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Mimicry in the Butterflies of Fiji considered in relation to the Euploeine and Danaine invasions of Polynesia and to the female forms of Hypolimnas bolina L., in the Pacific.

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XXVIII. *Mimicry in the Butterflies of Fiji considered in relation to the Euploeine and Danaine invasions of Polynesia and to the female forms of* Hypolimnas bolina *L. in the Pacific.* By Edward B. Poulton, M.A., D.Sc., F.R.S., Hope Professor of Zoology in the University of Oxford, Fellow of Jesus College, Oxford. With an Appendix On the Numerical Aspect of Reciprocal Mimicry (Diaposematic Resemblance), by H. H. Turner, M.A., D.Sc., F.R.S., Savilian Professor of Astronomy in the University of Oxford, Fellow of New College, Oxford.

[Read June 6, 1923.]

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INTRODUCTION.

The great interest of the Fijian islands in relation to the problems of Müllerian Mimicry first attracted my attention when, in 1899, I received examples of the two commonest Euploeas from my friend Prof. Gustav Gilson, of Brussels. We had met during the meeting of the British Association in Canada in 1897, and he had then told me of his intended visit to Fiji, and kindly promised to collect butterflies for me. When, two years later the specimens arrived and were studied, it at once became evident that, of two species of *Euploea* present in the collection, one, *E. helcita eschscholtzi* (Pl. XXX, fig. 1 ♂, fig. 2 ♀), appeared obviously to have acted as the model for the other, *E. boisduvalii proserpina* (Pl. XXX, fig. 3 ♂, fig. 4 ♀). It seemed certain, from a mere inspection of the pattern, that the principal spot on the fore-wing of *proserpina* had been lengthened inwards so as to bring about a superficial resemblance to the principal spot on the fore-wing of *eschscholtzi*, and that the likeness between the two, flying together on the same island, would be extremely close. The material at hand was, however, insufficient to suggest that this likeness is, as so often in mimicry, closer in the female than the male. I was so struck with the evident change, as it appeared, produced in one species by the power of selection directed by the presence of another species in the same locality, that I asked Mr. Alfred Robinson, of the Oxford University Museum, to prepare one of his beautiful photographs of synaposematic Danainae (chiefly Euploeini) and included in it the pair of Euploeas from Fiji (to become figs. 4 and 9 of the plate mentioned below). And when my friend, and at that time pupil, Major J. C. Moulton, was writing his paper "On some of the principal Mimetic (Müllerian) Combinations of Tropical American Butterflies" (Trans. Ent. Soc. Lond., 1908, p. 585) I suggested that it would be

interesting to reproduce this photograph as Pl. XXXIV in order to show that the very same principles illustrated for the New World tropics in his Pls. XXX–XXXIII were also illustrated in the allied groups, but with totally different patterns, in the tropics of the Old World.

Major Moulton's plate XXXIV was criticised by the late Col. Manders in a letter published in "The Entomologist's Record" (vol. xxi, p. 120, 1909), in which he suggested that the S. Indian association of three common Euploeas (figs. 1–3, 6–8) was of no more significance than that of the three commonest Pierines in Middlesex.* Following his letter were some editorial comments chiefly directed to the contention that recent work on mimicry took no account of the habits and the distribution of the insects themselves.

The latter criticism hardly needed a reply, and received none at the time. It will be clear to anyone who reads what has been published on this subject in the past thirty years that great pains have been taken to stimulate observation in the field and to record the results with the most minute attention to the data of time and place. But, as regards Col. Manders' letter, the present writer exhibited sets of Euploeas from various localities and showed that their patterns, which differed as we passed from one locality to another, were, in each locality, followed by various local species. (Proc. Ent. Soc., 1909, p. xxxvii). He also showed that the recognition of Müllerian resemblance among the Euploeas was not, as had been assumed in the "Record," a new thing, but had been originally suggested by the late Prof. Meldola, F.R.S., in 1882 ("Ann. Mag. Nat. Hist.," 5th ser., vol. x, 1882, p. 417), and worked out in detail with abundant illustrations of local Euploeine and Danaine associations in the following year by the late Dr. Frederick Moore (Proc. Zool. Soc., 1883, p. 201).

The small effect produced by Dr. Moore's memoir was probably due to the unjustifiable creation of genera founded on the secondary sexual characters of the male. The extent to which these genera have been sunk may be inferred from H. Fruhstorfer's treatment of the Euploeas in Seitz's "Macro-Lepidoptera of the World" (Sect. II, Vol. ix, translated by L. B. Prout). To take but a single

* The Pierines are probably a somewhat unpalatable group, and it is by no means certain that the upper surface resemblance between the commonest Middlesex species is without bionomic significance.

instance. Fruhstorfer recognises only the single genus *Euploea*, which he divides into various groups. One of these (p. 226) is "The group of *Crastia*" and, within this, "Subgroup A.," containing Euploeas without distinctly visible sexual stripes, is held to include *eleven of Moore's genera*, viz., *Nipara*, *Oranasma*, *Patosa*, *Sarobia*, *Vadebra*, *Lontara*, *Gamatoba*, *Menama*, *Tronga*, *Sabanosa*, and *Adigama*. So that what one author classifies under eleven genera is classified by another as a subgroup of one of the groups into which he divides a single genus! It is possible that the future investigation of structure and life-histories may show that Fruhstorfer has gone too far in this wholesale treatment, but no one, I think, will deny that his arrangement is far truer to nature than Moore's. In the present paper it will be shown (pp. 594, 595) that the New Hebridean Euploeine—"*Mestapra*" *paykullei* Butl., of Moore's monograph (*ibid.*, p. 285), has probably interbred with the east Fijian race of "*Deragena*" *proserpina* Butl. (p. 272).

This reckless and injurious creation of genera should not, however, prevent us from giving to Moore the great credit of being the first to recognise the prevalence of local mimetic associations among both Danaini and Euploeini. In order to direct attention to this important discovery the following paragraphs are quoted from pp. 205, 206 of his memoir:—

"When studying this subfamily of Butterflies in 1879, preparatory to describing the species for my work on the Lepidoptera of Ceylon, I separated the whole of the species then in my collection into groups, according to the presence and position of the 'sexual mark' or 'scent-producing organ' in the male insect. Having thus separated the species into such groups, I was then much surprised to observe that this operation had placed before me several species in each group which bore an extraordinary resemblance, in the pattern of the markings on the wings, to certain species which I had arranged in the other groups.

"Having thus taken these 'sexual marks' or, as they are now known to be, 'scent-producing organs,' as the primary structural character for separating the species of the old genus *Danais* and *Euplœa* into minor generic groups, these assemblies of species, thus grouped, brought to my mind at once the fact that here were evident illustrations of a form of mimicry occurring between closely related groups,

and that, too, *within* a protected family of Butterflies, or, more extraordinary still, *between species of the same genera*, as it would then appear, if the species are restricted to *Danais* and *Euplœa* respectively.

"At that time I had forgotten that this phenomenon of mimicry *between related genera* had been observed by my friend Mr. Bates among the Danaoid Heliconidæ; but subsequently, on again working with his memoir in the Linnean 'Transactions' before me, I became aware of his discovery.

"This analogous form of mimicry, occurring in *Danais* and *Euplœa*, had, however, not previously been recorded. Certain species, it is true, when being described, were noted by Mr. Butler as having a resemblance to certain other isolated species.

"Since my own observations were thus made, I have had the opportunity of showing and pointing out some of these mimetic groups in *Euplœa* to my friends Mr. Bates, Mr. Meldola, Mr. Distant, and others; and these facts have since served as materials for discussion in certain recent articles on mimicry in Butterflies.*

"The extent to which this form of mimicry exists among the species of the old genera *Danais* and *Euplœa* will be better understood by an examination of the accompanying Tables of the five primary groups into which I have divided each of these old genera.

"In these Tables the names of certain genera and species in each of these five groups are given, and the names of those genera and species, *inhabiting the same locality*, which imitate them."

After naming the collections he had studied in the preparation of the Tables, which, as he states in a footnote, could have been much extended had it been possible to bring the collections together at the time when the paper was written, he continued: "This imitative character pervades all the groups into which I have divided the species hitherto arranged under *Danais* and *Euplœa*. . . ."

The study of the Tables of "Mimetic Species in Euplœina" (pp. 208–212) together with the examples in P.Z.S., 1883,

* The following references are given in Dr. Moore's paper—"W. L. Distant, Rhop. Malayana, p. 33 (1882); R. Meldola, Ann. Nat. Hist. 1882, Vol. x. p. 417; W. L. Distant, Ann. Nat. Hist. 1883, Vol. xi. p. 43. See also Wallace, 'Nature,' May 25, 1882 [xxvi, p. 86]."

Pls. XXIX and XXX, or better still with the specimens themselves, will convince any one with an open mind of the reality of the local associations discovered by Dr. Moore, and supplies the answer to criticisms brought forward more than a quarter of a century later in the "Record."

Only within the past year, when collecting records of various kinds for the present paper, I have become aware of better evidence for the reality of these local Müllerian associations than any which Moore was able to supply. The evidence is better because it rests upon observation in the field, made too in the year before the appearance of Moore's work. Writing on February 23, 1923, Mr. Gervase F. Mathew, from whom I have received much help in this work, kindly copied for me the following record :—

"In my Lepidopterist's journal (which I kept all the time I was on the Australian Station) I find in Nov. 1882, when we were at Ugi, in the Solomon Islands, the following note—'*Euplœa assimilata* Feld., *E. brenchleyi* Butl., *Danais insolata* Butl. and *Diadema* [*Hypolimnas*] *fuliginescens* Math.—These 4 species, on the wing, looked exactly alike. It was a good instance of mimicry, but which mimicked which it is difficult to say; nor could I understand the reason, for as far as my experience goes all the species of these groups require no artificial protection, as birds do not seem to touch them, nor are their larvae much attacked by ichneumons, and I have proved that they are distasteful to birds.'"

Two of the above species, *brenchleyi* and *insolata*, are quoted, of course with different generic names, in Moore's Table Ia (p. 208), and *brenchleyi* again in Table V (p. 210), where it is associated with *imitata* Butler, which is doubtless the *Euploea* first mentioned by Mr. Mathew, *assimilata* being the name of an allied species from the Aru Islands. The *Hypolimnas* did not fall within the limits of the subject as treated by Moore. But we can imagine what his delight would have been to receive this evidence from the observation of living nature in support of the conclusions he had reached in the museum.

The Müllerian theory had only been published in this country in 1879 (Proc. Ent. Soc., p. xx), and any naturalist who was without this clue would have encountered the difficulty mentioned by Mr. Mathew, and felt by Bates, as we know from the thoughts expressed in his great monograph on mimicry (Trans. Linn. Soc., Vol. xxiii, p. 495, 1862).

As regards the parasitic foes referred to by Mr. Mathew, it is probable that prolonged investigation directed to this special subject would show that a comparative immunity from the attacks of vertebrates is compensated by the loss inflicted by invertebrate enemies, in accordance with the conclusions of Dr. G. D. H. Carpenter ("Report, British Association," 1913, p. 516).

A note made at the time, recording the observations of a particular day is, in some respects, even more forcible than the summing up of experiences over a longer period. On November 9, 1882, when he was at Selwyn Bay, Ugi Island, Mr. G. F. Mathew wrote in his journal :—" I noticed a very interesting example of mimicry to-day—a black *Euplœa* with broad white marginal bands was not uncommon, and, flying with it was a *Danais* with markings almost identical, and in addition to which I took a *Diadema* (*Hypolimnas*) which on the wing might have been mistaken for either of them! Which mimicked which I am at a loss to know. Also the reason of the mimicry, for all three species are, I believe, avoided by birds, both in their larval and perfect state."

I have quite recently received a letter dated October 22, 1923, giving an account of Mr. H. W. Simmonds' observation of the dominant Euploeine associations in some of the Solomon Islands. The illustrative specimens, to be shown to the Society in the near future, will throw light on the relative numbers of the associated species.

Several different Euploeine associations, together with the other butterflies which enter them, are beautifully represented in Plates I–III of "Bull. Hill Mus." (vol. i, No. 1, 1921), showing characteristic patterns of the Key, Aru, Tenimber and Fiji islands, and Australia, respectively. The resemblance in each locality, together with the difference from other localities, is here convincingly demonstrated.

Mimicry of Euploeas and Danaines by species of the genus *Hypolimnas* in many parts of the Old World is also the subject of a paper by the late Col. C. Swinhoe (Journ. Linn. Soc., Zool., xxv (1896), p. 339).

A. RECIPROCAL MIMICRY OR DIAPOSEMATIC RESEMBLANCE.

In his researches on the Pierinæ (Trans. Ent. Soc., 1894, p. 249 *; "Rep. Brit. Assoc.," 1894, p. 692) Dr. Dixey,

* See especially pp. 296–298.

F.R.S., first came across facts which suggested to him that Müllerian mimicry was sometimes brought about by the mutual approach of two species. In later investigations he considered that he found further evidence pointing in the same direction (Trans. Ent. Soc., 1896, p. 65 *; 1897 p. 317 †). In the course of the discussion which followed the last paper (Proc. Ent. Soc., 1897, pp. xx–xxxii, xxxiv–xlvii) it was suggested by the present writer (Proc. Ent. Soc., 1897, p. xxix, note) that the new terms "Synaposematic Resemblance" or "Common Warning Colours" expressed Fritz Müller's principle better than "Müllerian Mimicry," and that similarly the terms "Diaposematic Resemblance" or "Diaposematism" were advantageous alternatives to "Reciprocal Mimicry."

Later on it appeared that Fritz Müller, in a brief paper unnoticed in this country, had himself clearly stated the hypothesis of mutual approach between two species. The paper which had here been looked upon as Müller's original statement of his hypothesis ‡ appeared in "Kosmos" (May, 1879), and was immediately translated and published in our Proceedings (1879, p. xx) by the late Prof. Meldola. But in the previous year Fritz Müller had published in Carus' "Zool. Anzeiger" (I, 1878, pp. 54, 55) a brief paper, which, after the lapse of nearly forty years, was noticed in England, translated by Mr. E. A. Elliot, and printed in our Proceedings (1915, pp. xxii, xxiii). The concluding sentence states "that in all probability in many cases . . . the question which of the two species is Model, and which is Mimic, is idle; each has reaped some advantage from being like the other; they may even have gone to meet each other."

In 1908 Dr. G. A. K. Marshall, F.R.S., in an able paper (Trans. Ent. Soc., 1908, p. 93) criticised the principle of Diaposematism, objecting to the interpretations offered in the special examples and also maintaining that the numerical considerations were opposed to the conclusions.

Dr. Marshall's paper was followed by a discussion (Proc. Ent. Soc., 1908, pp. xiv–xvii) and by Dr. Dixey's paper

* See especially pp. 72–76. † See especially pp. 327–329.

‡ The "actual existence of diaposematism" is foreshadowed in this paper, although not directly stated as in the earlier, unnoticed one. On this point see Dixey in Trans. Ent. Soc., 1908, p. 583. Also, add to the above-quoted papers by him—Rep. Brit. Assoc., 1907, p. 736, and "Nature," lxxvi (1907), p. 673.

in the Transactions for 1908 (p. 559), to which Dr. Marshall replied in the Proceedings of the same year (p. lxx) and 1909 (p. xx), the last-named paper being followed by a brief discussion (pp. xxi, xxii).

These references have been given because, after the lapse of nearly fifteen years, the subject is again raised by Mr. Simmonds' discoveries in Fiji. It was well, I think, that the controversy was allowed to rest for a time during which observations could be made and recorded. In the attempt to reconstruct the changing scenes of organic evolution we require immense masses of data, and although I believe that Mr. Simmonds' material from Fiji and some of the neighbouring islands is, for this purpose, more important than any hitherto collected, yet nearly every part of the following investigation left me longing for more and still more evidence from the islands of the Pacific.

So far as the numerical argument is concerned I fear that my very non-mathematical mind is inclined to look upon it much as some of my non-scientific friends, principally ladies, look on the conclusions of Science, viz. that the safest prediction is the one that anticipates the most improbable result. Knowing full well my own weakness I asked for the help of my kind friend Prof. H. H. Turner, F.R.S., who, after reading the numerical arguments on both sides, has written the Appendix to the present paper.

B. MR. HUBERT W. SIMMONDS' OBSERVATIONS IN FIJI, WITH THE ILLUSTRATIVE MATERIAL.

Mr. Simmonds first wrote, June 7, 1919, saying that Mr. Jepson had shown him a letter I had written, asking for numbers of Fijian Euploeas, and that he had suggested to him that he might collect some for me to study. This he had done and was sending a consignment. I wish to thank both these gentlemen for enabling me to work with excellent material on a problem which had haunted me ever since the arrival of the Euploeas from Prof. Gilson, just thirty years before.

The first set of specimens received was described and tabulated in our Proceedings for 1919 (pp. lxix–lxxi). The name *Nipara eleutho* Quoy, by which the species was then known in the British Museum, has been replaced in this memoir by *Euploea helcita eschscholtzi* (see pp. 580, 581). Mr. Simmonds' material at once showed that the female

proserpina was, in average specimens, a much better mimic of *eschscholtzi* than its male, thus following the rule for mimetic species in which the sexes differ.

Another important result which became clear was the fact that the Fijian Danaine, *D.* (*T.*) *melissa neptunia* Feld. is a mimic of the Euploeas, Mr. Simmonds stating in his first letter that it "flies with the Euploeas and is very difficult to distinguish when on the wing" (*ibid.*, p. lxx).

In the following year Mr. Simmonds sent a most interesting series of *Hypolimnas bolina* from the Cook and Society Is., and Euploeas (*E. helcita walkeri* H. H. Druce) from the latter (Proceedings, 1920, pp. lxxii–lxxv). In the same year he also sent a further set of the two Euploeas and the Danaine, not only from various localities in the Fijian main island Viti Levu, but also from Ovalau and Moturiki (*ibid.*, pp. lxxx–lxxxiii). The rest of the splendid material, except for a brief account of the families of *H. bolina* bred from known female parents (*ibid.*, 1923, pp. ix–xii), has been reserved for the present paper.

When specimens began to arrive from the far eastern part of the Fijian group and from the outlying islands, such as Kandavu in the south, the extraordinary interest of Fiji as a whole became obvious to both of us; for Mr. Simmonds, in his letters, more than once pointed out that the dark Euploeas—almost or entirely patternless—were the same species as those with a pronounced white marginal pattern in the well-known islands of west Fiji.

I was naturally most anxious to study more and ever more specimens from the less-known islands, but the following extracts from Mr. Simmonds' letters will show what he went through and also the reasons why more could not be done.

November 29, 1921.—"Travel here is not too good; it is often in 15- or 20-ton cutters with no sanitary arrangements and no cabins, and Hindus, Chinese, Fijians and Whites all huddled up together, so that one naturally waits until an occasional better opportunity offers unless it becomes necessary to go on duty."

February 3, 1922.—"They have now taken off our little inter-island mail steamer. This means travel by cutters more than ever."

March 24, 1922.—"This country is most difficult to work, as there are no hotels outside the capitals, and one is dependent upon the hospitality of natives and settlers

when travelling : also for boys to carry one's baggage, and this latter is most difficult." Then, owing to the loss of the steamer, " one has to depend upon chance cutters to get from island to island. The only other way would be to make a serious expedition with a boy and take tents and all camping materials. "

Again on November 5, 1922, he spoke of the difficulty of communication between the islands, and especially of reaching the outlying parts of the group.

Another disheartening thing about collecting in Fiji is the growing scarcity of butterflies in the well-known islands. At first Mr. Simmonds put this down to the big *Polistes* wasp introduced into Fiji a few years before he came there. Thus, he contrasts the collecting on the eastern islands Thithia and Vanua Balavu with that on Viti Levu :—

September 10, 1921.—" I have had a most interesting and exciting trip round the group. We visited several islands where there are no mynahs or hornets and found butterflies in abundance."

November 29, 1921.—" You have no idea how scarce butterflies are on Viti Levu, and I can only blame the introduced hornets. These latter are spreading steadily over the group.

" Round Suva one can go all day and, except *Xois sesara* or *Terias* sp., not see a butterfly."

Later on Mr. Simmonds came to doubt whether the *Polistes* was responsible. Thus, on February 3, 1922, after referring to barren days in the Upper and Lower Rewa River districts (Viti Levu), he wrote : " Butterflies seem to have become even scarcer since I came here three years ago. I do not know why. I once thought it was hornets, but they are growing scarcer now, and I think that it must be the small ants, which simply swarm."

March 24, 1922.—" I do not know what has destroyed the butterflies in Fiji, but all agree here that they were much more abundant formerly. It may be ants, I can think of nothing else except mynahs."

