

# Parthenogenesis in New Zealand Stick Insects

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## Abstract

THE phenomenon of parthenogenesis is known to occur in many species of phasmids, but it has not hitherto been recorded among the phasmids of New Zealand. Most species of the genus *Clitarchus* can reproduce parthenogenetically as well as sexually and both processes of reproduction apparently occur together. With the exception of the species *Acanthoxylla senta*, found only on the Three Kings Islands, all the species of the genus *Acanthoxylla* reproduce parthenogenetically. Breeding experiments carried out over periods of four to six years with four species of *Acanthoxylla* have failed to produce any males. These are considered to represent true parthenogenetic species in which the male has been completely suppressed. The seven parthenogenetic forms of *Acanthoxylla* form a "parthenogenetic ring" of closely related but quite distinct species in which this relationship could probably be varied only by the intervention of a functioning male.

PARTHENOGENESIS is of common occurrence amongst insects, and is known to occur in many species of Phasmids. The Indian and South European species upon which much research has been done, breed almost entirely parthenogenetically. It is not surprising, therefore, to find the phenomenon of parthenogenesis of widespread occurrence in several genera of New Zealand stick insects. My attention was first drawn to this some years ago when I commenced breeding different New Zealand species in an attempt to relate male forms to their correct females. From these experiments I soon learned that parthenogenesis was of frequent occurrence among species of *Clitarchus* and *Acanthoxylla* and that it also occurred in certain species of *Mimarchus*, but was absent or very rare in the species belonging to *Argosarchus*. Although these breeding experiments have satisfactorily solved the relationships of the different male and female forms of stick insects found in New Zealand, they have not completely solved the riddle of parthenogenesis, but I thought that it might be appropriate at this stage to make public what I have so far learned on this subject.

The common smooth green or brown stick insect, found all over the country, belongs to the genus *Clitarchus* Stal, and is known as *C. hookeri* (White). *C. hookeri* breeds both by parthenogenesis and by the normal sexual mating process. Eggs from a mated female give rise to both male and female offspring, but eggs developing parthenogenetically give rise only to females. The genus *Clitarchus* also contains another new species, at present undescribed, and in which no male has so far been found, neither in the field nor by breeding. A female *hookeri*, taken in the field and kept alive in the laboratory, produced about 200 eggs from the hatchlings of which I selected six females. These females were segregated before maturity so that their offspring would be reproduced parthenogenetically. At the same time in another group six females and six males were segregated together to ensure that their offspring would develop from fertilised eggs. Each

of these series was inbred and kept going for six years, and each series produced one generation per year. At the end of this period the mated series was as vigorous as ever, but in the seventh year all the parthenogenetic females but one died before maturity. The one that survived was well below normal size and laid only eleven eggs. These eggs were also smaller than normal and none of them hatched. During the six years of parthenogenetic breeding there was always a very heavy mortality of nymphs during the second instar which, so far as I could ascertain by feeding experiments, was not due to dietary or water deficiencies. At no time during this parthenogenetic breeding was a recognisable male produced. The possibility of males having been produced but dying before they could be recognised cannot be discounted, though I think that it is extremely unlikely. A further series of *hookeri* which was bred parthenogenetically for four years and in which the originating female came from Cuvier Island gave very similar results. The average length had diminished from 8.3 cms. to 6.6 cms. over this period, though in the first parthenogenetic generation the average length was slightly greater than normal, a phenomenon I was to notice in conducting similar experiments with species of *Acanthoxyla*. In both these parthenogenetic series of *C. hookeri*, with the exception of the length of the body, the morphological characteristics of the species did not vary to any great extent. For example, the spines on the fore femora varied between five and seven, a percentage of variation which is much less than that found often between odd specimens taken at random in the field. This is in approximate agreement with Weismann's views on parthenogenesis (1893), but contrary to those of Warren (1899) dealing with parthenogenesis in *Daphnia*, and of Ling Roth (1920) dealing with the phasmid *Carausius morosus*.

It would appear from these observations that the species *C. hookeri*, though it can reproduce parthenogenetically, cannot continue to perpetuate itself indefinitely by this means, at any rate while kept in captivity. This is in strange contrast to the undescribed species of *Clitarchus*, which apparently reproduces only by parthenogenesis.

The genus *Acanthoxyla* was set up in 1944 by Uvarov for the species previously known as *Acanthoderus prasimus* Westwood and its related forms. This genus includes all those spiny or tuberculated species in which the operculum of the female is provided with a basal spine or large tubercle. Besides the species *prasima* the genus also includes forms described under the names *geisovii* (Kaup), *suteri* (Hutton), *senta* Salmon and the four new forms, *A. inermis*, *A. intermedia*, *A. huttoni* and *A. speciosa* described elsewhere in this volume. Of all these species the only one in which a male is known is *A. senta*, which occurs only on the Three Kings Islands. The remaining species are found practically throughout New Zealand, but none of them occur on the Three Kings. In all of them females only are known, and breeding experiments so far conducted have failed to produce any males. According to Hutton the species *geisovii* was described by Kaup from a male specimen; how Hutton came to this conclusion I do not know, as Kaup does not mention the insect's sex in his description. Intensive collection from all over the country and breeding experiments in which several thousands of specimens have been handled have both failed to yield a single male specimen of the form we call *geisovii*. In these breeding experiments four species of *Acanthoxyla* have been tried, including *geisovii*, *prasima* and two of the new species. All these were kept going for periods of four years, and in

