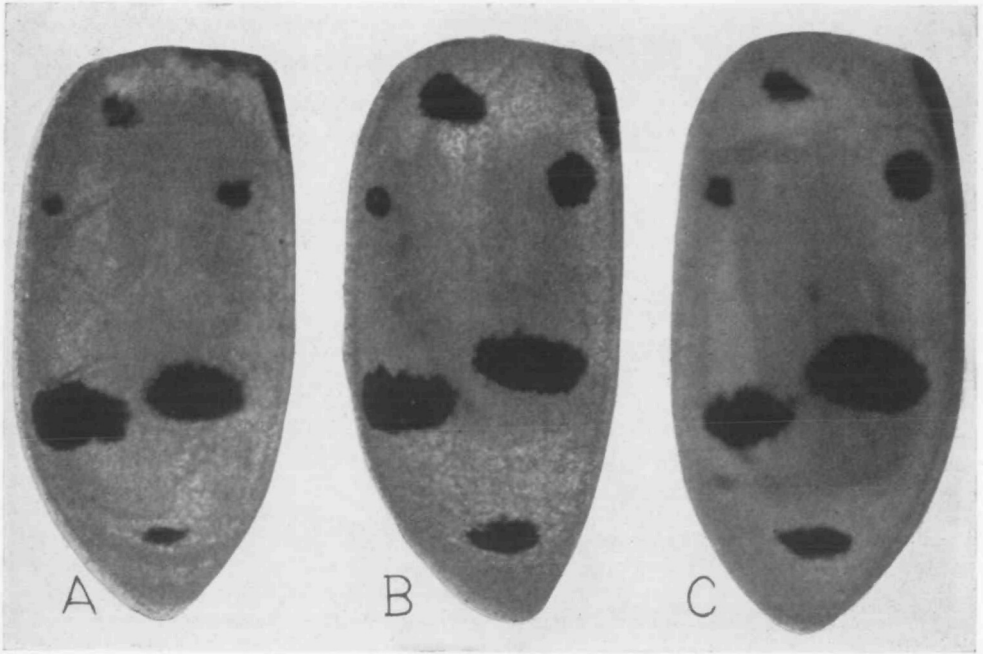
sion of the four separate characters, possible genotypes have been assigned to parents and offspring in the sixth, seventh and eighth columns of the table. In Experiment 258, two females are given because this was originally intended as a stock. In the first four experiments, the females were not assuredly virgin, hence two genotypes are given to the male in some instances. When the female was known to be virgin, as in all the other experiments, only one genotype is assigned to the male. For the progeny, two or three genotypes are often given. To save space, not all the possible genotypes are given; but those which are required by the phenotypes of the offspring or by subsequent matings are all included. In omitting unnecessary genotypes no particular attention was given to keeping those which would be numerically most probable; it was regarded as satisfactory to indicate a genotype which (1) was possible and (2) would explain the results.

It should be specifically pointed out that the wild Yosemite males introduced in Experiments 307 and 319-327, and the wild Colorado males in Experiments 333-339 were of the species *H. convergens*. Their genotypes were chosen in accord with their phenotypes and with the wild populations from which they were taken.

Attention should also be called to the genotypes  $Ff$  and  $ff$  assigned to the males in Experiment 260. The latter of these would represent previous matings of the non-virgin female. The progeny indicate that the earlier matings were much more effective than those which occurred after the isolation of the pair.

### The Species Cross

Anyone who examined only the elytral pattern might conclude that the beetle represent in Figure 12A is *Hippodamia iccontei* Muls., particularly if the intergrading anterior bands of Figure 11 were unknown, if the hibernation of the two forms together were ignored, and if the 2-spot were firmly joined to the scutellar stripe as in this specimen, to form (on the two elytra together) a three-



#### APPROACH TO HIPPODAMIA CONVERGENS

Figure 14

Early generation species hybrids resembling one of the ancestral species, *H. convergens*.

pointed star. However, the male genitalia are identical in the beetles with and without the band connecting spots 1 and 2. The genitalia of *lecontei*, which I have not seen, are said to be much shorter than in these forms.

The only species cross in this study is thus between *H. quinquesignata* and *H. convergens*, in Experiment 279. Descendants of this cross were bred together and backcrossed to both species, especially to *H. convergens*, in complex fashion. The details of these crosses may be ascertained from the table. The results indicate, as there shown, that the genetic differences between the species, so far as elytral pattern is concerned, are not very great.

It remains to point out the same conclusion arrived at in another way. How soon, in the generations following the species cross, do individuals appear which are reasonably near either contributing species? Because of the variation within *H. quinquesignata* (presence

or absence of the anterior band, for example) it would be difficult to say when that species had been recovered. It would be arbitrary to insist on a wide anterior band when such a band is not always present in nature. It is proposed, therefore, to look only for returns to the pattern of *H. convergens*.

It is unfortunate that the only species cross which succeeded was one in which the *convergens* parent was spotless, since the number of descendants in which the typical pattern could be recognized is thereby greatly reduced. It is also unfortunate that the only successful species cross was made with a *Hippodamia quinquesignata* which already lacked the anterior band. This beetle was also fathered by one in which spots 4 and 5 were separate, but it itself had them broadly connected in a postmedian band; so that, unless gene *F* here lacks dominance, the genotype of the beetle is *ff* and the separation of spots 4 and 5 in its father has been eliminated.