April 10, 1922.—" *H. bolina*, scarce three years ago on Viti Levu, is now almost non-existent. I do not think I have seen a dozen in the past six months, and it seems the same with other species. People tell me also that there were formerly far more about, even in Taveuni, where *bolina* is still in great numbers. I do not suppose they were ever so abundant in the wet areas, and last year was

exceptionally wet, as also has this been so far (nearly 80 inches in 3½ months). This may account for it. Hornets, which I formerly suspected, are undoubtedly growing fewer."

It is difficult to believe that the weather is responsible when Mr. Simmonds found the eastern islands still prolific, and we are driven to the depressing conclusion that man is responsible, either directly by the enemies he has consciously introduced, or, indirectly, by those which have followed in his wake. If this be so, we are probably witnessing a permanent change, or at any rate one that will endure for a long period, and therefore Mr. Simmonds's notes on the subject may have a historic interest which justifies the addition of the following to those which have been already quoted :—

December 16, 1922.—"So far as Suva is concerned collecting grows rapidly poorer, and it is very seldom now that I even see a specimen of *H. bolina*. Many other (in fact, most other) portions of Viti Levu are equally poor."

May 5, 1923.—"I have only seen one *H. bolina* here [nr. Suva], which I captured. . . . This gives an idea of how rare this species, formerly so abundant, has become. They tell me that they are growing scarcer on the other islands. . . .

"A walk of 10 miles in bright sunshine only showed 3 *neptunia* seen, 2 Euploeas, a few *Xois sesara* and *Zizera labradus* (?), and possibly another *H. bolina* or it may have been a *Euploea* flew past.

"I visited Moturiki and saw 2 or 3 ♀ *bolina* and brought back a large one of the Queensland type. Unfortunately it proved to be empty. This will give you a good idea of how disheartening it is trying to collect here. One goes miles and never sees a specimen."

May 23, 1923.—"The weather has been good, but I have not seen a single *H. bolina* since I last wrote."

These extracts from letters written during the past four years suggest something of the difficulties and disappointments endured by Mr. Simmonds. How much he has achieved in spite of them will, I hope, appear in the course of the present memoir. It is a great pleasure to thank him for helping me to realise a dream nearly a quarter of a century old.

C. COLLECTIONS STUDIED AND HELP RECEIVED.

I have also received much kind assistance from many scientific friends in this country and I wish to express my grateful thanks for all they have done—to Capt. N. D. Riley, for much help in the course of my work in the British Museum of Natural History, and to Mr. H. T. G. Watkins, in the work on *Hypolimnas bolina* in the same Museum; to Lord Rothschild, F.R.S., for freely lending material from the Tring Museum, and Mr. J. J. Joicey, F.L.S., that of the Hill Museum at Witley; to Dr. Karl Jordan, Ph.D., of Tring, and Mr. George Talbot, of Witley, for much assistance and advice in the systematic side of my subject; to the Royal Geographical Society, and especially to Dr. A. R. Hinks, F.R.S., for help on its geographical side.

To Commander J. J. Walker, M.A., F.L.S., and Paymaster in-Chief Gervase F. Mathew, who have such intimate and profound knowledge of the Pacific, I owe a deep debt of gratitude. Both have given me the benefit of records made forty years ago and of their memories. Commander Walker has also presented to the Hope Department his splendid collection of Danainae and of *Hypolimnas bolina* from the Pacific, and this, together with the fine collection recently presented to the Department by Rear-Admiral Edmund Bourke, has been of immense help in studying the Fijian problems.

Among the older specimens in the University Collection special mention must be made of duplicates presented by the late Dr. F. D. Godman, D.C.L., F.R.S., and Osbert Salvin, M.A., F.R.S. These include many specimens collected in Fiji by C. M. Woodford—all with excellent data. When it is remembered that in collections generally, the word "Fiji" is all that appears on the great majority of insects from this group of islands—on *all* the butterflies from these islands in the Adams and Crowley Collections in the British Museum—it will be realised that specimens from Fiji taken by Woodford, or from other parts of the Pacific by Commander Walker, are of the utmost value to one who desires to study the associations, invasions and local races in this part of the world.

In the Hope Department Dr. Eltringham, D.Sc., has, as on so many previous occasions, given me the kindest help, and I have depended upon his microscopic examination of structure to decide doubtful points of affinity.

The skilful assistance of Mr. A. H. Hamm and Mr. J. Collins, in preparing, labelling, and arranging the specimens for study and for photographing have been essential for carrying on this piece of work, and I wish to express my warm thanks to them, as also to Mr. Alfred Robinson for his care and skill in taking the photographs for all the uncoloured plates. I am very grateful to Miss O. Tassart for the great pains and interest she has taken in painting the families of *H. bolina* for the coloured plates. It was, I am aware, a great labour, but I hope that she will feel in some measure repaid by the beauty and success of the reproductions.

The possibility of obtaining a coloured plate illustrating the life-history of the Fijian *bolina* I owe to the kindness of Mr. G. F. Mathew in lending me the painting he prepared when visiting the islands in the early 'eighties of last century. I am glad to know that he is pleased with the result.

A paper of this kind which attempts to show the evolution of a pattern and in many cases the first steps which have led to its development, would be of little value without abundant illustration. And when we are trying to trace its gradual change as we pass from one island to another at no great distance, and to judge in each island of the effect produced by members of an association upon one another, it is of the utmost importance to be able to represent not selected individuals but a whole series taken at a particular time. And finally when at length a naturalist on the spot has bred from known female parents the astonishingly different female forms of the Fijian *Hypolimnas bolina*, nearly all of them described as distinct species, the full effect of this admirable investigation cannot be produced without coloured plates, showing the female parent, when possible, and an example of each female form present in her offspring.

That the Entomological Society has been enabled to publish this memoir upon organic evolution, with all these advantages, is owing to the Fund for Promoting the Study of Evolution presented to the University of Oxford by my friend Prof. James Mark Baldwin.

D. FIJI, THE GATEWAY INTO POLYNESIA.

The butterfly fauna of Polynesia includes no American species except that recent intruder *D. plexippus* which is apparently about to occupy every tropical land which

supports its food-plant. Nothing need be said of this butterfly here, as it has been so fully dealt with by Commander Walker (Ent. Mo. Mag., Vol. xxii, p. 217; l, pp. 181, 224).

The Old World affinity of the indigenous species is easily accounted for when we look, first at the wide expanse of ocean separating Eastern Polynesia from the American coast, and then at the Western Pacific and the distribution of its island groups. Innumerable stepping-stones are scattered over the track by which an entrance was effected from the nearest islands, and by which these became populated. From the east end of New Guinea the track runs north and then eastward, through New Britain and New Ireland and the small groups to the south of them, to the Solomons, and through these south-east, by way of the Sta. Cruz and Torres Islands, to the Banks Islands and New Hebrides—a huge mass of scattered islands lying due west of Fiji and stretching far to the north and south of it. Its importance is much increased by the Loyalties and New Caledonia, near at hand to the west of its southern extremity. I propose to speak of this mass as the Island Screen of the West. There can be no doubt that it was from this great multitude of islands, mostly small but rich in Austro-Malayan species, that Fiji received its butterfly fauna, and became the gateway through which Polynesia was invaded. Fiji itself cannot be regarded as oceanic, but rather as an outlying part of the Island Screen. When it is fully explored it will probably be found to support more than forty species of butterflies, a number far greater than that of any other Polynesian group.

In a study of the few Euploeas and Danaines of Polynesia and Fiji, and of their relationship to the species of the great Screen of Islands to the West, we shall find evidence of successive waves of invasion, and shall be able to infer something of the course of evolution in the areas from which the invaders came. It is, of course, very late evolution—just the last page or two of the last volume of the boundless library in which is written the history of organic change.

The conditions of life in the oceanic islands of the Pacific are not such as to lead to the preservation of ancient forms of life. The limited area and relative simplicity of the web of organic interdependence both tend to ensure the extermination of a species when unfavourable conditions arise. And these dangers are so greatly intensified in the

maximum simplicity of the low-lying coral islands and atolls that their butterfly fauna, with the exception of *Hypolimnas bolina*, is unlikely to throw much light on the problems considered in this paper. It is only from the oceanic groups which include islands with high volcanic peaks, or at least coral raised to 200 ft. or more, that illuminating material is to be expected. Such groups are the Samoan, the Friendlies (Tongatabu, etc.), Cook (Rarotonga, etc.), and Societies (Tahiti, Eimeo or Moorea, etc.). The low flat islands of the Ellice Group are important exceptions, yielding two forms of *Euploea helcita* (p. 583).

The great need for the investigation of these problems is abundant material with full and accurate data, and it is to be hoped that this memoir in which I have done my best with means, except in Fiji, wholly insufficient, will direct the attention of collectors to the want, and lead to its supply.

E. THE EUPLOEINE AND DANAINE INVASION OF FIJI AND POLYNESIA.

It will now be necessary to consider each indigenous species or island race of Euploeas and Danaines, and attempt to reconstruct its history in the immediate past—we cannot expect to reach farther back than that. In my opinion the evidence points to the conclusion that, either by replacement of species or by changes in species, the patterns of certain butterflies have been gradually reduced in the great Island Screen of the West, and that, as successive waves of invasion have proceeded eastward, some of them have carried and preserved in fresh islands the patterns which later on dwindled in the original home.

I. The Races of Euploea helcita helcita Boisd.

This butterfly is by far the most wide-ranging *Euploea* of the Pacific, its races, according to our present knowledge, extending from New Caledonia to the Society Islands. It was until recently given the name *eleutho* Quoy, in the British Museum Collection, and this determination was followed in Proc. Ent. Soc., 1919, p. lxix; 1920, p. lxxx; and Trans. Ent. Soc., 1908, p. 603. The history of the mistake has been recently published by Mr. G. Talbot in Bull. Hill Mus., vol. i, No. 1, p. 26 (1921). The species in New Caledonia and Navigators' Islands is

also correctly given as *helcita* by Moore (P. Z. S., 1883, p. 258), but erroneously as *eleutho*, in Samoa and the Ellice Is. (p. 272).

After comparing the material from the British, Tring, Hill (Witley), and Oxford Museums, I believe that the following island subspecies can be distinguished, following the principles so well and truly established by the work at Tring.

(a) *Euploea helcita helcita Boisd., of New Caledonia.*—Very close to the succeeding, but distinguished by the smaller spots of the two rows in the hind-wing, and the fact that the inner or sub-marginal row is shorter towards the anal angle; also, more obviously, by the much greater size of the principal spot of the fore-wing. The expanse of a specimen of average size is about 65·0 mm.

(b) *Euploea helcita lilybaea Fruh., of the New Hebrides.*— Very close to *helcita* and also to the succeeding species. I believe that a sufficient series would show that *lilybaea* is rather smaller than *helcita*, probably about 62·0 mm. on the average.

I have retained Fruhstorfer's name, but the description (Seitz, vol. ix, p. 276) of *lilybaea* does not correspond with any specimen I have seen from the New Hebrides. He describes it as transitional between *eschscholtzi* and *aglaina* —a nearly black form from Tutuila (Samoa) figured on by him, Pl. 86 A. But the New Hebridean species is very close to *helcita* on the one hand and to *eschscholtzi* on the other, and the position he gives to it raises a doubt as to whether he had before him some aberration or a specimen with misplaced label. He gives the locality as Tanna, New Hebrides.

(c) *Euploea helcita eschscholtzi Feld., of the Western Fijian Islands.*—The principal spot of the fore-wing longer and narrower than in *lilybaea*, and the spots of the hind-wing on the average rather more developed. Average expanse about 67·0 mm.

Many examples are figured in this memoir. See Pl. XXX, figs. 1, 2, and the race represented in these two figs. on Pls. XXXII–XXXIV, and XXXVI–XXXIX.

(d) *Euploea helcita walkeri H. H. Druce, widespread in Polynesia.*—I include under this subspecies all the Poly-

nesian *helcita* except those from the Samoan group and the Friendly Islands. I place under *walkeri* the *helcita* from the Societies, Cook Islands, Ellice Islands, Niue or Savage Island (an eastern outlier of the Friendlies), Fotuna, and Wallis Island; also from Eastern Fiji. *Walkeri* was originally described from Tahiti, and the type is in the Hill Museum. Fruhstorfer, not knowing that it had been already described, renamed it *matilica* in Seitz (ix, p. 276), as indicated by Talbot (*ibid.*, p. 29). It is a satisfaction that it should retain the name of an ex-President of our Society, Commander Walker, who has studied the Pacific so thoroughly, and generously helped the work of many naturalists with his admirably collected specimens.

E. helcita walkeri is an extraordinary butterfly, varying immensely in the different parts of its range. The typical form differs from the races of *helcita* hitherto mentioned, in the much greater size of the submarginal spots of the hind-wing. It is also rather larger, averaging about 69·0 mm. A series of 19 from Tahiti and 3 from Eimeo (Moorea) collected by Mr. Simmonds in 1920 are very constant, resembling the type from Tahiti. It also appears to be fairly constant and of the typical form on Fotuna I., as shown on Pl. XLII, figs. 13–19; but the size of the inner spots of the hind-wing are seen in figs. 13, 14, and 19 to be transitional towards *eschscholtzi*.

In other parts of the range we find extraordinary departures from the typical form in the direction of loss of pattern, many of the steps, leading finally to a patternless black butterfly, having received names. In the following order the progressive loss of pattern is from above downwards :—

1. *E. helcita walkeri* H. H. Druce—Tahiti, etc. Bull. Hill Mus., i, 1921, Pl. IV, B, fig. 2. Type ♂ in Hill Mus.
2. *E. helcita intermedia* Moore—Rarotonga (Cook Is.). Types ♂ ♀ in B.M.
3. *E. helcita distincta* Butl.—Ellice Is., Wallis I. Types ♂ ♀ (no locality), B.M.
4. *E. helcita perryi* Butl.—Niue or Savage I. P. Z. S., 1874, Pl. XLIV, fig. 1. Type ♂ in B.M.
5. *E. helcita indistincta* Moore—Rarotonga. Bull. Hill Mus., i, 1921, Pl. IV, B, fig. 3. Type ♂ in B.M.
6. *E. helcita unicolor* H. H. Druce *—Aitutaki (Cook Is.)

* A male from Aitutaki, figured in Bull. Hill Mus., i, 1921, Pl. IV, B, fig. 4, and referred to in Ent. Mo. Mag., Dec. 1890,

Bull. Hill Mus., i, 1921, Pl. IV, B, fig. 4. Type ♀ in Hill Mus.

There is a difference between the fore- and hind-wing markings which complicates the above order. No. 3 has a more reduced hind-wing, but stronger fore-wing pattern than No. 2.

If we were sure that each of these six steps in a graduated series was fairly constant in its locality then they would stand as geographical races, but it has not been proved for any of them. The most probable instance is the set of specimens shown on Pl. XLII, figs. 8–12. These were all taken together in Wallis I. by Mr. Simmonds (p. 629), and it is not unlikely that they represent a local race which seems to be *distincta*. But it will be noticed that Nos. 2, 5, and 6 are from the Cook Islands where *helcita* is extraordinarily variable, and it is probable that a long series would include examples of all the steps 1–6 and smaller steps between them. As a matter of fact a male from Aitutaki, very like No. 4, exists in the British Museum. Large collections of *helcita* from all the islands of this group would be of intense interest.

Furthermore, the two males and two females of No. 3 in the British Museum are accompanied by a female *helcita walkeri* (Rev. J. S. Whitmee), so that, unless there is an error in the labelling, *distincta* is not a local race in the Ellice Is. but a form of *walkeri*. In this, as in nearly all the islands, a long series, showing the extent of variation and the proportions of the different forms, is required.

The type of No. 4, *perryi*, is the only specimen from Savage I., and this, in such a species as *helcita*, tells us very little.

The E. Fijian *helcita* is, I think, best placed under *walkeri*, although its hind-wing pattern is often that of *eschscholtzi*. It is much the largest of the *helcita* group, an average specimen from Vanua Balavu being about 79·0 mm. in expanse, from Thithia about 76·0, Mango about 75·0. I need not describe it, as all the specimens received from Mr. Simmonds are represented very clearly

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p. 320, is even more unicolorous than *unicolor*—the female type. Both specimens, with Nos. 2 and 5 in the above list, were captured by Commander Walker in the Cook Islands (Rarotonga, Apr. 28; Aitutaki, May 1, 1883; Ent. Mo. Mag., 1883–4, pp. 95, 96). The type of No. 1 was also captured by him in Tahiti. The spots in the hind-wing of the figured example of No. 1 are unusually small.

on Pls. XXXI, figs. 1, 2; XXXIX, fig. 10; XL, figs. 9–13, 15; XLI, figs. 12–15. Some account of the specimens will be found under the three islands mentioned above. I think it will be clear that when figs. 1 and 2 on Pl. XXX, viz. the male and female of *eschscholtzi* from western Fiji, are compared with figs. 1 and 2 on Pl. XXXI, viz. a male and female from Vanua Balavu in eastern Fiji, the latter represent a larger, coarser-looking butterfly, and that, although the hind-wing spots are reduced nearly to the size of *eschscholtzi*, the true affinity is with the examples with much larger spots from the same island, represented on Pl. XLI, figs. 13, 14. Figs 12 and 15 on the same plate represent the same specimens as those shown on Pl. XXXI, figs. 1 and 2. The reduction of pattern in the fore-wing of some of these east Fijian *walkeri* is clearly shown in the plates.

Dr. Eltringham has kindly examined the male armature of the following specimens of *helcita* and finds nothing to indicate specific difference :—

The *eschscholtzi* from Vanua Levu, W. Fiji, represented on Pl. XXXIV, fig. 1.

The *walkeri* from Fotuna I., represented on Pl. XLII, fig. 15.

The *walkeri*, f. *distincta*, from Wallis I., shown on Pl. XLII, fig. 10.

4. The *walkeri*, large E. Fijian form, from Vanua Balavu, shown on Pl. XLI, fig. 13.

We finally reach the forms of *helcita* found in the Samoan group and the Friendlies, and I was much surprised to find that they form two closely related races which are quite distinct from all others in Polynesia. So far as I am aware they have not before been recognised as distinct, and it is therefore necessary briefly to describe them.

All the forms of *helcita* hitherto described are butterflies of so dark a shade of brown that they would be called black by most observers. The Samoan and Tongan races are, even when quite fresh, distinctly brown, and not a very dark brown. The hind-wing under surface of the former set is also very dark, although in some races overspread in parts with a bluish-grey giving a bluish or purplish shade to the ground-colour, but not of sufficient strength or brightness to relieve the impression of darkness. In

others, again, the dark surface is overspread with, but not much brightened by, a bronzy-brown shade. In the Samoan and Tongan races the under surface is far less dark, and presents a strong contrast to those just described. This is due both to far paler brown ground and the strength of the overspreading grey, or bluish- or purplish-grey, extending from the anal angle to the base of the hind-wing, and inwards to the cell which is partially, or generally wholly, invaded. In some specimens from Tonga the effect is so pale that the contrast between background and light spots is largely obliterated, and the butterfly has a faded or washed-out appearance. In all specimens from both island groups the contrast is naturally very much less than in the other forms of *helcita*. The upper surface pattern is that of typical *walkeri*, except that the large spots of the inner series on the hind-wing are distinctly larger. The pattern is, in fact, the farthest development reached by any known form of *helcita*.

When these differences were first noticed in a good series from the Tongan and Samoan groups they seemed so remarkable that I thought that perhaps the specimens had been exposed to light and were faded. But a Hill Museum specimen and two in the Hope Department were consistent with those from Tring and dispelled this suspicion.

There are small but nearly constant differences between the Samoan and Tongan subspecies, the latter representing the stronger development of pattern.

It has been a pleasure to associate these interesting races with the names of Rear-Admiral Edmund Bourke and Paymaster-in-Chief Gervase F. Mathew, whose specimens have been before me as the descriptions were written.

(e) *Euploea helcita bourkei n. s.-sp., of the Samoan Islands.* —As compared with the succeeding race, the three large double spots of the inner series of the hind-wing in areas 1*c*, 2 and 3 (that in 1*c* being often actually divided into two) are not quite so large, and there is a more sudden break in size between them and the small spots, owing to the relatively small size of the one in area 4. In the fore-wing the two chief spots are smaller. The brown shade of the ground-colour on the upper surface is a little paler. On the under surface of the hind-wing the grey colour is more distinctly bluish or purplish and does not extend so

far towards the outer margin or so greatly diminish the contrast with the white pattern, which has therefore a less faded appearance than in *mathewi*. The expanse of an average specimen is about 67·0 mm.

Habitat: Samoan Islands.

♂ Type, in Hope Department, Oxford University Museum. One of three males collected at Apia and Tutuila by Admiral Bourke in November and December 1892.

♀ Type, in Tring Museum. One of a series (3 ♂, 4 ♀) taken by Mr. G. F. Mathew at Apia and Pango Pango, June 19–29, 1884. All bear his number "998."* One male in the Hill Museum was also taken into consideration in the above account.