all but one the species continued to breed true to form with small but quite noticeable variation. In the aberrant specimens the number and positions of spines and tubercles did vary appreciably from generation to generation or between individuals of the same generation. This variation, however, was never of sufficient magnitude to constitute a new species. It is curious that in these Phasmids the first generation in captivity usually shows a small increase in length over the length of the originating female. With *geisova* in the fourth year there was also a noticeable diminution in the length of the body and in the number of eggs laid. The other three species still appeared to be quite vigorous, but the experiments had to be stopped at this stage for unexpected reasons. It would appear, therefore, that in the genus *Acanthoxyla* we have seven parthenogenetic species each of which breeds true to form and can always be recognised as distinct. When I first began collecting these *Acanthoxyla* species I at first thought that Hutton had been wrong in recognising four distinct species. They all appeared to me to be but variations of one common type, but the results obtained from breeding experiments confirmed that these forms were, indeed, distinct species. As a result, I now recognise eight species of *Acanthoxyla*, all but one of which reproduce only by parthenogenesis.

Among insects exhibiting agamic reproduction it has been found that the somatic cells are diploid in some, and haploid in others. In haploid parthenogenesis males only are produced (e.g., hive bees) whereas in diploid parthenogenesis both males and females can be produced (e.g., aphids). I have not made any cytological investigations into the condition of the body cells of any of the New Zealand phasmids but I should expect them to be in the diploid condition, in which case parthenogenetic development could normally be expected to produce males at regular though perhaps lengthy intervals. In all experiments I conducted the parthenogenesis exhibited by the species of *Chitarchus* and *Acanthoxyla* produced females only, and is, therefore, somewhat unusual. In the species *C. hookeri* parthenogenetic reproduction appeared to be quite sporadic and did not alternate with regular periods of sexual reproduction, and I consider that the phenomenon is not so highly developed in this species as in the species of *Acanthoxyla*. *C. hookeri* apparently resorts to parthenogenesis only in the absence of males. These results are in close agreement with what has so far been discovered in connection with parthenogenesis in the European phasmid, *Bacillus gallicus* and *Bacillus rossii*, as well as with the Indian species *Carausius morosus*. Various workers on this problem of parthenogenesis in phasmids have shown that the phenomenon is almost universal amongst these insects and that in the entirely parthenogenetic forms such as *B. gallicus*, *B. rossii* and *C. morosus*, males are very rarely produced. When they do occur these males are generally gynandromorphs. Pure functional males capable of a successful copulation are extremely rare.

It would seem to me that, in these parthenogenetic phasmids, we see an evolutionary trend which tends to dispense with the male form and which ultimately gives rise to a series of parthenogenetic species that continually breed true. We see the process started but not complete in *C. hookeri*, while in the seven New Zealand mainland species of *Acanthoxyla* we see it completed. In *Acanthoxyla* I regard it as forming what I would term a "parthenogenetic ring" of closely linked or related species. Quite possibly these species first arose as variations from normal sexual matings which were immediately capable of parthenogenetic

reproduction. If males should ever appear and, if they were functional, I should expect the progeny from a mating to produce variations equivalent to the species of the parthenogenetic ring. On the other hand, if males are entirely suppressed then we should expect these species to be fixed within certain limits and incapable of any great morphological variation from their norms, and this appears to be the case in these New Zealand species.

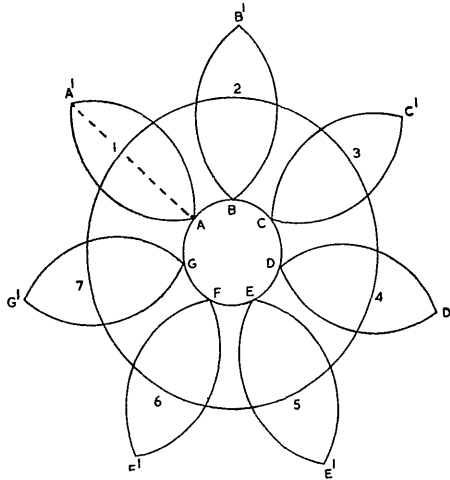


FIG. 1.—Diagrammatic representation of parthenogenetic variations in *Acanthoxylla*.

This continual variation round a norm can be depicted as a circle or ellipse. If the variations of these seven parthenogenetic species are plotted around the circle (1-7) we obtain a diagram as shown in Fig. 1, in which each species varies on either side of the axes  $AA'$ ,  $BB'$ , etc. As each species varies irregularly, it cannot be represented by a circle, but plots, instead, an elliptical figure and the inward limits of these seven figures subtend a further circle A-G, which should demarcate the limits of variation of the originating form. In the case of *Acanthoxylla*, this originating form from which the parthenogenetic species presumably arose, gives us a concept of the characters of the genus. This diagrammatic concept of variation might be applied to other groups of variant species, not necessarily parthenogenetic, with equally interesting results.