The mother in Experiment 279 still has spot 2 connected broadly with the scutellar stripe, to produce the 3-pointed star which has often been regarded almost as diagnostic of *H. lecontei* but which here is *quinquesignata* as distinguished from *convergens*. Probably, therefore, the only step toward *convergens* which could be regarded as having already been taken in advance of the species cross was the separation of spots 1 and 2.

Close approximation of the *convergens* pattern is reached already in the F<sub>2</sub> generation (Exp. 291). In Figure 14A is shown one of the five spotted members of that family. If collected along with *H. convergens*, this beetle would no doubt be regarded as belonging to that species. Two other spotted ones in the same progeny had spots 4 and 5 separate and about as far apart as the one illustrated. All three of these had spot 2 separate from the scutellar stripe.

Other *convergens*-like hybrids are found among the offspring of Experiment 307. To obtain them a spotless F<sub>1</sub> from the species cross was backcrossed to a *lecontei*-like *quinquesignata*, and one of their *lecontei*-like offspring was backcrossed to a spotless wild *convergens*. All five of their spotted offspring, of which Figure 4B is one, could have been regarded as *convergens*.

Finally, an F<sub>2</sub> backcross (Exp. 312) produced Figure 14C. A spotless F<sub>2</sub> from the species cross was backcrossed to a typical *quinquesignata* with anterior band (whose mother, however, had the *lecontei* pattern). One of their four spotted offspring is shown.

No superior merit is claimed for the arguments advanced in this section, which go to show that the pattern differences between the species are not very complex, as compared with the genetic analysis of the separate characters in the preceding sections which shows the same thing. They should be of some interest, however, to those who are concerned with specific distinctions in nature. It is recognized, of course, that pattern is not the only feature by which the species are judged. The male geni-

talia, on which taxonomists place considerable reliance, are not here considered.

### The Evolution Problem

The purpose of these studies is to throw light on the probable evolution of the Coccinellidae by revealing the genetic relations of species, or of varieties which might be on their way to becoming species. Varieties which show differences in distribution are of especial interest. So far I have no information to indicate that the banded and bandless forms of *Hippodamia quinquesignata* have any differential distribution. The range of the species as a whole appears to be of some size. Leng<sup>1</sup> describes it as occurring from New York to California, through a northern area, but dipping to the south in the mountains of Utah, Colorado and even New Mexico. So far I have not found it in the Lower Peninsula of Michigan.

The genetic relations of the *quinquesignata* pattern to that of *convergens*, as shown by these studies, are simple enough to indicate that no large number of mutations would be required to evolve one species from the other or both from a common stock. Perhaps that is a reason why the species cross was possible. In this connection it should be stated that the cross was attempted five times. In one of these the female died several days after confinement with the male, and in another both male and female escaped in transferring them to a new culture. Thus one success in three is probably the proper measure of the ease or difficulty of making the species cross. In the two failures, mating was observed, and eggs were laid, but these did not hatch. During the copulation, the beetles were often running restlessly about, which is unusual. These facts may indicate that species crosses in nature are not likely to be frequent.

### Summary

Within the species *Hippodamia quinquesignata* and in crosses between it and *H. convergens*, four principal pairs of genes affecting elytral pattern are dem-

onstrated. The spotless gene introduced from *convergens* is as effective in suppressing the spots of the usual pattern of *quinqesignata* as that of *convergens*, and it is dominant as in the latter species. It is concluded that the band across the anterior ends of the elytra is recessive to the bandless condition (two separate spots). Presence of a lateral spot behind this band is dominant over its absence. The oblique postmedian band of *quinqesignata* is regarded as recessive to the separation of the spots whose fusion makes this band.

There are some irregularities in the inheritance of three of these characters which probably require the assumption of modifying or accessory genes. In each of these three the dominance postulated

is occasionally lacking or reversed. The postmedian band may almost certainly be partly produced by other genes than the one indicated above. There is strong indication that in *H. convergens* from Colorado, a nearly spotless pattern may be attained without the dominant gene called spotless.

All in all, so far as pattern is concerned, the genetic differences between *H. quinqesignata* and *H. convergens* are not very complex. Crosses between them are not very common, however, in nature.

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## ADDITIONAL DATA ON SEX CONTROL IN RABBITS

J. H. QUISENBERRY\*

A SYMPOSIUM of papers on sex control, given at the annual meeting of the American Society of Animal Production, was published in the December, 1940, number of the JOURNAL OF HEREDITY. In that symposium the author and Mr. S. V. Chandiramani published the results of an attempt to modify the sex ratio in rats and rabbits by using lactic acid and sodium bicarbonate douches. No modification of the sex ratio was observed for the rats. The number of rabbits obtained at that time was small but the ratios appeared abnormal. Additional litters of rabbits

have been obtained and the sex ratios are shown in Table I.

No effects of the douches are apparent in this table. Based on the results obtained in our laboratory with small animals, douching of farm animals to modify the sex ratio seems not only a hopeless procedure, but a dangerous one as well. Introduction of the douche into the vagina of the female may result in the spread of disease unless extremely sanitary measures are used and if too strong a solution is used the fertility may be reduced.

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TABLE I. Sex Ratios Obtained from Rabbits Douched with Lactic Acid and Sodium Bicarbonate Solutions.

3% Lactic Acid			5% Sodium Bicarbonate		
♂	♀	% ♂	♂	♀	% ♂
48	45	51.6	66	55	54.5

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