"998" — all from Pango Pango, 25-29. VI. 1884. C. G. F. M., 30. IV. 1925.

It is to be noted that the form of *helcita* described by Fruhstorfer from Tutuila, Samoa (Seitz, ix, p. 235, pl. 86 A) and named by him *aglaina* has nothing to do with the Samoan subspecies *bourkei*. The figure suggests that it may be a female of *Euploea schmeltzii*, or, if it belongs to *helcita*, a dark form of *walkeri* near *indistincta* (p. 582). This latter interpretation is supported by a specimen in the British Museum—a male *walkeri*, with the hind-wing pattern of *eschscholtzi*, from Navigators' Islands * (Samoan group).

See also for this and the next subspecies, Mr. G. F. Mathew's notes on pp. 606, 607.

(f) *Euploea helcita mathewi n. s.-sp., of the Tongan Group (Friendlies).*—The characters of the Tongan race have already been given in the general account preceding the last subspecies. It is rather larger than *bourkei*, the expanse of an average specimen being about 70·0 mm.

Habitat: Tongatabu, Vavau, and Hapaii, and probably other islands of the Friendly Group.

* The possibility of erroneous labelling in "*aglaina*" and the specimen from Navigators' Islands must be taken into account. It is especially likely to occur in the collections from small thickly clustered islands, when many are visited. The British Museum specimen was received at an unknown date before the Register was started. Fruhstorfer's account of *helcita helcita* is incomprehensible to any one familiar with the New Caledonian race. He says (*ibid.*, p. 235) that it "seems to approximate very nearly to the figured *aglaina*," represented by him (pl. 86 A) as a nearly patternless form, and again, speaking of *aglaina*, that it differs from *helcita* in being *more* spotted. Yet *helcita* is, in the fore-wing, the most strongly patterned of all the races except those from Samoa and Tonga!

♂ Type, in Tring Museum. One of a series (7 ♂, 3 ♀) taken by Mr. G. F. Mathew in July 1884. For his notes on the abundance of the subspecies and its occurrence on Tongatabu (at Nukualofa) and Vavau, see p. 607.

♀ Type, in Hope Department, Oxford University Museum. One of two females taken at Hapaii (Friendlies) by Mr. W. H. Legge in August 1895.

A characteristic male, labelled Tonga, and (in error) "J. J. Walker, 1. vii. 1889," from the Hill Museum, was also before me. It is represented as "*walkeri*" in Bull. Hill Mus., i, 1921, Pl. IV, B, fig. 1, and a Tonga female on Pl. III, B, fig. 5, also as "*walkeri*."

(g) *The Invasion of Fiji and Polynesia by the Races of Euploea helcita.*—It is probable that the most highly patterned races, *bourkei* and *mathewi*, came in the earliest wave of invasion and that they represent a more fully developed pattern in the islands to the west from which they started. There is in the Hope Department a male specimen collected by Mr. W. H. Legge and labelled "Thursday Island, Torres Straits, 1896," but it so closely resembles the above two specimens from Hapaii in the Tonga group collected by the same naturalist that an error in the labelling seems probable. All three specimens were presented to the University Collection by the late Mr. R. S. Standen in 1906. But, if this specimen be dismissed, it is quite likely that others throwing light on the parent race from which the invaders came will be discovered in some locality far to the west or north-west of Fiji. The Tongan race with a slightly more developed pattern probably represents the original invader more nearly than the Samoan. It will be observed (pp. 608, 609) that the earliest invaders among the Danaine races of *melissa*, also more strongly patterned than their western representatives, are now found in the same two island groups, but in their case the Samoan form is probably the nearer of the two to the original invader.

E. helcita walkeri was probably next in order, and certainly earlier than *eschscholtzi*, which has not advanced beyond western Fiji. *Walkeri* represents a rather less-developed pattern and a much darker ground-colour on both upper and under surfaces. Where it has met with a dark patternless *Euploea* (*E. boisduvalii simmondsi*), as in Wallis I., and eastern Fiji it has, as will be shown, tended to lose

its pattern and by reciprocal mimicry the dark *Euploea* has, in varying degrees and in a varying proportion of specimens, advanced to meet it. In some other islands (Societies and Fotuna), where it is the only known *Euploea*, it retains the typical form; in others (Cook and Ellice Is.), it has lost its pattern to a varying extent, reaching the maximum reduction in the black *unicolor* of the Cook Islands. In my opinion, the most probable hypothesis is that in all the groups where it has reduced or lost its pattern, dark Euploeas exist or have recently existed; and it may well be possible to find them in some of the remote islands even if they have disappeared from others. That the change is recent is shown by the number of transitional forms, even in the Cook Islands, where the loss of pattern is carried furthest.

It is also in favour of the opinion that a dark *Euploea*, probably a form of *boisduvalii simmondsi* (p. 591), is present in the islands and has there acted as a model for *walkeri*, as it has in Wallis I. (p. 629), that Commander Walker took in Rarotonga on April 28, 1883, specimens of *Hypolimnas antilope*, a Nymphaline mimic of dark Euploeas of the *simmondsi* type. This form had been described by Godman as *H. unicolor* from New Ireland, but the male and female presented to the Hope Department resemble the darker male and the two females of *antilope* from Vanua Balavu, where their model *simmondsi* also occurs. The Commander did wonders in a single day at Aitutaki and another at Rarotonga, but the whole of the butterfly fauna cannot be exhausted in so short a time, not even by a naturalist as keen and observant as he is.

Another and a tempting explanation of the *walkeri* race is to suppose that it has resulted from interbreeding between the first invaders and the most recent, *eschscholtzi* —the former strengthening the pattern, the latter conferring the dark ground-colour of both surfaces. It would be an interesting experiment to attempt this cross, using the west Fijian and the Samoan or Tongan races. It would be difficult because of the habits in courtship, including the use of the scent-brushes by the male, but success should be attainable by the construction of a large chamber in which natural conditions could be reproduced. The great variation in size as well as pattern and the ease with which *walkeri* gains the *eschscholtzi* hind-wing

pattern in eastern Fiji are points which seem to support this suggestion, but I am inclined to think it is less probable than the hypothesis of a separate invasion.

The interpretation of the West Fijian form *eschscholtzi* as the result of the last and very recent invasion is obvious. It closely resembles the two races in the Island Screen of the West, and the little difference between them is of the usual kind, the retention by the invader of a slightly increased pattern. It will be shown on p. 612 that, in the long series of *eschscholtzi*, three specimens only, and of these each in a different West Fijian island, exhibited more or less closely the hind-wing pattern of *walkeri*. This is in striking contrast with the high proportion of East Fijian *walkeri* gaining the hind-wing pattern of *eschscholtzi*, but there is the disturbing effect of the dark *Euploea simmondsi* and two other members of the association to be taken into account in the east, for their presence may provide the explanation of the reduced pattern in the hind-wing of many examples of *walkeri*, as it, I believe, certainly accounts for the clouding over of the principal mark on the fore-wing.

The three exceptions in the west may be lingering traces of *walkeri* which have not been quite obliterated by the last invasion, or they may be the result of interbreeding with an occasional migrant from East Fiji. Their distribution in the islands is rather unfavourable to the latter view.

I must here repeat what has often been said in this memoir, that the great need is more material with full data, from as many islands as possible. With this aid I have hopes that we may be able to decide between these and other speculations, or replace them all by sounder ones.

II. Euploea boisduvalii boisduvalii Luc., and its Races in Western and Eastern Fiji (including Wallis Island).

The West Fijian race of this species, long known as *Euploea* (*Deragena* of Moore) *proserpina* Butl., is included by Fruhstorfer (*ibid.*, p. 241) under *eleutho* Quoy, a very doubtful arrangement. It is safer, until more is known about their structure, to consider these two forms distinct species, as Mr. Talbot has done (*ibid.*, p. 29). Mr. Talbot has also explained (*l.c.*) why *boisduvalii* becomes

the name of the species. In 1853 Lucas published a description, under this name, of a single male *Euploea*, labelled "Australia." Examination of this specimen in the Paris Museum proved that it was an aberration of the common Western Fijian *Euploea* named *proserpina* by Butler in 1866. The aberration must be very rare, for it has not been met with in the large amount of material studied in the preparation of this memoir. There is, however, in the British Museum an interesting female (Coll. Hewitson) in which the shape of the principal white mark on the male fore-wing is made up to the size of the larger female mark by a white extension clouded over like the whole pattern of *boisduvalii*. In making out the true synonymy of this form and also *helcita* (p. 580) Mr. Talbot states that he received help from M. F. le Cerf of the Paris Museum, to whom I also wish to express my thanks.

It is probable that *boisduvalii proserpina* is the West Fijian race of a species which includes two or three subspecies in the Island Screen of the West, and others far beyond it to the north-west. It may well happen, when the affinities of all these are made out, that *boisduvalii*, as the oldest name, will stand for the whole group. It is the rule of the game, and we must not grumble while the rule remains, but there is irony in the fact that its acceptance in this case involves the subordination of names founded on the description of adequate material with trustworthy data in favour of one founded on an aberration hitherto unique and provided with a false locality!

The object of this memoir is not systematic, but we must know where we stand with the species whose associations and invasions are studied, and therefore the systematic aspect of the subject has been considered in the first place. But, having considered it in the preceding paragraphs, I do not propose, on the present occasion, to follow it to the bitter end, and sink altogether the well-known name *proserpina*, but intend to speak of the commonest and best-known Fijian *Euploea*, not as *boisduvalii boisduvalii*, but as given below.

(a) *Euploea boisduvalii proserpina Butl., of West Fiji.*—The appearance of this subspecies with its conspicuous white marginal pattern is illustrated, first, in Pl. XXX. fig. 3 (male), and fig. 4 (female), and then abundantly in

figures, which will at once be recognised, on Plates XXXII–XXXIV, XXXVI–XXXVIII, and XLIV. In these plates the pattern of *proserpina* from the two chief islands of Fiji, and from some of the smaller islands near them, is clearly shown. It varies greatly but not locally, so far as we know, in this part of the group (see Map, Pl. XXIX). There are, however, two exceptions—the very large specimen with a greatly reduced pattern shown on Pl. XXXVI, fig. 7. This butterfly was taken in Taveuni which lies to the south-east of Vanua Levu and is the nearest of the western islands to East Fiji where the pattern is still further reduced and sometimes wanting. Furthermore, in the southern island of Kandavu, a rather remote outlier of West Fiji, the single specimen taken (Pl. XXXIX, fig. 5) has a pattern more reduced than that just referred to from Taveuni. These transitional forms lead naturally to the second subspecies.

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(b) *Euploea boisduvalii simmondsi n. s.-sp., of Eastern Fiji and Wallis Island.*—The discovery of this most interesting race is entirely due to Mr. H. W. Simmonds. A detailed description is unnecessary. It is sufficient to point out that it differs from *proserpina* in the complete or nearly complete absence of pattern on the upper surface. The whole of the material is figured—three males from Vanua Balavu, on Pl. XLI, figs. 1–3; one male and another transitional to *proserpina*, from Thithia, on Pl. XL, figs. 1 and 2, respectively; two males and five females from Wallis Island (between Fiji and Samoa), on Pl. XLII, figs. 1–7. The individual differences to be observed in this series will be considered under the next heading.

Types: in the Hope Department, Oxford University Museum. From Wallis Island. Male, represented on Pl. XLII, fig. 2; female—fig. 4.

Comparison with Pls. XL and XLI will show that the males generally exhibit a trace of pattern, while Pl. XLII proves that the majority of the five females are patternless. Therefore one of the latter and a male with a slight pattern have been selected as types.

The dyslegnic female pattern is very clearly seen in Pl. XLII, figs. 6 and 7, and also the fact that the female varies more than the male, fig. 7 showing a more advanced pattern than any other example of *simmondsi* from East Fiji or Wallis I. More specimens are greatly needed,

* Synonym of mangoensis, Butl. (Proc. Ent. Soc. Lond., 1925, p. xvii).

especially females from East Fiji and long series of both sexes to show the amount of variation.

mangoensis (c) *The Invasion of Fiji and Wallis Island by Euploea boisduvalii simmondsi, and the Changes it has undergone in the new Home.*—It will be remembered that it was the obviously mimetic modification in the principal spot in the fore-wing of *proserpina* that first directed my attention, in 1899, to the study of mimicry in Fiji (p. 566). The subject was untouched at the time, for no examples of mimicry from these islands are mentioned by Moore. Having concluded that the pattern of *proserpina* was a recent development in mimicry of *E. helcita* it was most inspiring to receive from Mr. Simmonds the evidence that a parent subspecies with only a trace of a pattern or with none at all exists in East Fiji—and not only this, but transitional forms bridging the gap between the two races. But if *simmondsi* be the ancestral form in Fiji, from what land did it come?

There are in the Western Island Screen three dark, patternless Euploeas diminishing in size from north to south. All three have on the male fore-wing a single brand much like that of *simmondsi*. The largest, *Euploea fraudulenta* Butl., is common in the Solomons, but spreads southward into the Torres Islands, where Commander Walker captured several specimens. To the south, in the New Hebrides, it is replaced by *E. paykullei* Butl., a much smaller species with narrower wings, dark brown in the male, much paler in the female. In both sexes the border of both wings is much lighter in tint, giving the butterfly a very characteristic appearance. It is very abundant, and I have had the opportunity of studying in Oxford a series of sixty-seven nearly all taken by Commander Walker and Mr. J. R. Baker. Finally, in the Loyalty Islands, lying west of the extreme south of the New Hebrides, *paykullei* is replaced by a species with broader wings, slightly less in expanse—*E. torvina* Butl. Its brand is somewhat smaller, and both it and *fraudulenta* differ from *paykullei* in the possession of variable traces of a marginal and submarginal white pattern on the under surface, in *torvina* sometimes upon the upper surface also.*

* The names *paykullei* and *torvina* are here employed in their usual acceptation; but an examination of the types in the British Museum shows that the use is incorrect. The type of *torvina* is a male from Aneiteum, of *paykullei* a female from the same island.

In *fraudulenta* this under surface pattern becomes stronger to the north in the Solomon Islands.

All three races enter into Müllerian association with others in their respective localities, the two northern and far more abundant Euploeas undoubtedly taking the central position. One other member of each of the two northern associations will be mentioned in later pages.

As to the affinity of these forms to each other and to the two races of the Fijian *boisduvalii*, Moore, who placed the three next to one another, in his genus *Mestapra* (*ibid.*, p. 285), included *proserpina* in his *Deragena* (p. 272), separated from *Mestapra* by many other genera. Fruhstorfer (Seitz, ix, pp. 241, 244, 245) placed *paykullei* and *torvina* as successive but distinct species, and separated both *fraudulenta* and *proserpina* from them and from each other by many intervening species. The probable affinity of *proserpina* to *paykullei* is pointed out by Talbot (*ibid.*, p. 29).

I therefore asked my kind friend Dr. Eltringham if he would help me by comparing the male armature of the following forms :—

E. fraudulenta, from Hiu I., Torres Is., Sept., 1900.

E. paykullei, from Renée R., Esp. Santo, N.H., July, 1900.

They are obviously the same subspecies and *paykullei* (1876) is therefore a synonym of *torvina* (1875). Aneiteum, although included in the Loyalty Is. on the type labels and by Moore (P.Z.S. 1883, p. 285), is the southernmost island of the New Hebrides, and *torvina torvina* becomes the name of the race from these islands, generally called *paykullei*. The Loyalty race, hitherto commonly known as *torvina*, requires a subspecific name, and, remembering the help kindly given in unravelling these tangles, I propose to call it *Euploea torvina rileyi*, n. s.-sp. Distinguished from "*paykullei*" in the text under the name "*torvina*."

Types: ♂♀: in Hope Department, Oxford University Museum. From Lifu, Loyalty Is. (1894).

It is probable that additional races of *torvina* will be recognised in the future. Aneiteum is the nearest of the New Hebrides to the Loyalties, and *torvina* in this island appears to be transitional between the race to the north and that in the Loyalties to the west. If this probability is confirmed by sufficient material from Aneiteum, then *torvina torvina* will be the name of the transitional race and the one in the more northern New Hebrides will require a new subspecific name. Similarly a single male with a very narrow fore-wing brand, in the British Museum, from New Caledonia, may indicate the existence of another race of *torvina*. But with such a variable species a large amount of material is required.

E. boisduvalii proserpina, from Viti Levu, Jan., 1920 (Pl. XXXIII, fig. 7).

E. boisduvalii proserpina, the very large specimen transitional to *simmondsi*, from Taveuni, Mar., 1922 (Pl. XXXVI, fig. 7).

E. boisduvalii simmondsi, from Vanua Balavu, Sept., 1921 (Pls. XXXI, fig. 3; XLI, fig. 1).

E. boisduvalii simmondsi, from Wallis I., May, 1922 (Pl. XLII, fig. 1).

Dr. Eltringham examined the structures and found no evidence that any of these forms belonged to distinct species. *E. torvina*, unfortunately was not among them, but there is little doubt that it belongs to the same series. We may, provisionally at least, regard them all as geographical races of one species.

It now becomes important to examine the relationship between *simmondsi* and the three Euploeas from the Island Screen.

The small brand of *simmondsi*, sometimes very small, as in Pl. XLI, fig. 1, is rather nearer to that of *torvina* than to that of the others, as also is the arrangement of discal spots on the hind-wing below. The incipient traces of a pattern in such a high proportion of *simmondsi*, and their development into the marked pattern of *proserpina* suggest affinity with both *torvina* and *fraudulenta* rather than *paykullei*. In size *simmondsi* is larger than *paykullei*, but (with exceptions) nearer to it than to *fraudulenta*. In shape the wings are broader than *paykullei*, but they vary a good deal in this respect.

In other features the influence of *paykullei* seems also to be clear. The pale margins of the two male *simmondsi* represented on Pls. XLI, fig. 1 and XLII, fig. 2, and of the females in figs. 3–5 of the latter plate, strongly suggest the characteristic border of *paykullei*, although in a diminished state. The male on Pl. XLI, fig. 3, if fresh, would probably have been even more convincing—all the more so because, like *paykullei*, the specimen is patternless.

I have already mentioned some of the points which suggest affinity with the larger species *fraudulenta*. It is strikingly supported by a single specimen, intermediate between *simmondsi* and *proserpina*, which appeared among Mr. Simmonds' captures in Taveuni. It is the huge, broad-winged butterfly represented on Pl. XXXVI, fig. 7. Its size and proportions, and, above all, the length and

form of the brand,* awaken the thought that perhaps there has been occasional interbreeding with *fraudulenta*. Another striking difference, both in breadth of fore-wing and especially in size of brand, is seen when the two *simmondsi* from Vanua Balavu on Pl. XLI, figs. 1 and 2 are compared.

How are these differences, which so strongly suggest mixed strains, to be explained? Comparatively little has been done in the experimental interbreeding between different geographical races. How fruitful such investigations may prove is seen in the intersexes of Goldschmidt. In continental areas the experiment is often performed for us by nature along the common boundary of two subspecies. And I think that here, too, the experiment has been performed by nature, although in a somewhat different manner. I suggest that Fiji has been invaded by dark subspecies of *Euploea*, now from the south, then again from the centre, occasionally from the north of the great Island Screen to the West, and that these invaders have interbred in their new home. It may be asked—"Why have they not interbred and become transitional in the Island Screen itself?" It may be so; the islands require investigation from this point of view. Again, the conditions are different. The effect of an invader reaching a flourishing and old-established community is likely to be quickly eliminated; furthermore, the intruder must compete with a vast preponderance of the indigenous race. Our present knowledge, slender as it is when compared with what remains to be known, makes it highly probable that there are slight differences in the scents produced by the brands of the different races, and that mating would tend to be preferential in the different sections of the Island Screen. Among a mixture of invaders reaching Fiji this difficulty is likely to be reduced.

Whatever be the interpretation of the mixed characters which seem to be revealed on the wings of *simmondsi*, its later history in Fiji is, I think, quite clear. In East Fiji (and in Wallis Island) it met with *helcita walkeri* and by reciprocal mimicry an incipient pattern appeared in a large proportion of its numbers, while the pattern of *walkeri* became reduced—in Wallis I., where we have a

* Not quite so long as that of three Torres Is. *fraudulenta*, but some males of the latter in the Solomon Is. have brands even smaller than this Fijian *Euploea*.

standard of comparison with Fotuna I., very greatly reduced (see Pl. XLII). In West Fiji it encountered *helcita eschscholtzi*, and under its influence developed into *proserpina*. Some reciprocal effect may perhaps be seen in the hind-wing pattern of *eschscholtzi*, which is more pronounced than that of the parent race *lilybaea* in the New Hebrides.* This history will, I think, receive ample confirmation in the freely illustrated section of this memoir which deals with several islands in West Fiji. The history, however, is not quite so simple as here set forth. Two other Fijian Euploeas, *E. tulliolus forsteri*, and *E. nemertes macleayi*, enter the association in the east as well as the west, and they must have borne some part in the evolution of the eastern and western patterns. The Euploeas themselves are described below as IV and V of the present Section, and their part in the associations of each island in Section **F**.

III. Euploea schmeltzii H.-S., of Samoa, an Island Race of E. whitmei Butl., of the Loyalty Islands.

The Fijian Euploeas are interrupted by this butterfly because of its near affinity to *E. boisduvalii*. *Schmeltzii* and *whitmei* were placed by Moore (*ibid.*, p. 272) with *boisduvalii* in his genus *Deragena*, but he unfortunately gave the locality "Lifu" (Loyalties) as well as Samoa for the first and called the locality of the second the "Royalty Islands"!

Fruhstorfer (Seitz, ix, pp. 241, 242) considers the two forms as distinct species, following *eleutho*. He gives another example of the carelessness with which he had studied the Euploeas by writing of *E. whitmei*, "fore-wing with very short, but broad sexual stripe"—this of a butterfly with one of the narrowest brands to be found in the Euploeas!

* The suggestion of possible reciprocal effect in this case requires some explanation. The fore-wing of *proserpina* having gained a pattern in mimicry of *eschscholtzi* a correlated hind-wing pattern has also developed and been carried further than that of the model, which, in view of the abundance of *proserpina*, may perhaps have been affected. Two other possible influences must, however, be taken into account—(1) inheritance from the invading ancestor of *eschscholtzi*, (2) the swamping effect of successive waves of invasion from the west. It will be understood, I trust, that these are only hypothetical suggestions which may stimulate the collection of further evidence.

The extremely narrow brand in both *schmeltzii* and *whitmei*, together with the shape of the fore-wing, rendered it almost certain that they were distinct from other known Euploeas in the area we are considering. Dr. Eltringham made a structural examination and found the armature different from that of the previous series (p. 594), and the two to be mentioned later (pp. 600, 603). On the other hand, he could detect no significant difference between them. They become, departing from Fruhstorfer's arrangement, two subspecies of the one with the older name, which is unfortunately *schmeltzii* (1869), so that the parent race *E. schmeltzii whitmei* (1877) becomes a subspecies of its island daughter *E. schmeltzii schmeltzii!*

The two races are apparently neither of them abundant, and we know too little about them to speak with confidence as to their part in the local associations. In Samoa it seems likely that *schmeltzii* is an isolated form; in the Loyalties *whitmei* probably enters an association with *torvina*.

It seems at first sight surprising that these two peculiar little Euploeas, so closely related and so different from all others, should be so widely separated geographically. But how little we know of the area between West Fiji and Samoa, and how much has been learnt by Mr. Simmonds' visits to three out of all the islands of East Fiji and by his day or two at Wallis and Fotuna Is. The numerous islands between Fiji and Samoa are in large part volcanic, with high elevations, and are likely to support many species of butterflies. Among them links between these two not very different races will probably be found, together with others of much greater interest.

IV. Euploea tulliolus forsteri Feld., and its Race protoforsteri n. s.-sp., in West and East Fiji.

This species and the next, for both of which Fruhstorfer's names are provisionally adopted, belong to a section of the Euploeas very different from that of the species hitherto considered. The male may bear no scent-brand on the upper surface of the fore-wing, or one of a very different kind from that of the preceding species; but, in addition, a scent-producing apparatus is developed along the border of the hind-wing which is overlapped by the fore-wing. The overlapping edge of the fore-wing is widened to form

a cover,* doubtless of value in preventing loss of the scent. It therefore follows that the fore-wing of the female has an entirely different shape, being straight where the male's is strongly curved, as may at once be seen when figs. 5 and 7 (males) on Plates XXX and XXXI are compared with 6 and 8 (females). Furthermore, in his investigation of the genital armature, Dr. Eltringham discovered an accessory pair of scent-brushes in addition to the usual pair. This fact was already known (Seitz, ix, p. 261) in the group often called "*Salpinx*" (which includes *macleayi*, to be next discussed), but is, so far as I am aware, new for the species, such as *forsteri*, often united under "*Calliploea*."

To found a genus on secondary sexual characters applicable to a single sex is, I believe, wrong, but when they are as distinct and peculiar as they are in these two species and their allies, it seems probable that good generic characters will ultimately be found.

E. tulliolus forsteri was placed by Moore in the genus *Calliploea* (*ibid.*, p. 296), as a species next to *adyte* Boisd., from New Caledonia and the Loyalties. Fruhstorfer (Seitz, ix, p. 254) considered *forsteri* as a race of the Australian *tulliolus* F., and *adyte* as an allied but distinct species.

Although, as will be seen from Pls. XXX and XXXI, figs. 5, 6, and others which will be recognised as similar on Plates XXXII, XXXIII, XXXV (all figs.), XXXVI, XXXVII, and XXXIX—XLI, I have had the opportunity of studying a splendid series of the Fijian races, I have not been so fortunate in the parent islands to the west. But comparison with the other Fijian and Polynesian Euploeas renders it almost certain that the invasion started from the same source, and, if so, the invader may well be, as Fruhstorfer believes, a race of the Australian *tulliolus* which reached first the Island Screen of the West and then Fiji.

In Fiji we may distinguish between the eastern and western races by the comparatively strong development of pattern in the latter. On the other hand, in East Fiji the pattern may even be wanting, as in the male from Mango represented on Pl. XXXIX, fig. 12. In Fiji as a whole there is complete transition from one form to the other,

* A patch of scent-scales is also apparently present on the under surface of the overlapping fore-wing. The structures in this group of Euploeas are an inviting subject for microscopic investigation and their use for observation in the field.

but nevertheless a great difference between East and West Fiji. However, the transition is so gradual and the proportion of exceptions, especially in the east, so high, that I have figured nearly every specimen received from Mr. Simmonds.

The question arises—"Did Felder describe *forsteri* from a specimen with a well-developed or a reduced pattern?" Formerly in the British Museum Collection the latter alternative was adopted and the western race labelled as undescribed; but Capt. Riley agrees with me that Felder's description makes it certain that he had before him a common example of the west Fijian race. Dr. Jordan has kindly compared a male specimen from the Felder Collection in the Tring Museum with a good photograph of the specimens represented on Pl. XXXV, and he informs me that the pattern corresponds with that of fig. 12, all the spots being blue with white centres, but with very few white scales on the third from below (posterior angle). Three of the apical spots are confluent. The hind-wing upper surface is spotless. This specimen evidently agrees with Felder's description which applies to the well-patterned race of West Fiji. The race from some of the islands of East Fiji is undescribed.

Euploea tulliolus protoforsteri n. s.-sp. This name is proposed for the race without a pattern on the upper surface of the fore-wing, or those with relatively small submarginal spots, at least one of which is either wanting or entirely blue. This latter appearance is, in my experience, only seen when the series is made up of small spots. If the whiteness of any spot requires a lens for its certain detection it will be best to consider the specimen as transitional. The spot which first becomes entirely blue or soonest disappears is probably always the third from the double spot nearest to the posterior angle of the wing. The under surface generally follows the upper and may become, like it, entirely spotless.

E. t. protoforsteri may occur as a form and not as a race in some of the islands of West Fiji. Thus in the long series from Vanua Levu represented on Pl. XXXV, three males (figs. 13–15) and one female (fig. 21) are *protoforsteri*. From this plate the completeness of the transition and the difficulty in making a dividing line will be apparent. In three islands of East Fiji—Thithia, Mango, and Vanua

Balavu—*protoforsteri* exists as a race, *forsteri* appearing as a form in the single female from Thithia (Pl. XL, fig. 8). The distinction is very difficult and often impossible to draw in figures prepared from photographs, because of the high actinic quality of the blue. Exceptions among the islands of West Fiji, in which almost all the specimens are *forsteri*, are Taveuni and the Yasawa group, where the only forms captured are near the border line. The specimens from Mango in the British Museum are consistent with those sent by Mr. Simmonds (Pl. XXXIX, figs. 12–18) and like them are *protoforsteri*.

♂ Type: in Hope Department. Mango. Captured December 8, 1921, by H. W. Simmonds. A specimen with very small blue spots (Pl. XXXIX, fig. 13).

♀ Type: in Brit. Mus. Mango. A spotless specimen corresponding to the male shown on Pl. XXXIX, fig. 12.

Dr. Eltringham compared the armature of the male *forsteri* from Viti Levu represented on Pl. XXXIII, fig. 13, with that of the *protoforsteri* from Mango, on Pl. XXXIX, fig. 12, finding nothing to suggest specific difference. It will be observed that an extreme form of the latter was chosen, and a well-marked although not extreme example of the former.

It will have been inferred (p. 598) that there is little that is decisive to be said about the original invader. The forms allied to *forsteri* are so extremely similar and their simple patterns so variable that a detailed and systematic examination of the male armature is essential for the trustworthy determination of the specific limits. I think it is probable, however, that future work of this kind, together with further collections from the great Island Screen to the West, will enable us to identify with certainty the form representing the original invader.

It is likely that the immediate ancestor of *forsteri* exists in a *Euploea* from the Loyalties, of which there are three males and four females labelled *seriata* H.-S., in the British Museum. They resemble the *protoforsteri* from Mango, but are smaller, with less of the iridescent blue over the wing surface, and the minute submarginal spots of the fore-wing rather whiter, in this and other respects being very like a single male in the same collection from the isolated Fijian island Moala (p. 623). This suggestion accords well with Moore's arrangement, for he places *seriata* immediately before *adyte*, and *forsteri* immediately

after it (P.Z.S., 1883, pp. 295–6). It accords too with Fruhstorfer, who also places *seriata* next *adyte* and considers that the two should perhaps be united (Seitz, ix, 254).

Whatever be the form which now represents the original invader, there is no doubt about the course of evolution after the entrance into Fiji. The intruders took their place in the two Euploeine associations of West and East Fiji, contrasted in plates XXX and XXXI respectively. It is far more probable that change proceeded, as it did in *boisduvalii*, in the direction of an increasing pattern than towards its reduction, and for this reason I have suggested the name *protoforsteri* for the less patterned or patternless eastern forms.

V. Euploea nemertes macleayi Feld.; its Origin and the Changes it has undergone in Fiji.

The general characteristics of the male scent-producing structures have been mentioned under the preceding species. *Macleayi* is placed by Moore in the genus *Salpinx*, following *perdita* Butl. from New Britain, which itself follows *consanguinea* * Butl., *graeffiana* H.-S., and *iphianassa* Butl., all from the New Hebrides (P.Z.S., 1883, p. 303). Fruhstorfer includes it in an immense series of subspecies under *E. nemertes* Hbn., from the southern Moluccas, placing it next to *iphianassa* and *graeffiana* (Seitz, ix, p. 266).

In the fine collections made in the New Hebrides by Commander Walker and Mr. J. R. Baker, with a few additional specimens previously in the Hope Department, I find thirty-five examples of *graeffiana* from the same islands as the sixty-seven *paykullei* (p. 592), and evidently entering into association with these latter, the males of both species being very dark brown with paler borders, the females of both a much lighter brown with borders paler still. Accompanying the form of *fraudulenta* and taken with it in the Torres Islands by Commander Walker are six males and two females of a much larger species, considered, when compared with the British Museum series, to be a form of *iphianassa*. It is darker than *graeffiana*, without the pale borders, and evidently enters into an association centred by the *fraudulenta* in the same islands. That the

* Now placed as a form of *iphianassa* in the British Museum Collection.

two Euploeas fly together is proved by the fact that four males of *iphianassa*, and three males and two females of *fraudulenta* were taken by the Commander between 6.0 and 8.0 a.m., September 14, 1900, in Hiu island.*

When a good series of the Fijian *macleayi* is compared with these species from the Island Screen in the West there can be no doubt that the great majority of the specimens resemble, both in size, tint and pattern, the form from the Torres Islands. It will be observed, however, that among the figures of *macleayi* taken by Mr. Simmonds (Pls. XXX, XXXI, figs. 7, 8; XXXVII, figs. 6–13; XXXIX, figs. 6–8; XL, figs. 3, 4; XLI, fig. 11) there is great variation in size, and also that some examples have pale borders to the wings, *e. g.* on Pl. XXXVII, figs. 11, 12, 13, the last figure representing a very pale- almost white-bordered butterfly. In Mr. Simmonds' series such specimens are females, but there is a white-bordered male in the British Museum (p. 621). It also seems to be the fact, but confirmation by much larger numbers is required, that these pale-bordered exceptions occur among the smaller specimens. It is difficult to resist this conclusion when figs. 11–13 on Pl. XXXVII, and fig. 8 on XXXIX are compared with the other representations of *macleayi* on the same plates. No one can suppose that the large and small forms or the dark and the pale-bordered, on the same small island, such as Ovalau (Pl. XXXVII : see also p. 615), are anything but an interbreeding community, and I am therefore led to conclude that the history of *macleayi* resembles that of *simmondsi* (p. 592)—that Fiji has been invaded by *iphianassa* and also by the smaller, paler *graeffiana* and that inheritance from the latter has given us the small, pale-bordered specimens.

* Commander Walker was referring to this capture when he wrote :—"Two species of that genus so characteristic of these islands, *Euploea*, were very common close to the beach" (Ent. Monthly Mag., 1902, vol. xxxviii, p. 203). The precise locality was Picot Bay in Hiu, the northernmost of the Torres Is. The date is accidentally given as Sept. 13, instead of 14.

Commander Walker also took a *Euploea* which I cannot distinguish from *iphianassa* further south in the New Hebrides and New Caledonia. It appears to be rare, but its occurence with *graeffiana* suggests that they may be distinct species, although no structural difference could be detected (p. 603). It has already been shown (p. 601) that Moore gives the New Hebrides as the only locality of *iphianassa*.

The conclusion thus reached made it important to examine the genital armature in order to discover whether there was anything to suggest specific distinction. Dr. Eltringham has kindly studied the following examples of the two forms from the Island Screen and from East and West Fiji, without finding any such indication :—

Euploea iphianassa : Torres Is., Hiu I. : Sept. 14, 1900. J. J. Walker.

Euploea graeffiana : New Hebrides, Epi (Api) I., Ringdove Bay : July, 1900. J. J. Walker.

Euploea macleayi : E. Fiji, Vanua Balavu : Dec. 9, 1921. H. W. Simmonds (Pls. XXXI, fig. 7 ; XLI, fig. 11).

Euploea macleayi : W. Fiji, Ovalau : Apr. 28, 1922. H. W. Simmonds. (Pl. XXXVII, fig. 7.)

If the hypothesis concerning the origin of *boisduvalii simmondsi* and *nemertes macleayi* be confirmed it will follow that Fiji has been invaded by two members of the *fraudulenta*-centred, and two of the *paykullei*-centred association, that, in Fiji, the central member of one has interbred with the central member of the other, and, with probably a further accession (*torvina*), has become one mixed race, that the two outlying members have also fused into a mixed race, finally, that the two mixed races have formed, together and with other Euploeas, associations differing in East and West Fiji.

The subsequent history in the islands is almost exactly like that of *forsteri*. *Macleayi*, with reduced pattern, enters the darker association of East Fiji, with increased pattern that of West Fiji. Here it is difficult to determine whether the East is ancestral to the West or *vice versa*; for both *iphianassa* and *graeffiana* possess a submarginal pattern. It may be that in a small island with a single Euploeine association certain forms of selection operate more quickly and completely than in a larger one.*

* Some support to the conclusion that selection may act more powerfully in small islands is perhaps to be found in the especially strong development in the opposite direction, viz. towards emphasis of pattern, in the small island of Ovalau (p. 615). By "certain forms of selection" I mean selection as brought about by the attacks of certain enemies under particularly favourable or peculiar conditions, such as the existence of a single synaposematic association in a small island in place of several in larger areas. The conclusion that there has been an exceptional development of mimicry among the butterflies of certain small islands was suggested by the remarkable examples in Bourbon and Mauritius (Proc. Ent. Soc., 1908, pp. iv–vii.)

If so we should be able to understand the reduction of pattern in East Fiji beyond the point attained in the Island Screen to the West.

VI. The three Allied Races of Danaine Butterflies in Fiji and Polynesia, and their Origin.

(a) *Danaida melissa melittula* * *H.-S., of Samoa.*

(b) *Danaida melissa angustata Moore, of the Tongan Islands* (*Friendlies*).

(c) *Danaida melissa neptunia Feld., and protoneptunia n. f., of Fiji.*

It will be convenient to discuss these closely allied races together. All three are placed with others, by Fruhstorfer, as subspecies of *Danaida melissa* Cram., from Java (Seitz, ix, p. 203). Moore, on the other hand, considers them as three different species of his genus *Tirumala*, placing them far apart from *melissa*, and (with *obscurata* and *moderata*) immediately following the Australian *hamata* McLeay (P.Z.S., 1883, pp. 232–3). In examining the relationship between these races, as I believe them to be, and their past history, it will be necessary to consider two others—obviously closely allied and so considered by both Moore and Fruhstorfer—*D. melissa moderata* Butl., of the New Hebrides, and, very briefly, *D. obscurata* Butl., from the Solomon Islands.

These five races are the only Danaine butterflies considered in this paper. I have already referred to the recent intruder *plexippus* (pp. 578, 579), and the only other form at present known is *Danaida petilia* Stoll, the race of *D. chrysippus* L. (or perhaps a distinct species), inhabiting Australia, the southern and eastern islands of the Malay Archipelago and the chain of island groups extending S.E. from New Guinea. It clearly entered Fiji by way of the Island Screen. Apparently it is uncommon and does not enter into mimetic relationship with any Fijian butterfly.

Fruhstorfer falls into error in his statements (*ibid.*, p. 203)

* The small size of this butterfly, as indicated by its name, is not considered in the present memoir; but it is very marked and shared by the Samoan Nymphaline *Hypolimnas bolina*. After comparing both butterflies with those of other Pacific islands, it appeared probable that a small size may have been mechanically selected in those island groups which lie in the track of Pacific hurricanes. The subject is at any rate worth a systematic enquiry, and I hope to be able to pursue it at no distant date, with the kind help of a skilled meteorologist.

about the relationship between the markings of some of the five races. Thus, he says of the Tongan species *angustata* that it "has even narrower white bands and more extended brown areas than *neptunia*." The reverse is true; the pattern of *neptunia* is far more reduced than that of *angustata*. As Mr. G. F. Mathew correctly stated in his journal, *angustata* is "intermediate between the Samoan and Fijian" Danaines (p. 607), *i. e.* it is on the whole less patterned than *melittula* and a great deal more so than *neptunia*. *D. obscurata* Fruhstorfer suggests may be synonymous with the Samoan *melittula*. It is certainly allied and may probably represent the parent race, but its present locality is the Solomon group. Fruhstorfer, in writing of it as Samoan, has been misled by Butler, who in the original description (P.Z.S., 1874, p. 275) gives "Upolu" (Samoan Is.) as the locality. Moore combines Upolu with the Solomons (P.Z.S., 1883, p. 233), in this following the labels on the type specimen. Capt. Riley has kindly looked up the British Museum Register and writes:—

"The type of *Tirumala obscurata* Butler came from the Solomons, not from Samoa. The entry is perfectly clear in the Register on this point, and the specimen has been labelled Solomons and a note added that 'Upolu,' which it also bears, is wrong."

Of the four Western Pacific races, the Samoan *melittula* and the Tongan *angustata*, with strongly developed patterns, are evidently very closely allied, as are the New Hebridean *moderata* and the Fijian *neptunia*, with greatly reduced patterns. The main difference between the first-named pair is that the pattern is more fully developed in the fore-wing of *melittula* and in the hind-wing of *angustata*. *Obscurata* is characterised by a peculiar and conspicuous hook-like fusion of markings within the inner margin of the fore-wing, a feature closely resembled by many specimens of *melittula* and approached by many others.

As regards the second pair, *neptunia* is clearly a modified form of *moderata* or some closely similar ancestor of *moderata*. The latter is a dark form with reduced markings. In Fiji the markings of the great majority of specimens have become much further reduced * and the ground-colour blacker, in mimicry of the dark Euploeas with a

* In the minority, however, the pattern is slightly stronger than in *moderata* (p. 608), suggesting that the latter at the time of the invasion was itself rather more strongly marked.

white marginal pattern. Looking at a series of the four subspecies, the dark ground-colour of the two latter and the predominant blackness of *neptunia* become obvious.

The question naturally arises—"If *neptunia* mimics Euploeas in Fiji why does not *melittula* do the same in Samoa and *angustata* in Tongatabu?" The answer seems clear, at any rate in Samoa. The ancestral form which entered Fiji (*moderata*) was already sufficiently dark, even though it may have been a little lighter than its present form, to provide a starting-point from which selection could proceed. Furthermore, and perhaps of even greater importance, the resemblance was favoured by the relative abundance of the Euploeine models. In Samoa the conditions are very different, as proved by the following notes on *melittula* and other Samoan butterflies which Mr. Gervase F. Mathew has kindly extracted from his journal written when he visited the islands in 1884, being at Apia, June 19–24, and Pango Pango, Tutuila, June 25–29. He also informs me that his memory coincides with the impression created by his record at the time.

"*June* 20.—A *Danais* [*melittula*], coming near *limniace*, but much prettier, was very abundant, and I took a good series.

"*June* 22.—The *Danais* like *limniace*, was very plentiful, and is a beautiful object on the wing. Masses of white flowers (*Sida rhombifolia*, var. ?), were growing by the sides of the paths, and in open places in the forest, and were very attractive to butterflies, and these pretty Danaids were quite the most numerous species present. It is by far the most common butterfly at Apia.

"*June* 23.—Took a number of the local Danaid.

"We left Apia on June 24th, and arrived at Pango Pango harbour, Tutuila Island, Samoa, the next day.

"*June* 25th.—It poured with rain all the morning, but cleared up a little during the afternoon, so I landed after lunch at the village of Tonga Tonga, and walked from thence to Pango Pango harbour, about a mile, along a path through the bush. It was raining off and on most of the time, but notwithstanding this there were a good many butterflies on the wing—*Euploea* [*helicita bourkei* and *schmeltzii*], *Danais*, *Lycaenae*, etc., etc."

"*June* 26.—The next day was very bright and warm and I had a long day on shore. The *Danais* was just as numerous at Pango Pango as at Apia."

In the Friendly Islands the Danaine *angustata* was evidently much less common. Mr. Mathew wrote on July 9, 1884, when he was at Nukualofa, Tongatabu:—

"Took 4 specimens of a *Danais* which seems to be intermediate between the Samoan and Fijian *limniace* [*neptunia*]. It is probably only a local variety. In one place this evening a vast number of the local *Euploea* [*helcita mathewi*] had congregated for the night among the boughs of a large tree, and a stone thrown into the tree dislodged them in hundreds. They associated with a few *D. limniace* and *D. erippus* [*plexippus*]. The Nukualofa *Euploea* was also common on Vavau island—of the same group—on July 16th, 1884."

Mr. Mathew also recorded of the Fijian *neptunia*, when he was at Suva and Levuka, June 2–11, 1884, that "they were fond of 'roosting,' in little companies, upon dead branches."

The proportions of *helcita mathewi* (p. 586) and *angustata* in the Friendlies appear to be such as would encourage mimicry by the Danaine, and it is possible that the reduction of the fore-wing pattern of *angustata*, which is especially marked in the basal half, is a slight step in this direction. We require evidence, such as Mr. Simmonds has supplied in Fiji (p. 574), that there is some superficial resemblance between the two when on the wing.

There can be no doubt that the Fijian *neptunia* is a modified form of *moderata*, the race which now inhabits the New Hebrides, but, as has been already suggested, there is reason to believe that it was somewhat less dark at the time when it entered Fiji, and that the pattern of the original invader still persists as a form in West Fiji and perhaps as a race in some of the eastern islands. This ancestral form is represented in this memoir on Pl. XLIII, figs. 1–3, and it is very different from *neptunia* as described by Felder in Reise Nov., Lep. II, p. 349 (1867), and figured on *his* Pl. XLIII, fig. 1. He there describes and figures a butterfly with a fore-wing resembling the specimen I have represented in fig. 7 and a hind-wing rather more strongly patterned than is usual with so dark a fore-wing. Its pattern is about the same as that of fig. 4—in some respects a little more, in others a little less developed. The changes in the fore-wing have apparently led the way in the mimicry of the white-patterned Euploeas, and it will be reasonable to apply Felder's name to the form represented in figs. 7–9.

I propose for that shown in figs. 1–3 the form name, and it may be the race name, *protoneptunia*. Figs. 4–6 are transitional forms linking the two extremes.

Danaida melissa neptunia, n.f., protoneptunia.—This form differs from *neptunia* in the presence of a well-developed pattern on the inner half of the fore-wing and of a more strongly developed pattern on the hind-wing. It closely resembles *moderata*, but, when many specimens of the two are compared, the following differences will be found to hold :—

(1) The proportions of the mark, inadequately described by Fruhstorfer (in Seitz, ix, p. 203) as "roundish" ("die rundliche Makel vor dem Zellapex"), towards the outer end of the fore-wing cell. This mark is like nothing so much as a child's drawing of the head, neck, and upper part of the body of a bird seen from the side and it may therefore be conveniently called the "aviform mark." In *moderata* it is slenderer than in *protoneptunia*.

(2) This comparison holds for the markings as a whole, especially in the distal half of the fore-wing;—they are slenderer in *moderata* than in *protoneptunia*.

(3) The ground-colour is blacker on both the upper and under surface of *protoneptunia*. The under surface of *moderata* is more uniform in tint and brownish.

(4) *Protoneptunia* is a little larger than *moderata*.

Type ♂: in Hope Dep., Oxford University Museum. From Taveuni, Fiji, Dec. 20, 1921. H. W. Simmonds (Pl. XLIII, fig. 1).

Type ♀: in Zoological Museum, Tring. From Suva, Nov. 1894: Wet Season. Woodford. (No. 1, Table B., p. 633).

The proportions of the different forms of *neptunia* in various Fijian islands are considered in detail in later pages (pp. 630-639), but it may be here mentioned that all the specimens in Section I of the Tables are *protoneptunia*, all in Sections Ia and II—intermediates, and all in III—*neptunia*; further, that the final analysis (p. 639) supports the probability that *protoneptunia* exists as a subspecies in some of the islands of East Fiji.

It is probable that the history of these three Pacific Danaines is nearly the same as that of *Euploea helcita bourkei, mathewi*, and *eschscholtzi*. In the more remote Samoan and Tongan islands are preserved the stronger

patterns which have now disappeared from the Island Screen in the West. The stronger of the two is found in Samoa, the weaker in Tonga, thus reversing the relationship of *bourkei* and *mathewi*. In *obscurata* of the Solomons we have probably a near approach to that of the parent race, at any rate of *melittula*. *Angustata* may be the result of a later invasion by a parent race with reduced pattern, or it may have been reduced in the Tongan Group in incipient mimicry of *Euploea helcita mathewi*. Finally, in Fiji there is the interesting occurrence of two forms transitional into each other—*protoneptunia* nearly representing the parent *moderata* of the New Hebrides but at a slightly earlier stage with a slightly more developed pattern, and *neptunia* evolved in Fiji as an outlying mimic of the great Euploeine association.

F. THE EUPLOEINE ASSOCIATIONS, SO FAR AS THEY ARE KNOWN, IN THE ISLANDS OF WEST AND EAST FIJI AND WALLIS ISLAND.

The islands from which Mr. H. W. Simmonds has sent this most interesting material are here arranged from West to East, nearly following the order of the plates, and, as in these, beginning in each island with the central member or primary model. This in West Fiji is *Euploea helcita eschscholtzi*, in East Fiji *Euploea boisduvalii simmondsi* followed by the other members of the dark-winged association, and finally by *helcita walkeri*. In Plates XXX and XXXI, however, which are intended to show at a glance the difference between the two associations, the same order, that of West Fiji, is followed in both, to facilitate comparison.

It should be remembered that the Euploeine associations have attracted to them the Fijian Danaine *neptunia*, considered in Section **G**.

In all but the best-known islands the whole of the Euploeas received are figured. The differences being often small and the transition from one pattern to the other often complete, it has been thought well to represent as many specimens as possible, and, in the account of each island, to incorporate the results of an examination of other collections.

These Fijian associations have no striking patterns like those observed by Mr. G. F. Mathew (pp. 570-571) or

represented in Mr. Talbot's beautiful figures to which I have already referred (Bull. Hill Mus., Vol. i, Pls. I, II). But they are, as illustrated by this splendid material, the most interesting of all, because in them we get nearer than we do in any others to the actual process of evolution. The associations as a whole or some of the members are preserved in various islands at various stages of change, and what we have learnt from the material here illustrated encourages the hope that far more will be learnt in the future.

I am anxious to guard against an interpretation which may be put upon the facts recorded and the inferences drawn in the present paper. A form which develops into another is of course ancestral in time relatively to its descendant, but by no means necessarily ancestral in evolutionary progress. Organic evolution has probably never been a continuous ascent but a climb of endless ups and downs, only known to lead upward when averaged over long periods. And this is especially true of such fleeting features as colour and pattern. Some of the island forms here considered, have, I believe, been descended from ancestors with more developed patterns, some from ancestors with less. Increase and reduction of pattern have, I doubt not, succeeded each other again and again in the past, especially in the members of distasteful associations, as changes of distribution have brought them into contact now with this predominant species or combination, now with that. There is nothing in the facts here recorded to justify the inference that we are witnessing the evolutionary origin or progressive growth of any type of pattern, or its evolutionary decline, but we have strong proofs as to the course taken in particular phases of evolution.

Mr. F. Allen of the Royal Geographical Society has kindly sent me the following notes on the spelling and pronunciation of Fijian names by Mr. Reynolds of the Permanent Committee on Geographical Names :—

" Spellings should be either phonetic or the conventional Fijian, in which b = mb, d = nd, g = ng, c = th (as in *this*), q = ng-g.

" *Phonetic.*	*Fijian.*
Thithia	Cicia
Mango	Mago
Mbalavu	Balavu
Kandavu	Kadavu

" The P.C.G.N. has not yet determined which to use. The Admiralty and the 6-miles-to-an-inch map use the phonetic. The Colonial Office is inconsistent.

" Motoriki should be Moturiki (all authorities).

" Waisala „ „ Waialailai (all authorities)."

I. The Islands of West Fiji.

The Euploeine associations in the main islands of this western group will be found to be strongly patterned, but there are slight differences in the level reached in the different islands. There are indications that the extreme western Yasawa group is at a rather lower level of development, while specimens from Taveuni, nearest to East Fiji, and the remote southern Kandavu, are clearly transitional to the more ancestral eastern association.

(*a*) The Yasawa Group.

(Plate XXXII, figs. 1–13).

Mr. Simmonds paid a short visit to some of the small westernmost islands of Fiji in October 1921. Three out of the four Fijian species of *Euploea* were taken, the absentee being *E. nemertes macleayi*. Altogether four *E. helcita eschscholtzi*, three *E. boisduvalii proserpina* and five *E. tulliolus forsteri* or *protoforsteri* were received, together with a single Danaine transitional between *protoneptunia* and *neptunia*. All are represented on the plate, which clearly shows the captures effected on the separate islands, Waisala, Naviti, Yasawa and Kowata.

The specimens are, as a whole, typical western forms with a well-developed marginal pattern. The Danaine (fig. 10) is No. 11 in Table A (p. 632), and thus fairly advanced in mimicry of the West Fijian type of Euploeas, resembling in this respect the specimen represented on Pl. XLIII, fig. 5. The *forsteri* are all on the border-line between this form and *protoforsteri*; in fact figs. 5 and 12 represent the latter. It is interesting to find that these outlying western islands are in this respect not far advanced towards the western type of pattern, but more specimens are required, especially of *nemertes macleayi*, which I expect is at about the same stage of evolution as *forsteri*.

(*b*) **Viti Levu.**

(Plates XXXII, figs. 14–25; XXXIII; XLIII, figs. 7, 9; XLIV, figs. 5–7.)

It is unnecessary to add much to the evidence already made known that the two principal Euploeas of the chief Fijian island are of the western type with pronounced white patterns. The examples of *eschscholtzi* and *proserpina* figured in this paper, together with many others of the same two species, captured together in various localities in Viti Levu, are quoted with full data in Proc. Ent. Soc. (1919, pp. lxx, lxxi; 1920, pp. lxxxi,* lxxxii). Then there is the original publication of this example of mimicry by Major J. C. Moulton in Trans. Ent. Soc. (1908, p. 603, Pl. XXXIV, figs. 4, 9). Of the large proportion of specimens in museums unfortunately labelled "Fiji" without further details, the great majority probably came from the neighbourhood of Suva and most of the others from Levuka in Ovalau, an island near Viti Levu, and with the same type of pattern.

Euploea helcita eschscholtzi.—Out of the large number of *eschscholtzi* kindly sent to me from the western islands by Mr. Simmonds only three specimens show an approach to the *walkeri* race, with a much broader submarginal band to the hind-wing, although this is the predominant form in Eastern Fiji so far as we know it. The first to be received was a male from Viti Levu, and it is represented on Pl. XXXII, fig. 15. Mr. Simmonds specially remarked in his letter of June 7, 1919, that it was the only one he had taken. The specimen is referred to in Proc. Ent. Soc. (1919, p. lxxi). The next example, also a male with the character far less developed, is shown on Pl. XXXIV, fig. 6. It was taken with thirteen typical *eschscholtzi* in Vanua Levu, May 25–31, 1921. The third specimen, with the broadest band of the three, is a female taken in Ovalau, April 27, 1922 (see p. 615). It is represented on Pl. XXXVII, fig. 1.

Euploea boisduvalii proserpina.—I may briefly add a few more to the published records of this species in Viti Levu

* Lami, referred to on this page of the Proceedings, is five miles from Suva, on the Waidoi road. On the line above that in which Lami is mentioned, the second ♀ *eleutho* [*eschscholtzi*] should have appeared in the year 1919 instead of 1920. The day and month are correct.

and to those of Mr. Simmonds, appearing for the first time in this memoir. All the following are of the western type of pattern :—4 ♂, 1 ♀ from Suva, in the British Museum; 2 ♂, 1 ♀ from Suva, in the Hill Museum; 4 ♂, 2 ♀ in the Bourke Collection (Suva or Levuka : Jan. 1893).

Euploea tulliolus forsteri.—Of the other members of the association in Viti Levu only three examples of *forsteri* (Pl. XXXIII, figs. 12–14) were received from Mr. Simmonds and none of *nemertes macleayi*. The *forsteri* are of the western type, perhaps not quite so far advanced as those of Vanua Levu (Pl. XXXV), but a good series is required to make sure that this comparison is trustworthy. It is, however, confirmed by an examination of the British Museum series.

There are in the National Collection three males and three females from Suva. They have fore-wings of the western type, and, in the hind, the inner series—there is no trace of the outer—is represented by two faint spots in one male and one female, two fairly distinct in two males, two distinct in two females, one of which, however, has three spots on one side. There are also six males and eight females labelled " Fiji," and these are all of western type except two females with marginal markings reduced, but not to the extent seen in typical eastern specimens. The hind-wing spots of the inner series are never more than two, and these are wanting in four females and very faint in the other four; wanting in two males, and very faint, faint, fairly distinct, and distinct in the four others, respectively.

The Bourke Collection, at Oxford, contains three males and three females, taken in January 1893, either near Suva or near Levuka. As regards the fore-wing pattern, two females are about equal to figs. 18 and 19 on Pl. XXXV and one equal to fig. 20, but with the white spots smaller. Two males are as strongly patterned as figs. 1–3, except that the fused spots are not quite so large. The third male is about equal to fig. 12. There is no trace in the males, and only the faintest in the females of a hind-wing pattern.

There are also in the Hope Department two males labelled " Suva " (C. M. Woodford, Febr., Mar., 1886), two males taken at Suva by Prof. Gilson, Oct. 5 and 8, 1897, four males and two females labelled " Fiji." All are of a distinct, although some of them not very strong, western

type. There is also present a pair of Woodford specimens with the above data which are almost certainly the Australian *tulliolus tulliolus*, labelled in error. When the male was taken to the British Museum Mr. F. A. Heron pointed out that their series of *tulliolus* also contained specimens of the same kind with the same misplaced label.

The Hill Museum possesses three males and two females labelled "Fiji," all with moderately developed western patterns, strongest in the females.

Considering this additional evidence supplied by many examples of *forsteri* from Viti Levu and by others labelled "Fiji," there can be no doubt about the prevalence of the western pattern in the main island, and also great probability that this pattern is not quite so fully developed as in Vanua Levu.

Euploea nemertes macleayi.—The British Museum series includes three males and three females from Suva, resembling Pl. XXXVII, fig. 6 (♂♂), fig. 8 (♀♀), and ten males and twelve females labelled "Fiji." Nearly all are distinct western types, a single female, unfortunately from "Fiji," being as white as the whitest Ovalau female (Pl. XXXVII, fig. 13). It is, however, a large specimen. Two small females with pale brown borders suggest the *graeffiana* strain. Two females nearly resemble Pl. XXXIX, fig. 11, from Mango, and one male is correspondingly dark-bordered. In one male and female internervular white streaks pass outwards from the submarginal white spots as in Pl. XXX, fig. 8, and indications of the same feature appear in other specimens.

The Hope Collection contains two males and one female taken by C. M. Woodford at Suva in February and March 1886. The males are distinctly less white-patterned, especially upon the hind-wing, than the Ovalau male represented on Pl. XXXVII, fig. 7, while the female resembles fig. 8.

The Hill Museum possesses one male from Suva, resembling Pl. XXXIX, fig. 6 (Kandavu), also one male and two females labelled "Fiji," resembling Pl. XXXVII, figs. 6 and 11, respectively (Ovalau).

Dr. Jordan has very kindly compared the Tring series with a good photograph of the specimens from Ovalau shown on Pl. XXXVII. One male from Suva is less advanced than fig. 6, having smaller spots on the fore-wing and fewer on the hind. Six are labelled "Fiji," but

probably came from Viti Levu. Three males, one of them from the Felder Collection, are all like the one from Suva, a little behind fig. 6 in both fore- and, except the Felder specimen, hind-wings. Of the females two, including a Felder specimen, resemble fig. 9, but in one (not Felder) the posterior spots of the hind-wing are rather smaller. The third female resembles fig. 8, but the posterior spots of the fore-wing are smaller and the fore-wing suffused with white on the proximal side of the upper submarginal spots—a feature I have not hitherto encountered except when combined with a white border.

The pattern of this species is therefore of the western type in the main island, but when the record is examined as a whole it will be seen that the average development of the white pattern is distinctly behind that of *macleayi* in Ovalau.

(*c*) Ovalau.

(Plates XXX, figs. 1, 3, 4, 7, 8; XXXVII, XXXVIII, XXXIX, figs. 1–3; XLIII, figs. 3–6, 8.)

On this comparatively small island lying to the east of Viti Levu, the development of a white marginal pattern seems to reach its maximum. This is especially pronounced in the females of *E. nemertes macleayi* such as those shown on Pl. XXXVII, figs. 12, 13. Mr. Simmonds specially mentions these in a letter of July 19, 1922, in which he points out that some of the females are very close mimics of *proserpina*, a conclusion emphasised by a study of Pl. XXXVII. On November 29, 1921, he wrote that *E. tulliolus forsteri* was common on Ovalau, where he had not met with it before. From this it is to be inferred that the four included in the table on p. 617 do not convey a correct impression of its proportions. All four are males with patterns of western type.

Among the forms of *Euploea helcita* was a single specimen (Pl. XXXVII, fig. 1) with the hind-wing pattern of *walkeri* (see also p. 612). It is, however, a rather unusually small example even for *eschscholtzi*, whereas *walkeri*, in the eastern islands of Fiji, is considerably larger than the western race.

Another *helcita* (Pl. XXXIX, fig. 3) is very interesting in the reduction in size and clouding over of the principal spot of the fore-wing, in this respect closely resembling

one of the forms from Wallis I. (Pl. XLII, fig. 12). So far as my experience goes this is the only example of the kind from West Fiji.

The fact that all the four white-patterned Euploeas fly together and that the mimicking Danaine *neptunia* flies with them is well shown in the accompanying table, upon which are recorded all the specimens of these five species from Ovalau received from Mr. Simmonds. Plate XXXVIII emphasises this evidence, inasmuch as the principal model *eschscholtzi* (fig. 1) with its chief mimic *proserpina* (fig. 2) and a female form of *Hypolimnas bolina* (fig. 3) which would resemble them on the wing, were taken within two minutes of each other on a hill near Levuka.

It should be remembered that the Ovalau specimens represented on the plates were not specially selected to show the white pattern, but are fair samples of the others included in the table. Two female *macleayi* (Pl. XXXVII, figs. 12, 13) are, however, exceptional, and were included to show the extent of variation in the species, and also the resemblance to a common form of female *E. graeffiana* (New Hebrides). Allowing for these two, selected for a special purpose, the figures of *macleayi* represent, I believe, an average development of pattern slightly below that of the complete series. I wish the whole could have been figured, as in Pl. XXXV for *forsteri* from one locality in Vanua Levu. I have already implied that all the Ovalau examples of this latter in the table are shown on Pl. XXXVII, figs. 14–17.

In addition to Mr. Simmonds' captures the following specimens from Ovalau are all of western type—*proserpina*: 1 ♂ labelled "Ovalau," in the British Museum; 5 ♂♂ labelled "Levuka: 1882," in the Hill Museum. A little series in the Hope Department, labelled "Levuka: 1878," in the handwriting of Prof. Westwood, includes 1 ♂ *proserpina*, 1 ♂ 1 ♀ *eschscholtzi*, 1 ♀ *Danaida neptunia* (p. 633). The date of the last figure on the *neptunia* is not very clear, but there is no doubt that "8" was intended, as the specimens were evidently labelled together. The Euploeas are of western type and the Danaine is one of the best mimics of this association that I have seen (pp. 631, 637).

The series collected by Admiral Bourke at Suva or Levuka, and described under Viti Levu and on p. 633, should also be taken into consideration.

OVALAU I. Captures in 1920–1922.	*Euploea helcita eschscholtzi.*		*Euploea boisduvalii proserpina.*		*Euploea nemertes macleayi.*		*Euploea tulliolus forsteri.*		*Danaida melissa neptunia.*	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
1920, Sept. 9		1 (XXXVIII, 1)	1 (XXXVIII, 2)							
1921, May 12	5 (XXXIX, 1–3)		2	2	1				1 (XLIII, 4)	
,, ,, 17	5		1	2						
,, ,, 18	2									
,, Oct. 22	1						2 (XXXVII, 14, 15)			
,, ,, 23									2	
,, ,, 27	1									
1922, Apr. 27		1* (XXXVII, 1)		1 (XXXVII, 5)	1 (XXXVII, 6)	1 (XXXVII, 9)			2 (XLIII, 3, 5)	
,, ,, 28					1 (XXXVII, 7)	1 (XXXVII, 10)				
,, ,, 29						2 (XXXVII, 11, 13)				
,, ,, 30			2 (XXXVII, 2, 3)	1 (XXXVII, 4)		2 (XXXVII, 8, 12)			1	
,, May 3	2		6	1	2	2	1 (XXXVII, 16)		3 (XLIII, 6)	
,, ,, 7					3	1				
,, ,, 8	2		1		1	1				
,, ,, 9			1				1 (XXXVII, 17)			
,, ,, 10						1				
,, ,, 17	1	1	2	1						
,, ,, 18	1		1		1				1 (XLIII, 8)	
,, June 7				2						
,, ,, 8		1	1		1	1				
TOTALS	20	4	18	10	11	12	4	0	10	0

* The hind-wing has the pattern of *helcita walkeri*.

(*d*) Moturiki.

(Plate XXXVI, figs. 1 and 2.)

There is little to be said about this small island, which lies close to Ovalau, on the south-west side of it. Moturiki was visited by Mr. Simmonds on August 11, 1920 and in 1923, when it was found to be very barren (p. 576). The two Euploeas captured in 1920 were females of *eschscholtzi* (fig. 1) and *proserpina* (fig. 2), both of the western type like those of the adjacent islands Ovalau and Viti Levu. The pattern of *proserpina* is developed to an extent which is somewhat unusual. The specimens are recorded in our Proceedings, 1920, p. lxxxi.

(*e*) Vanua Levu.

(Plates XXX, figs. 2, 5, 6; XXXIV; XXXV.)

Until I received the excellent series of Euploeas sent by Mr. Simmonds I had only found (in the British Museum Collection) three specimens with labels showing that they came from this fine island, next to Viti Levu much the largest in the group. Mr. Simmonds visited it on several occasions, by far the most prolific visit being to Vunilagi, on the north-east coast on May 25–31, 1921. This locality is not given on any maps of the island, and the Geographical Society have not been able to find a reference to it, but they kindly inform me that "Vunilangi" is a village on the south coast of Vanua Levu. It is too late to obtain verification from Mr. Simmonds before the appearance of this memoir, but should any correction be found necessary it will be made at the earliest opportunity.

All the Euploeas captured at Vunilagi are represented on Plates XXXIV and XXXV, and they are sufficiently numerous to create an accurate picture of the average patterns, which are seen to be of a pronounced western type. The locality was near sea-level, and included patches of primitive jungle.

In addition to the Vunilagi Euploeas the following captures were made at other times in various parts of the island.

All the Euploeas here tabulated are of pronounced western type, the patterns of *forsteri* being unusually strong, with distinct hind-wing spots, like those shown on Pl. XXXV.

VANUA LEVU. LOCALITIES AND DATES.	*E. helcita eschscholtzi.*		*E. boisduvalii proserpina.*		*E. tulliolus forsteri.*	
	♂	♀	♂	♀	♂	♀
E. Coast: Buca Bay. Dec. 27, 1921.				2	1	
S. Coast: Wainunu. Feb. 19, 1922.		1			1	
S. Coast: Wainunu. Mar. 1, 1922.	1					
N. Coast: Macuata distr. Sept. 18, 1922.	1	2				2

Euploea helcita eschscholtzi.—Although this species is often less abundant than its chief mimic *proserpina*, it was much commoner at Vunilagi—three times as numerous according to Mr. Simmonds' letter quoted below. The male represented on Pl. XXXIV, fig. 6, has been already referred to on p. 612, as tending towards the *walkeri* form in the hind-wing pattern.

Euploea boisduvalii proserpina.—The patterns of the females (Pl. XXXIV, figs. 19–22) are as usual stronger than those of the males (figs. 15–18), and the dyslegnic edges of the markings are very evident. The fore-wing brand of the male represented in fig. 15 is exceptionally small, a good example of the variability of this character.

In addition to Mr. Simmonds' material a male and female from Vanua Levu exist in the British Museum Collection—both of western type.

Euploea tulliolus forsteri.—Concerning this species Mr. Simmonds wrote on June 12, 1921, a few days after taking the butterflies represented on Plates XXXIV and XXXV:—

"At Vunilagi the purple *Euploea* was by far the most abundant of the group, being in the proportions of not less than 5 to 3 of the *eschscholtzi* and to 1 of *proserpina*."

These proportions are all the more interesting because of the comparative scarcity of *forsteri* in Viti Levu. There is probably great variation from time to time in the proportions of all the members of the group. Thus Mr. Simmonds has noted the sudden appearance in numbers of this species on Ovalau (p. 615). Such changes probably play an important part in the rapid evolution of reciprocal mimicry.

The much higher average development of pattern in

the females is well shown when figs. 16–21 are compared with 1–15 on Pl. XXXV; also the much greater variability of this sex, for fig. 21 is less patterned than the darkest male (fig. 15), although the female series is, as a whole, far more strongly patterned.

The development of a hind-wing pattern with two rows of spots seems to be carried further in Vanua Levu than elsewhere in Fiji, but longer series from other islands are required in order to confirm this impression. It will be seen from Pl. XXXV that this feature is more strongly developed in the females, although figs. 4, 6 and 8 represent males in which both rows of spots are distinct. All the specimens sent by Mr. Simmonds are *forsteri* except three male and one female *protoforsteri* (Pl. XXXV, figs. 13–15, 21).

Euploea nemertes macleayi.—I only know of a single specimen of this species from Vanua Levu, a female of western type (like Pl. XXXVII, fig. 8) from the south-east coast, in the British Museum.

(*f*) Taveuni.

(Plates XXXVI, figs. 3–12; XLIII, figs. 1, 2. *All figures quoted without further reference are from Plate XXXVI.*)

Three of the Fijian Euploeas were collected by Mr. Simmonds, December 11–21, 1921, two of them on March 18, 1922, and a single *proserpina* on March 9 of the same year. The date at which each was captured is recorded in the explanation of the plate. All the Euploeas received are figured except three male *proserpina* (December 19, 1921, March 9 and 18, 1922), with patterns intermediate between those of the males represented in figs. 5 and 6.

Euploea helcita eschscholtzi.—The male (fig. 3) and female (fig. 4) are typical examples of this race.

Euploea boisduvalii.—All are of the race *proserpina* except the male represented in fig. 7, which is beautifully transitional towards *simmondsi*, and more primitive than any in the long Fijian series of the species except the single specimen from Kandavu (Pl. XXXIX, fig. 5), one from Thithia (Pl. XL, fig. 1) and three from Vanua Balavu (Pl. XLI, figs. 1–3). The specimen is also remarkable for its great size and the length and relative narrowness of the male brand on the fore-wing (pp. 594, 595). In this latter respect it confirms the conclusion arrived at from other

specimens, that this secondary sexual character is excessively variable and that to place any reliance upon it for classificatory purposes is extremely unsafe. The appearance of the specimen was so peculiar that I asked Dr. Eltringham if he would kindly examine the armature, but the investigation entirely supported the conclusion that the specimen was *boisduvalii*. It was taken on March 18, 1922, together with one of the unfigured males of *boisduvalii proserpina* and the male of *tulliolus forsteri* shown in fig. 10. Apart from this most interesting specimen, the five male *proserpina* are rather more primitive than those, represented on Pl. XXXIV, figs. 15–18, from the adjacent large island of Vanua Levu, while the more advanced development of the white marginal pattern in the female *proserpina* is strikingly shown when the two Taveuni females (figs. 8 and 9) are compared with the two males shown in figs. 5 and 6 and with the three unfigured examples.

The Hill Museum possesses a male specimen labelled "Niusawa, Taveuni. April. 1905." It resembles fig. 6.

Euploea tulliolus forsteri.—The two males (figs. 10 and 11) and one female (fig. 12) exhibit, like the male *proserpina*, a less developed pattern than that seen in the form from Vanua Levu. When figures 10–12 are compared with 1–21 on Pl. XXXV it will be recognised that the average pattern is distinctly stronger in the latter.

Euploea nemertes macleayi.—Although the Hope Department possesses no example of this species from Taveuni, there are two males and one female from this island in the British Museum. One male is nearly as strongly white-bordered on the fore-wing as the Ovalau female represented on Pl. XXXVII, fig. 13, but the hind-wing spots are very small and few, and the border is dark. The second male is very dark, especially so in the hind-wings, and probably on the whole equals the Balavu male (Pl. XLI, fig. 11). The female resembles Pl. XXXVII, fig. 8.

It is interesting to find that the Euploeas of this, the easternmost island of the western group, are somewhat more primitive than those of any other except the next island Kandavu, which, although not so eastern in position as Taveuni, is far more remote.

(*g*) Kandavu.

(Plate XXXIX. *All figures quoted without further reference are from this plate—figs.* 4–9.)

The little assemblage, taken in this outlying southern island on July 24, 1921, includes one example or more of all the four Fijian Euploeas. All are represented on the plate.

Euploea helcita eschscholtzi.—A typical male (fig. 4).

Euploea boisduvalii.—The single male (fig. 5) is one of the most interesting specimens (p. 628) captured by Mr. Simmonds, being a beautiful intermediate between *simmondsi* and *proserpina*, and nearer to the former than any specimen known from any Fijian island except the eastern Thithia and Vanua Balavu.

Mr. Simmonds referred to this specimen in a passage which, in view of the longed-for series, is somewhat tantalising :—

"*July* 31, 1921.—There is also a *Euploea* from Kandavu, and I think you will find that this differs from the Ovalau form in the smaller area of white spots. I think this was the commonest species at Kandavu, although *tulliolus forsteri* was common."

Euploea tulliolus forsteri.—The single male is western in pattern, having distinct traces of a double series of spots on the hind-wing and a strongly developed pattern on the fore-wing, differing widely in both these respects from the Mango specimens represented in figs. 12–18 on the same plate.

Euploea nemertes macleayi.—The single male (fig. 6) and one of the two females (fig. 7) are rather dark forms for this race, the latter nearly as dark as the Mango female (Pl. XXXIX, fig. 11), the former in some features darker, in others lighter than the darkest Ovalau male (Pl. XXXVII, fig. 6). The second female (fig. 8) bears a more developed pattern, and outside the series of spots the ground-colour becomes pale as in the Ovalau female shown in Pl. XXXVII, fig. 12. The spots, however, are about as in the female from the same island represented in fig. 8 of the same plate.

There is a female from this island in the British Museum series. It is of western type, resembling Pl. XXXVII, fig. 8.

A long series of all the Euploeas from Kandavu is much to be desired. The evidence, so far as it goes, suggests that *eschscholtzi* reached this rather remote island later than those of the western group, and has therefore produced less effect. The assemblage, as a whole, may be compared with that shown on Pl. XL, from the eastern island Thithia (Cicia), where, however, *helcita walkeri* takes the place of *eschscholtzi*.

II. The Islands of East Fiji, including Moala.

(*a*) Moala.

(Long. 179° 50′ E.; Lat. 18° 35′ S.)

This small isolated island is due south of the south end of Taveuni and south of a point midway between Kandavu and the group of three eastern islands to be considered next —Thithia, Mango, and Vanua Balavu.

I have only seen a single butterfly from the island, a male *Euploea tulliolus forsteri* in the British Museum. It is, as we should expect, eastern in pattern, resembling the males from Mango with which it is placed in the Museum series, but the blue spots of the fore-wing show rather more evident traces of white. Its resemblance to a race in the Loyalty Is. has already been mentioned (p. 600).

A good collection from isolated islands such as Moala may be expected to throw much light on the patterns of the original invaders.

(*b*) Thithia (Cicia).

(Plates XXXI, figs. 4, 8; XL. *All figures quoted without further reference are from Plate XL.*)

Mr. Simmonds visited this eastern Fijian island on August 31 and again on December 8, 1921, and collected in Vanua Balavu a day later on both occasions. Two or more examples of each of the four Fijian Euploeas were taken on August 31—(figs. 1–13). The character of the collecting ground is described on p. 627.

The whole of the Euploeas received from Thithia are figured. The assemblage, although darker than in any western Fijian island, is less dark than that of Mango, as will be recognised when figs. 3–8, and 14 are compared with 11–18 on Pl. XXXIX. Comparison with Pl. XLI

will show that the Euploeas of Vanua Balavu were on the whole darker than either of the other eastern islands.

In this and the remaining islands the order of the associated Euploeas is changed in accordance with the plates, the form of *E. helcita*—now the race *walkeri* (although often modified) instead of *eschscholtzi*—being placed last instead of first. This change has been made to indicate that in these eastern islands *helcita* acts as a mimic rather than a model, although there is reciprocal approach on the part of the dark Euploeas which, in most of the examples, is so strong in Thithia that the earlier arrangement would perhaps have been better. But we cannot be sure of this until more specimens have been collected in the island.

Euploea boisduvalii.—Of the two examples fig 1 represents the darkest *simmondsi* hitherto taken in Fiji, except that shown in Pl. XLI, fig. 3. A slight trace of a submarginal pattern is seen at the apex of the fore-wing. Fig. 2, on the other hand, is intermediate between *simmondsi* and *proserpina*, resembling a small proportion of the examples found on western islands, *e. g.*, those from Viti Levu represented on Pl. XXXIII, figs. 5, 6 and 11. Like these last, the specimen from Thithia is well advanced towards *proserpina*, considerably more so than the single example of *boisduvalii* taken on Kandavu (Pl. XXXIX, fig. 5), and rather more than one of those from Taveuni (Pl. XXXVI, fig. 7).

Euploea tulliolus forsteri.—The three males (figs. 5, 6 and 14) and one of the females (fig. 7) are *protoforsteri*, but very near the border-line between this form and *forsteri*, while the second female (fig. 8) is a pronounced example of the latter with two rows of spots on the hind-wing. Faint traces of the same feature are to be seen in the males, especially the one represented in fig. 14. The advance towards the western pattern, although much behind that of West Fiji, is thus ahead of that reached in Mango or Vanua Balavu—a result consistent with the pattern of the intermediate *boisduvalii* (fig. 2).

Euploea nemertes macleayi.—The two females (figs. 3, 4) exhibit a stronger pattern than that of the single female from Mango (Pl. XXXIX, fig. 11), but far weaker than in those from Ovalau (Pl. XXXVII, figs. 8–13). Of the two females from Kandavu, represented on Pl. XXXIX, one (fig. 7) has a somewhat weaker and the other (fig. 8) a distinctly stronger pattern than the examples from Thithia.

All three species of dark *Euploea* seem therefore to show a marked diaposematic approach towards *helcita walkeri*, which itself exhibits traces of reciprocal influence, as will be indicated below.

Euploea helcita walkeri.—The five males (figs. 9–12, and 15) and one female (fig. 13) are all typical examples of this form except one (fig. 11), which approaches *eschscholtzi*. Furthermore, the partial clouding over of the principal fore-wing spot in figs. 9 and 10, its slightly dyslegnic lower border in the others, and the more or less distinct trace of a notch in its outer end, to be seen in all but fig. 9, are modifications, shown by comparison with other island forms, *e. g.*, those figured on Pl. XLII, to be a small variation which may lead towards reduction.

So far as the evidence goes *walkeri* appears to be the commonest of the four species of *Euploea* in Thithia.

(*c*) **Mango.**

(Plates XXXI, figs. 5, 6; XXXIX, figs. 10–18. *All figures quoted without further reference are from* Pl. XXXIX.)

This island is more eastern in position than Thithia, but less so than Vanua Balavu. Mr. Simmonds visited it December 8, 1921, and all the Euploeas received from him are represented in figs. 10, 12–18.

Euploea boisduvalii.—It is very unfortunate that no Mango example of this species exists, so far as I am aware, in any collection. There can be little doubt that it is among the island butterflies; for Mr. G. F. Mathew informs me that he saw four species of *Euploea* there on June 12, 1884. Looking at the reduced patterns of *macleayi* and *protoforsteri* (figs. 11 and 12–18), it is highly probable that the Mango race of *boisduvalii* is *simmondsi*. It is to be hoped that this prediction may be tested at an early date.

Euploea tulliolus protoforsteri.—The five males and two females (figs. 12–16 and 17, 18) are darker than any examples of this *Euploea* sent by Mr. Simmonds from other Fijian islands; and, as the British Museum series of four males and two females is very similar, we may feel confident that this dark butterfly with a greatly reduced pattern in which the partially white spots become entirely

blue, is the prevalent form in Mango. It will be seen that the darkest Oxford specimen (fig. 12), a male, is patternless. In the British Museum series, on the other hand, the darkest, patternless specimen is a female. The hind-wing pattern is wanting, except for two vestigial spots on one male in the British Museum. The faint trace seen on the right side of fig. 18 is due to the under surface spots showing through. This under surface pattern is also extremely reduced in the series of both museums.

There are also in the Hill Museum two examples labelled "Mago" from the Grose-Smith Collection—a male resembling fig. 15, and a female resembling fig. 18.

Euploea nemertes macleayi.—The female represented in fig. 11 was kindly lent me by the British Museum authorities. It was captured by C. M. Woodford on July 18, 1882. Its pattern is much reduced, especially on the hind-wing. There are also two females labelled "Mago" from the Grose-Smith Collection in the Hill Museum. The development of pattern is about equal to that of the Kandavu female represented in fig. 7, and therefore slightly greater than the British Museum example.

Dr. Jordan has kindly compared the Tring examples from Mango with a photograph of the Ovalau specimens shown on Pl. XXXVII. Two males have fewer and smaller spots than those represented in figs. 6 and 7 of that plate; the single female has smaller spots on the fore-wing and fewer on the hind than fig. 8.

Euploea helcita walkeri.—The single example received from Mr. Simmonds is the typical female represented in Pl. XXXIX, fig. 10.

Capt. Riley has kindly sent me a note on the Mango *helcita* in the British Museum. A male has the principal spot of the fore-wing much suffused, like *intermedia*, and the hind-wing pattern intermediate between that of *walkeri* and *eschscholtzi*, but much nearer the latter. Of three females two are typical *walkeri* and the third, in the hind-wing at any rate, typical *eschscholtzi*.

Two males in the Tring Museum are labelled "Mango," with the name "*intermedia*." Both resemble the darkest example from Vanua Balavu (Pl. XXXI, fig. 1), one having the chief spot rather more clouded over than the figure, the other rather less so. The subapical fore-wing spots are much reduced, especially in the former. The specimens are large, like *walkeri* in this part of its range, but

the hind-wing pattern is, as in this Vanua Balavu example, that of *eschscholtzi*.

Of two males in the Hill Museum, one labelled "Mango, 1882," also resembles Pl. XXXI, fig. 1, except that the hind-wing is intermediate between *eschscholtzi* and *walkeri*. The second labelled "Mago," from the Grose-Smith Collection, resembles Pl. XLI, fig. 13, except that in the fore-wing the principal spot is slightly less, and the sub-apical series slightly more, reduced. The hind-wing pattern is as in the last specimen.

More evidence is required, but on the facts before us, the three Euploeas of Mango appear to be darker than those of any other island except Vanua Balavu. Indeed, *protoforsteri* is darker than in this latter island. The two other species are not quite so dark, but there is only one *macleayi* from Vanua Balavu, so that the comparison is not very trustworthy.

(*d*) **Vanua Balavu (Bavatu).**

(Plates XXXI, figs. 1–3, 7; XLI. *All figures quoted without further reference are from* Plate XLI.)

Vanua Balavu, the most eastern Fijian island in which Mr. Simmonds collected, was visited on September 1, and again on December 9, 1921. On this latter date one or more representatives of all four species of *Euploea* were taken, viz. the specimens shown in figs. 3, and 8–15.

The collecting-ground, similar to that of Thithia, was "near sea-level in patches of primitive jungle, perhaps growing on rough limestone land too rocky to cultivate. Naturally these places were the most prolific."

Mr. Simmonds recognised that the dark form of *Euploea boisduvalii* (figs. 1–3) was the local race (*simmondsi*), representing *proserpina* of western Fiji, and that *E. tulliolus protoforsteri* had, in some specimens (*e.g.*, figs. 5 and 8), the "white spots on the upperside almost suppressed."

The whole of the Euploeas received from V. Balavu are represented on Plate XLI. The assemblage of the three dark Euploeas (figs. 1–11) is, on the whole, the darkest of any received from a Fijian island.

Euploea boisduvalii simmondsi.—The three male specimens (figs. 1–3) are all *simmondsi*, figs. 1 and 2 showing a

slight development of the marginal pattern. The position of the minute spot between veins 3 and 4 of the fore-wing foreshadows its inward development in *proserpina*, as will be recognised if the following succession of figures be compared—Pl. XLI, fig. 1; Pl. XXXIX, fig. 5; Pl. XXXVI, figs. 7, 6, 5.

The specimen of *simmondsi* represented in fig. 1 is especially interesting in the pale brown border, clearly recalling an ancestral form in the New Hebrides—*paykullei*, although marginal white spots are never found on the upper surface in this race (pp. 592, 594). The same pale border is feebly indicated in fig. 2 and strongly in fig. 3, but the specimen being worn and faded the resemblance to *paykullei* is less evident.

Euploea tulliolus protoforsteri.—The six males (figs. 4–9) and one female (fig. 10) are the darkest set received from any Fijian island except Mango (Pl. XXXIX, figs. 12–18), two of the males (figs. 5 and 8) being almost patternless and none of the others with strongly developed marginal spots. Reciprocal mimicry is most evident in the female (fig. 10), in which alone a faint trace of a pattern appears on the hind-wing. This last specimen is intermediate between *protoforsteri* and *forsteri*.

Euploea nemertes macleayi.—The single male (fig. 11) is the darkest of any example of the species taken by Mr. Simmonds. It is unfortunately the only specimen from this East Fijian Island.

Euploea helcita walkeri.—The three males (figs. 12–14) and one female (fig. 15) are extremely interesting. They are all probably *walkeri* forms modified by mimetic approach towards the dark Euploeas. Figs. 13 and 14 are typical *walkeri* in the hind-wing pattern and also in the fore-wing except for the partial clouding over of the main spot. Fig. 12 has the hind-wing pattern of *eschscholtzi*, and fig. 15 has nearly reached the same condition, but in size the specimens all resemble *walkeri* from eastern Fiji. The reduction of the principal spot is carried furthest in fig. 12, and both it and fig. 15 show on the outer end of the spot a minute notch which is emphasised in races where the reduction is carried much further, *e.g.*, in the Wallis I. forms (Pl. XLII, figs. 8–12).

III. Wallis and Fotuna* Islands, about midway between Fiji and Samoa.

(Plates XLII, figs. 1–12, Wallis I.: XLII, figs. 13–19; XLIV, fig. 4, Fotuna I.)

These two small islands lie about midway between Samoa and Fiji, Fotuna being 178 stat. miles N.E. of Cape Undu, at the N.E. tip of Vanua Levu, and 296 miles from Nairai, the centre of the Fiji group; Wallis being 322 and 430 miles from the same points, and the two islands 150 miles apart. All the Euploeas received from these islands are represented on the plate.

Mr. Simmonds visited Fotuna May 25 and 26, 1922, and found only one species of *Euploea*, viz. *helcita walkeri* (figs. 13–19). The form is similar to that from the Societies, where it is the only *Euploea*.

Wallis I. was visited, May 30, 1922, and here two Euploeas were found—the *simmondsi* race of *E. boisduvalii* (figs. 1–7) and, accompanying this dark subspecies, a form of *helcita* with greatly reduced markings (figs. 8–12). This is similar to a form from the Ellice Islands, named *distincta* Butl., in the British Museum.

One male (fig. 2) and two females (figs. 6, 7) of *simmondsi* exhibit a reciprocal mimetic approach to the forms of *helcita*, thus resembling some of the examples of *simmondsi* from Thithia and Vanua Balavu. This will become clear when figs. 2, 6, 7 are compared with figs. 1, 2 on Pls. XL and XLI, especially the latter. Unfortunately no female *simmondsi* were received from these two Fijian islands, but on Wallis I. the female represented in fig. 7 exhibits the strongest diaposematic approach to the forms of *helcita*. This is only to be expected in a race conspecific with *proserpina*, but it is to be hoped that far more evidence will become available in the near future.

Mr. Simmonds wrote on June 19, 1922, of his visit to the two islands, pointing out that the *E. helcita* from Wallis and Fotuna were distinctly different, and referring to "a *Euploea* near *proserpina* from Wallis, possibly new." Of the general butterfly fauna he wrote—"Butterflies were not numerous on Wallis or Fotuna, and I did not see *Papilio* or *Atella*, both of which occur in Samoa, and I expected to find them.

* Futuna is the spelling accepted by the P.C.G.N. of the Royal Geographical Society.

"I saw on Wallis—*bolina*, *helcita*, *J. woodfordi*, *D. archippus*, the strange *Euploea*, a skipper and two Lycaenids. Fotuna was the same except for the second *Euploea* and *D. archippus*.

". . . . It was interesting to find so marked a difference between the Euploeas of Wallis and Fotuna."

It would be difficult to find a more convincing illustration of mimetic approach than that afforded by a comparison of the Euploeas on these two islands.

G. THE EVOLUTION OF DANAIDA MELISSA NEPTUNIA FROM PROTONEPTUNIA IN FIJI. PROPORTIONS OF THESE FORMS IN DIFFERENT ISLANDS.

(Pls. XXXII, fig. 10; XXXIII, figs. 15–18; XLIII, all; XLIV, figs. 6, 7. *Figures quoted without further reference are from* Pl. XLIII.)

In the following pages I have adopted the opinion set forth in the British Museum Collection, that the pale Fijian Danaine *claribella* Butl. is a relatively rare female form of *neptunia*. In a previous section (p. 608) the non-mimetic or least mimetic forms of *neptunia*, similar to figs. 1–3, have been given the name *protoneptunia*, *neptunia* being retained for specimens resembling figs. 7–9, which also resemble Felder's figure, figs. 4–6 being regarded as transitional.

The mimetic relationship between this Danaine and the Euploeines is of the greatest interest. It will be seen that in Fiji a high proportion of the specimens of the Danaine have almost or sometimes entirely lost the pale markings on the basal half of the fore-wing and, to a less extent, on the same part of the hind; so that, upon the wing, they superficially resemble the white-bordered, dark Euploeas of West Fiji. What has happened in East Fiji we do not sufficiently know, because only a few examples of the Danaine have been received from these islands. The seven specimens from Taveuni (the western island nearest to East Fiji) and Mango (p. 639) suggest, however, that the reduction of pattern has not been carried so far in the islands where *helcita walkeri* is apparently the only *Euploea* normally possessing a pronounced marginal pattern. Large numbers of specimens from as many islands as possible are very much wanted in order to test this suggestion.

I had always felt confident that *neptunia* was a mimic of the Euploeas ever since I first noticed what was, until 1919, the only example in the University Collection, a dark female taken at Levuka (p. 616). The suspicion was entirely confirmed in 1919, when I received specimens from Mr. Simmonds, and above all his observation that the Danaine " flies with the Euploeas and is very difficult to distinguish when on the wing. They occur as 1 to 20 or 30 of the two Euploeas "—*helcita eschscholtzi* and *proserpina* (Proc. Ent. Soc., 1919, p. lxx). Furthermore, as material accumulated, it became evident that a larger proportion of the females were advanced in the direction of mimetic resemblance than of the males (Proc. Ent. Soc., 1920, pp. lxxx, lxxxi).

Referring to these communications, Mr. G. Talbot, in " Bull. Hill Mus." (vol. i, No. 1, p. 24, 1921), published an excellent figure (Pl. IV, A, fig. 3) of a male about midway between the most developed (*protoneptunia*) and the most reduced patterns (*neptunia*), very similar to that shown on Pl. XLIII, fig. 5.

In order to determine as far as possible the relation of sex and locality to the mimetic reduction of pattern it was important to compare all the specimens that were available—an investigation in which much kind help has been received from scientific colleagues. The results appear in Tables A–D (pp. 632–636).

The figures on Plate XLIII represent specimens chosen to illustrate the progressive reduction of the internal parts of the pale pattern, from fig. 1, showing about the maximum development found in *protoneptunia*, to fig. 9, showing the minimum in *neptunia*. Figs. 1–3 represent, by means of three specimens of *protoneptunia* arranged in the order of gradually increasing reduction of the internal pattern, the group described in Section I of the following Table A, which includes all the specimens of this Danaine received from Mr. Simmonds, over and above the nine shown on the plate, the data of these latter being fully recorded in the explanation. Figs. 4–6 and 7–9 similarly represent, respectively, the groups described in Sections II (transitional) and III (*neptunia*) of Table A. It will be observed that this table also includes Section Ia, not represented on Pl. XLIII. This section was created in order to contain additional transitional specimens which have nearly lost the three basal marks of the fore-wing,

TABLE A.

Specimens of *D. melissa neptunia* in the Hope Dept., collected by H. W. Simmonds, in addition to the nine represented on Pl. XLIII.

I. *Protoneptunia.* Ancestral pattern well developed. Similar to figs. 1–3, and like these arranged in order of increasing reduction in F.W. pattern.

1	S. Viti Levu, Waidoi . .	May 27, 1919.	♀
2	Ovalau	Oct. 23, 1921.	♂
3	Taveuni, Ura	Mar. 18, 1922.	♂
4	S. Viti Levu, Waidoi . .	June 1, 1919.	♂
5	Taveuni, Ura	Mar. 18, 1922.	♀
6	S.E. Viti Levu, Nasinu .	Apr. 10, 1921. Pl. XXXIII, figs. 15, 16.	♂ ♂

IA. *Transitional.* Further reduction of innermost part of F.W. pattern, but retention of mark in outer part of cell, although reduced in the ninth and greatly reduced in the tenth specimen.

7	Ovalau	May 3, 1922.	♂
8	Taveuni	Dec. 11, 1921.	♀
9	S. Viti Levu, Waidoi . .	June 6, 1919. Pl. XLIV, fig. 7.	♂
10	Ovalau	Apr. 30, 1922.	♂

II. *Transitional.* Innermost F.W. pattern as in IA, but the aviform mark in the cell absent. Similar to figs. 4–6, and like these in order of increasing reduction of F.W. pattern.

11	Naviti, Yasawa Group .	Oct. 13, 1921. Pl. XXXII, fig. 10.	♂
12	S.E. Viti Levu, Nasinu .	Dec. 18–19, 1919.	♀
13	Ovalau	Oct. 23, 1921.	♂

III. *Neptunia.* Inner half of F.W. patternless or with faint traces only, and of H.W. greatly reduced in darkest specimens. Similar to figs. 7–9 and similarly arranged. The last six specimens with F.W. as dark as in figs. 8 or 9, but H.W. of none quite so patternless as in fig. 9.

14	S. Viti Levu, Waidoi . .	May 27, 1919.	♀
15	S.E. Viti Levu, Nasinu .	Apr. 10, 1921. Pl. XXXIII, fig. 17.	♂
16	S. Viti Levu, Waidoi . .	June 5, 1919.	♂
17	S.E. Viti Levu, Nasinu .	Apr. 10, 1921. Pl. XXXIII, fig. 18.	♂
18	S. Viti Levu, Waidoi . .	June 20, 1919.	♀
19	Ovalau	May 3, 1922.	♂
20	S. Viti Levu, Waidoi . .	June 1, 1919.	♂
21	S.E. Viti Levu, Lami . .	Aug. 28, 1920. Pl. XLIV, fig. 6.	♂
22	„ „ „	Aug. 28, 1920.	♂

but still retain the irregular aviform mark in the outer part of the cell, as in Pl. XLIV, fig. 7.

Great care has been taken to insure that the sections in the different tables correspond with one another, and for this purpose the nine specimens shown on Pl. XLIII and the four in Ia of Table A were taken to London in order that the British Museum series of *neptunia* might be compared with them.

In addition to the splendid series collected by Mr. Simmonds, the Hope Department possesses the female *neptunia* from Levuka mentioned on p. 616. It resembles No. 27 of Table B, and, like it, is very nearly as dark as fig. 9. Furthermore, the collection recently presented by Admiral Edmund Bourke contains three male *neptunia*, collected January 1893, either at Suva or Levuka. Two resemble fig. 7, and one fig. 8.

TABLE B.

Specimens of *D. melissa neptunia* in the Zoological Museum, Tring.

I. *Protoneptunia.* As in Table A and similar to figs. 1–3.			
1	Suva, Nov. 1894: Wet Season. Woodford .	Resembles fig. 1.	♀
2	Fiji	,, ,, 2.	♂
3	Fiji	,, ,, 2.	♂
4	Suva (1895). Woodford	,, ,, 3.	♂
Ia. *Transitional.* As in Table A. An example is shown on Pl. XLIV, fig. 7.			
5	Fiji	Resembles No. 8 of Table A.	♂
6	Suva (1895). Woodford	,, No. 8 ,, ,,	♀♂
7	Suva, Nov. 1894: Wet Season. Woodford .	Slightly darker than No. 10 in Table A. Probable beak-mark on R.F.W.	♂
8	Fiji	Slightly darker than No. 10 in Table A.	♀
II. *Transitional.* As in Table A and similar to figs. 4–6.			
9	Fiji	Resembles fig. 5.	♂
10	Fiji	Between figs. 5 and 6.	♀

III. *Neptunia.* As in Table A and similar to figs. 7–9.			
11	Fiji (85)	Resembles fig. 7.	♂
12	Fiji	,, ,, 7.	♂♀
13	Fiji	,, ,, 8.	♂♀
14	Fiji	,, ,, 8.	♂
15	Coll. Felder (5) "*neptunia*"	,, ,, 8.	♂♀
16	Suva, Nov. 1894: Wet Season. Woodford .	Between figs. 8 and 9. Very faint trace of line within inner margin of F.W. Probable beak-mark on L.F.W.	♀
17	Fiji (85)	Resembles No. 16.	♀
18	Fiji	,, ,, 16.	♂♀
19	Fiji	Between figs. 8 and 9.	♂
20	Suva, Nov. 1894: Wet Season. Woodford .	,, ,, ,, ,,	♂♀
21	Fiji	,, ,, ,, ,,	♂
22	Suva, Nov. 1894: Wet Season. Woodford .	,, ,, ,, ,,	♂
23	Suva, XI, XII, 1894. Woodford . . .	,, ,, ,, ,,	♀
24	No data	Nearly as dark as fig. 9, even in H.W.	♀
25	Fiji	Nearly as dark as fig. 9, even in H.W.	♀
26	Fiji	Nearly as dark as fig. 9, even in H.W.	♀
27	Suva, Nov. 1894: Wet Season. Woodford .	Nearly as dark as fig. 9, even in H.W.	♀

TABLE C.

Specimens of *D. melissa neptunia* in the British Museum.

I. *Protoneptunia.* As in Table A.			
1	Fiji (Crowley) . . .	Lighter than fig. 1, especially in H.W.	♀
2	Fiji (Crowley) . . .	Resembles fig. 1.	♂♀
3	Fiji (Godm. and Salv.).	Resembles fig. 2, but H.W. very dark, compared with figure.	♂
4	Fiji (Godm. and Salv.) .	Resembles fig. 3.	♂
Ia. *Transitional.* As in Table A.			
5	Fiji (Crowley) . . .	Resembles No. 7 of Table A.	♂
6	Tairuni, Mango, IX, 1882. Woodford .	,, No. 8. ,, ,,	♀

II. *Transitional.* As in Table A.			
7	Fiji (Godm. and Salv.) .	Resembles fig. 4.	♂
III. *Neptunia.* As in Table A.			
8	Fiji (Godm. and Salv.).	Resembles fig. 8.	♂
9	Natova, Fiji, 25. X. 1918. R. Veitch. . . .	,, ,, 8.	♂
10	Fiji (Crowley) . . .	,, ,, 8.	♂♂
11	Fiji (Crowley) . . .	,, ,, 8.	♂♀
12	Fiji (Hewitson) . . .	,, ,, 8.	♀
13	Fiji (Hewitson) . . .	,, ,, 8.	♂
14	Fiji (Rego : G. and S.).	,, ,, 8.	♂♂
15	Suva, II–III, 1886. Woodford . . .	,, ,, 8.	♂
16	Fiji (Rego : G. and S.).	,, ,, 9, but H.W. not so dark as fig.	♂
17	Fiji (Hewitson)	Resembles No. 16.	♀

In addition to the 18 specimens tabulated above, 2 others in the British Museum Collection are considered separately.

The name *claribella* was given by Butler to a remarkable female with the pale markings immensely developed and confluent over the basal area of both wings. The type bears "Viti" (= Fiji), and was purchased from the Godeffroy Museum in 1882. That the locality is correct is shown by a second female with the data "Natova, Fiji, 27. X. 18. R. Veitch." It was therefore taken within two days of the capture of male No. 9 in the above Table C. *Claribella* is, I believe, correctly labelled in the British Museum series as a female form of *neptunia*. If this be so, its female, like that of *Euploea tulliolus forsteri* (pp. 619, 620), varies in both directions—towards a stronger pattern and towards a weaker one—more freely than the male.*

The second specimen, also a female, is from the Banks Collection. It bears the locality "Fiji," but has been labelled "probably from Tonga." The basal part of the fore-wing resembles fig. 9, but the distal markings are

* On January 14, 1920, Mr. Simmonds wrote: "I took what I believe to be a lovely variety of *neptunia* in which the greenish-white ground-colour is enormously extended, when it makes a beautiful insect." There can be little doubt that this is a third example of *claribella*, and it will be very interesting to know whether it is a male or female.

very strong, and the hind-wing markings even stronger than in fig. 1. The specimen, if from Fiji, supplies further evidence of the superior power of variation in the female of this race.

TABLE D.

Specimens of *D. melissa neptunia* from the Hill Museum, Witley.

I. *Protoneptunia.* As in Table A.			
1	Tairuni, Fiji, 1882. [Mango. Compare data of No. 6, Table C.]	Resembles fig. 1.	♂
2	Suva. Woodford . .	,, ,, 2.	♂
3	Suva	,, ,, 3.	♂
Ia. *Transitional.* As in Table A.			
4	Fiji	Between Nos. 9 and 10 of Table A.	♂
II. *Transitional.* As in Table A.			
5	Suva	Resembles fig. 5. Bull. Hill Mus., Vol. i, pl. IV, A, fig. 3.	♂
III. *Neptunia.* As in Table A.			
6	Fiji	F.W. resembles fig. 9; H.W. is between figs. 7 and 8.	♂
7	Fiji	Resembles No. 6.	♂
8	Fiji: Rego	,, No. 6, but H.W. resembles fig. 8.	♂

The whole of the specimens in the tables, with the additional specimens in the Hope Department, are tabulated on p. 637, so as to show the distribution of the sexes in the four sections.

Thus, 33 out of 65 males, or $\frac{1}{2}$, are in Section III (*neptunia*), with the most reduced pattern; 14 out of 24, or $\frac{7}{12}$, of the females. At the opposite end of the scale, with the greatest development of pattern, the difference

is more striking, 17 out of 65 males, or about $\frac{1}{4}$, being in Section I (*protoneptunia*), and 4 out of 24, or $\frac{1}{6}$ of the females.

Stages in reduction of pattern.	*Proto-neptunia.* I. As in Figs. 1–3.		*Trans-itional.* Ia. As described in Table A and shown on Pl. XLIV, Fig. 7.		*Trans-itional.* II. As in Figs. 4–6.		*Neptunia.* III. As in Figs. 7–9.		Totals.
Sexes . . .	♂	♀	♂	♀	♂	♀	♂	♀	
Pl. XLIII (Hope Dep.) . . .	3				3		2	1	9
Table A. (Hope Dep.) . . .	5	2	3	1	2	1	7	2	23
Bourke Coll. and Hope Dep. .							3	1	4
Table B. (Tring Mus.) . . .	3	1	2	2	1	1	10	7	27
Table C. (Brit. Mus.) . . .	3	1	1	1	1		8	3	18
Table D. (Hill Mus.)	3		1		1		3		8
Totals . .	17	4	7	4	8	2	33	14	89

The greater development of mimicry in the female *neptunia* is more convincingly proved by noting the sex of the specimens which resemble or most nearly approach fig. 9, representing the most perfect mimic hitherto seen. It is a female and so is the specimen from Levuka in the Hope Department which is nearly equal to it. The four darkest specimens in Table B are females, as is one of the two darkest in Table C, all five approaching fig. 9.

In this, the most completely mimetic pattern attained by *neptunia*, it is the extent to which the hind-wing participates which becomes the chief criterion, the fore-wing having almost or entirely lost its internal pattern while much remains upon the hind. In this later stage of elimination the female has a distinct advantage over the male from the existence of sexual dimorphism—I believe hitherto unnoticed—in the species grouped by Moore under his genus *Tirumala* (P.Z.S., 1883, pp. 230–233). The characteristic V-like mark in area 2 of the hind-wing and the smaller one in area 3 are, in nearly all the species, shorter

and often vestigial in the female. The reduction in length, which is accompanied by a thickening of the remaining portion, proceeds from the distal end and often leaves only the point of the V. In the species with little or no shortening the female marks are still distinguished by a thickening. In *neptunia*, however, the shortening is pronounced, even in the strongly-patterned *protoneptunia* form, and, in the most perfect mimics (fig. 9), leads to the entire disappearance of the marks from both areas. But this is not the whole explanation of the more complete loss of pattern in the hind-wing of this sex. The existence of the scent-pocket in area 1c reduces the adjacent marks of the male, which are therefore in this area much longer in the female of *protoneptunia*. But these marks, together with others on the basal half of the hind-wing, disappear or become vestigial in the most completely mimetic females. And yet, as regards the marks in area 1c, sexual dimorphism gives the advantage to the male—an advantage over-ridden by female variation and the pressure of selection.

Another interesting result is the concentration of specimens at the two ends of the scale and especially in Section III, which contains over half of the total. It is probable that the examples in Sections Ia and II, the transitionals bridging the gap between the extremes and making the whole series exceedingly "continuous," are in large part due to interbreeding between *neptunia* and *protoneptunia*.

The table strongly suggests that natural selection is favouring the pattern of *neptunia*, especially in the females, and perhaps also that female variation makes available for selection a larger proportion of butterflies with reduced patterns than are produced by the males.

The following table, unfortunately very limited because of the number of specimens with "Fiji" only upon them, holds out the hope that, with future material from many islands of the group, collected as Mr. Simmonds or Mr. Woodford collected it, we may be able to decide whether the proportion of females in Section III (*neptunia*) is due to natural selection alone or to natural selection aided by freer variation, also to decide whether *protoneptunia* exists as a subspecies in any of the islands.

Stages in reduction of pattern.	I. *Proto-neptunia.*	Ia. *Transitional.*	II. *Transitional.*	III. *Neptunia.*
Naviti, Yasawa Is. .			1	
Viti Levu	7	3	2	17*
Ovalau or Viti Levu (Bourke) . . .				3
Ovalau	2	2	4	3
Taveuni	4	1		
Mango	1	1		

All the islands mentioned in the above table, except Taveuni and Mango, belong to the western part of the group in which the marginal patterns of the Euploeas are best developed. In Taveuni (p. 620), the most eastern of these western islands, patterns transitional towards the dark eastern forms occur as well as the others. In Mango (p. 625) the Euploeas are darker than in any part of known Fiji except Vanua Balavu. It may be significant that in this island and Taveuni the seven specimens are either *protoneptunia* or transitional, with patterns ancestral as compared with those of the great majority of the examples from the other islands in the table. More material is wanted to test this suggestion; but it is not unreasonable to suppose that the reduction of pattern, although it has produced mimicry of the western type of Euploeas, leads to no advantageous resemblance to the dark eastern type and has therefore not been selected.

H. HYPOLIMNAS BOLINA L., IN FIJI AND POLYNESIA.

Further evidence that West Fiji was, like East Fiji, inhabited by dark Euploeas is provided by a mimetic female form of *Hypolimnas bolina* which has retained the appearance now lost by its models in the west. This mimetic female is well shown in Pl. XLV, fig. 3, as well as in Pls. XLVII, fig. 4; XLIX, fig. 6; LII, fig. 3; LIII, figs. 1, 2. Its dark surface, which is almost patternless except for the submarginal series of small white spots on the fore-wing, presents a remarkably close resemblance to the dark Euploeas of East Fiji, shown on Pl. XXXI, figs. 3–8.

* No. 9 of Table C is included, as it is believed that Natova is in Viti Levu.

This mimetic female is, however, only one out of a considerable series of forms which have been described as distinct species by various authorities, especially Dr. A. G. Butler. The names can now be conveniently retained for the female forms.

The credit of the discovery that these Polynesian butterflies with so many and such different female patterns are all forms of one species, belongs to Mr. Gervase F. Mathew, F.E.S., who, on November 4, 1885, "exhibited a number of specimens of *Hypolimnas Bolina*, Linn., from Fiji and other islands of the Western Pacific. They were interesting from the fact that many of them were bred from a single brood of larvae found near Levuka. The males varied in no way whatever, but of the females, of which forty-eight were exhibited, scarcely two were alike, and the difference between the two extremes was very great. . . . From a short examination of the types at the British Museum, he felt sure that several which had been described as new within the last few years were referable to this single species, for from this brood were bred individuals agreeing with varieties from the Gilbert, Ellice, and Marshall islands, the New Hebrides, New Guinea, Tonga, Samoa, etc. The larvae were identical, fed upon the same food-plant, and were altogether similar in their habits. None of the females were found mimicking *Danais Erippus*. Mr. Mathew proposed that it might be advisable to collect these varieties together, and unite this oceanic race under one specific name." (Proc. Ent. Soc., 1885, p. xxvi.)

In addition to *bolina* an apparently allied new species of *Hypolimnas* has recently been discovered by Mr. Simmonds in Viti Levu and described as *H. inopinata* by Mr. G. A. Waterhouse in Proc. Linn. Soc., N.S. Wales, xlv (1920), pp. 468, 469. The female is larger and more highly coloured on the under surface than the male. The species is mentioned here because it is probably mimetic of the males and male-like females of *bolina*; but whether the close resemblance between the patterns is due to affinity or mimicry or both together is a subject for future investigation. *H. opinata* appears to be common where Mr. Simmonds discovered it in the rain-forests (200–500 ft.) of south-east Viti Levu,* for he wrote on January 27, 1920, of a week-end at Waidoi—"I saw about ten of the new

* Mr. Waterhouse records that a male was also taken by Mr. E. J. Goddard at Nasogoto, Navai, Fiji.

Hypolimnas, but all were badly damaged. I only took two"; and again on March 16, 1921—"The specimen came from the rain-forest above Waidoi where it was not uncommon but most difficult to catch." We may hope that the life-history will soon be made out and its true affinity discovered.

(a) *Invasion of Fiji and Polynesia by H. bolina from the West and the Changes undergone in the new Home.*

There can be little doubt that the invading *bolina* belonged to the race now inhabiting the south and south-east islands of the Malay Archipelago, and north Australia—a race whose predominant female form is generally known as *nerina* F., resembling Pl. XLV, fig. 2, but with larger white and reddish markings. The suggestion that this form arose in Celebes, as a mimic of *Danaida chionippe* Hübn., was made by the late Col. Charles Swinhoe (Journ. Linn. Soc. Lond., Zool., xxv (1896), pp. 342, 343); and no other model, except this or some allied island race near *D. malayana* Fruhst.,* is likely to be proposed for it. The difficulty remains that the model appears to be comparatively rare and is certainly restricted in range, while the mimic is extremely common and wide-ranging. It is possible, however, that the Danaine was formerly abundant in the locality where the *nerina* female was evolved, and that the acquisition by mimicry of a conspicuous type of warning pattern was advantageous to an independently distasteful Müllerian mimic (cf. pp. 647, 648), and facilitated its spread into areas far outside the range of its model. It is even possible that the model is still abundant in the original area unvisited by collectors, or that it is neglected because it is so common.

The hypothesis that the pattern was originally mimetic and has spread beyond its model gains in probability when

* Fruhstorfer regards *malayana* as a race of *D. affinis* F., but "almost worthy of specific rank" (Seitz, ix, p. 201). His experience with *malayana* supports the opinion that the Danaine model of the *nerina* female, though hitherto barely noticed, may still be abundant:—"For a decade only one male was known" and even its supposed locality, the Malay Peninsula, was doubtful. Nevertheless, he found the butterfly fairly numerous at Bangkok (*l.c.*). Fruhstorfer gives the locality of *chionippe* as Timor, and, from his description and the series of Danaines in the British Museum, it is evident that this butterfly was not the model for *nerina*, but a race with a pattern closely resembling *malayana*.

the history of the most western form of *bolina* is taken into account. In India, Burma, etc., the female is the well-known form, mimicking dark, white-bordered Euploeas with patterns of the *core* and *coreoides* type. Three of the models from South India are represented by Maj. Moulton in Trans. Ent. Soc., 1908, pl. xxxiv, figs. 1–3, 6–8. But *bolina* with this well-marked type of mimetic female has also spread a long way beyond the range of its models. It was discovered in Socotra by W. R. Ogilvie Grant in 1899 (Bull. Liverpool Mus., ii, (1900), p. 10). A small male of the wet-season form, taken between July 1900 and March 1901, in Mauritius, by Capt. J. B. G. Tulloch, exists in the British Museum Collection. I have also been informed by my friend Mr. J. A. de Gaye, F.L.S., that he took the male on the shore at Cassis, Mauritius, in December 1902, and that he gave the specimen to the late Col. N. Manders; also that the female was taken in the island six months later, at Val Ory, Moka, by M. Réynard.*

The Indian race of *bolina* was, so far as I am aware, first seen in Madagascar, in Feb. 1903, by Mr. de Gaye, who captured both male and female examples in the garden of the British Consulate at Tamatave. The specimens were given to the Carnegie Library in Mahé, Seychelles. The butterfly was then taken by Archdeacon Kestell-Cornish, now Bishop of Madagascar, in January 1911 (Proc. Ent. Soc., 1916, p. xxiii). Since that date its increase in the district where it appeared in 1911—Mahanoro, on the east coast—has been very rapid (*ibid.*, 1915, p. lxi; 1916, p. xxi). M. Charles Oberthür, who has had such a long and intimate experience of Lepidoptera from Madagascar, had never seen an example of *bolina* from the island until his brother received it from the southern area in May 1920 (*ibid.*, 1920, p. lviii).

The observations recorded above supply abundant evidence of the power to spread and increase possessed by *H. bolina*. Even more convincing is the island race †

* These three Mauritian records of *bolina* are evidently the same as those published by the late Col. N. Manders (Trans. Ent. Soc., 1907, p. 442). Capt. Tulloch's specimen in the B.M. is briefly mentioned, the date of Mr. de Gaye's male given as Feb. 1906, and a female from the Moka district (evidently M. Réynard's) stated to be in the Port Louis Museum.

† This subspecies has not been described. In the hope that

established on the Chagos Islands in the Indian Ocean, far to the north-east of Mauritius, Bourbon and Rodriguez.

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more attention will be paid to it and a search made for transitional forms and for the Euploeine model, a short description is here given.

Hypolimnas bolina euphonoides n. s.-sp.—*Female.*—The oblique white bar of the *fore-wing* either very narrow or (in one example out of three) broken up into separate small spots. An extensive, iridescent blue suffusion spreads over a broad area round the narrow oblique bar of two specimens forming, in one of them, a very prominent feature. In the *hind-wing* there is a marked development of the marginal and submarginal pattern, and the chief mark (yellowish in two examples) is prolonged, narrowing, towards the anal angle.

Male.—The two specimens in Brit. Mus. differ from the Indian males in the blackness of the general tone of the under surface, especially in the marginal area of the hind-wing.

Types: ♂ ♀ in Brit. Mus. Coll. The ♂ is No. 1 below. The ♀ (No. 5 below) resembles fig. 3 in Trans. Linn. Soc. Lond., Ser. ii, Zool., vol. xiii, pl. 17, and is probably the specimen there represented.

The effect of the above-described development of pattern in the female is to produce a striking resemblance to *Euploea euphon* F., at present only known from Mauritius. In the fore-wing this likeness is increased in one specimen by the breaking up of the oblique bar into spots. Upon the wing the area of iridescent blue would probably resemble the corresponding part of the fore-wing of *euphon*.

Prof. T. Bainbrigge Fletcher (*ibid.*, p. 291) states and Commander Walker quotes in Proc. Ent. Soc., 1919, p. cxii, that the Chagos females of *bolina* resemble those from Palawan in the Philippines. Being unable to visit the British Museum at the time I asked Capt. Riley if he would compare the females from these two localities. He has very kindly sent me the following list of the Chagos specimens, together with the results of the comparison he has made.

"1. ♂. Chagos Is. Ile Anglaise. 31.5.1905. T. B. Fletcher.
"2. ♀. „ „ „ „
"3. ♂. „ 'J.S.G.' (in MS. J. Stanley Gardiner), no date. T. B. Fletcher.
"4. ♀. Chagos Is. Ile Boddam. 3.6.05. T. B. Fletcher.
"5. ♀. „ Peros Banhos, Ile du Coin, 25.6.05. T. B. Fletcher.

"All 3 ♀♀ from Chagos Is. have the submarginal white dots well developed, Nos. 2 and 4 much as in Palawan ♀♀, No. 5. larger than in Palawan ♀♀. The transverse white band just beyond cell of F.W. is very variable—as in Palawan ♀♀. The H.W., however, is much paler than in any Palawan specimen we have, the white discal patch being produced towards anal angle so as to form quite a distinct band rather than an oval patch."

The differences described by Capt. Riley, and especially the band-like modification of the chief H.W. mark, are such as to promote strongly the resemblance to *euphon*.

Prof. T. B. Fletcher states (*ibid.*, pp. 290, 291) that altogether 14 ♂♂ and 5 ♀♀ were taken in the Chagos group, and he quotes the

This race must have reached these islands long ago, for the female form is different from any other in the known range of *bolina*, being an evident mimic of *Euploea euphon* F., now only known in Mauritius, but mimicked by the female of *Papilio phorbanta* L. in Bourbon,* and therefore formerly a resident in that island. A glance at the map of the Indian Ocean at once suggests that this Oriental *Euploea* and *E. mitra* Moore, of the Seychelles, reached their present localities by way of the Laccadive, Maldive, and Chagos groups and the islands between them; thence westward and south-westward by many other scattered islands. The route of the invading *euphon* clearly passed through the Chagos Group, and it is not an extravagant exercise of the imagination to see in the race *bolina euphonoides* the persistent effect of its residence in these islands. It is but an extension of the hypothesis advanced by Col. Manders to account for the phenomena in Bourbon, although he also suggested a special cause for the model's disappearance, viz. the accidental introduction by the sugar-planters of the competing *Euploea goudoti* Boisd.

It is possible that *euphon* still exists in some of the immense number of islands referred to above, or it may be that it has now disappeared after a residence long enough to have acted as the model for the female *bolina* in the Chagos Islands. Dr. G. C. Bourne, F.R.S., states that the greatest elevation reached in Diego Garcia is from 25 to 30 ft. (P.Z.S., 1886, p. 331), indicating conditions which, as in the Pacific, may be unfavourable to the permanent residence of a *Euploea*, but not to *H. bolina*. But the

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following localities: Salomon Atoll, Peros Banhos, Diego Garcia and Egmont Atoll.

Commander Walker (*l.c.*) speaks of Dr. G. C. Bourne's captures of *H. bolina* in Diego Garcia, but although this species is included in the list of butterflies in P.Z.S., 1886, p. 333, I have no doubt that *H. misippus* L. was intended. The two names have often been confused; and the male butterfly presented to the Hope Department by Dr. Bourne is *misippus*. It was taken Dec. 22, 1885, and the captor remembered that it was pursuing a butterfly with a very different appearance, evidently the mimetic female. It is an addition to the species hitherto recorded from the Chagos Is.

* Also mimicked by *Salamis augustina* Boisd., formerly known to exist in Mauritius and still to be found, although very rare, in Bourbon. For this and the mimicry of *Pap. phorbanta*, female, see Proc. Ent. Soc., 1908, pp. iv–vii, xlii–xliv and references there given.

great need is further careful investigation of these islands, an investigation almost certain to throw further light on the Chagos race of *bolina*, even if its model has now entirely disappeared from the track by which it reached the western side of the Indian Ocean.

Returning to the invasion of Fiji and Polynesia by *H. bolina* with a predominant female of the *nerina* form, it will be found that in Australia, and wherever *nerina* occurs in the Malay Archipelago and the associated island groups, the amount of "*nerina* red" in the fore-wing of the female varies greatly in extent and in tint, passing usually from red to orange as it covers a larger and larger area; furthermore, that the chief mark of the hind-wing is often bordered externally with orange, the amount varying from a narrow to a very broad edging, occasionally passing inwards and replacing the white patch. A female form in New Caledonia, with great extension of orange in the fore-wing and, in the hind, of the white patch, with a broad border of orange externally, narrow basally, was described by Dr. A. G. Butler as *pulchra* (P.Z.S., 1874, p. 281, pl. xliv, fig. 2). Its pattern, as suggested by the author, resembles the *alcippus* form of *D. chrysippus*, and it helps us to understand the origin of the mimetic female in the closely allied *H. misippus* L. It is possible that *pulchra* may have gained some advantage by its very rough resemblance to *D. petilia*. However this may be, there is little doubt that in Fiji and Polynesia a further great development of orange, starting from a form resembling *pulchra*, led to the most remarkable of all known female forms of *bolina*, viz. the orange or yellow, occasionally nearly white, female named *pallescens* Butl. (Pl. L, figs. 1, 2), well known in Fiji, the Friendlies, and probably some other Polynesian groups. But we are also obliged to assume that *nerina* itself was present as an invader, for in all parts of Polynesia traces of the "*nerina* red," and sometimes the complete pattern, although in a somewhat reduced form, are liable to appear.

No Euploeine model, except the forms of *helcita* (p. 580), is known, and probably no other has ever existed, in the great majority of the Polynesian groups, and we find that the females of *bolina*, as they spread eastward, tend to lose their polymorphic forms and resemble the male pattern, a tendency especially marked in the Societies. But even

here *nerina*-like forms exist. The first few Tahitian examples received from Mr. Simmonds were male-like (Proc. Ent. Soc., 1920, pp. lxxii–lxxv), but a later and much larger consignment of bred specimens included several with the reduced *nerina* pattern.

In Fiji, with four species of *Euploea*, it has already been stated (p. 639) that there is a beautifully mimetic female * *bolina*, probably derived, by suppression of markings, from one of the male-like forms.

All the female forms of *bolina* in Fiji and Polynesia may, I believe, be classified in three sections :—

A. Non-mimetic forms derived from the *nerina* pattern, either directly, or more commonly by a continuation of the changes begun in *pulchra*.

B. Male-like forms.

C. The mimetic *euploeoides* derived from a male-like form.

It will also be shown that the forms in one section commonly exhibit traces of patterns which fall into another section. The attempt to carry the classification further under heads A and B, with full references to the coloured plates, will be found on pp. 652, 653, in the part of this memoir which describes the families of *bolina* bred by Mr. Simmonds.

(b) *The Life-history and Habits of H. bolina in the Pacific, discovered by G. F. Mathew and J. J. Walker.*

The beautiful plate (XLV) representing the life-history of the Fijian *bolina* has been reproduced from a coloured

* I propose the name *euploeoides* for this mimetic Fijian form which may perhaps be found in other Pacific islands where *E. boisduvalii simmondsi* occurs, or formerly existed.

Euploeoides n. female f.—Characterised by the suppression of the chief marks, the obscurity of the marginal pattern, and the retention, in the fore-wing, of the series of small submarginal white spots, parallel with the outer margin, and culminating in two subapical spots, of which the first is much larger than the others and the second (nearest to the costa) rather larger.

It will be observed that this mimetic pattern has been entirely evolved by suppression or reduction of markings.

Type ♀, No. 2 (p. 661) in all-female Family 7, of female parent W. from Kandavu, Fiji. Hope Dept., Oxford University Museum.

This female form is very liable to exhibit traces of the patterns of other forms. It is represented pure on Pl. XLV, fig. 3; combined with a trace of "*nerina* red" on Pl. LIII, fig. 2; of orange margin on Pl. LII, fig. 3; of chief marks, fuscous on F.W., blue on H.W., on Pl. XLVII, fig. 4; of the F.W. mark alone on Pl. XLIX, fig. 6.

drawing kindly lent to me by Mr. Gervase F. Mathew. "It was," as he has written, "difficult work having to do my painting on the ward-room table of a small ship, where the light was often very bad, and interruptions frequent. My own cabin was far too dark. The two females are figures of the most common form of that sex. I think they were about equally numerous."

Mr. Mathew has also kindly looked through his notes * made at the time, showing that he captured or observed the butterfly or its larvae in the following Pacific islands in addition to Fiji :—

Funafuti, Ellice Islands, May 29, 1883—larvae.

Matthew I., Gilbert Group, June 9, 1883—larvae.

Pitt I., Gilbert Group, June 10, 1883—the only butterfly seen, also larvae.

Majuro I., Marshall Group, June 16, 1883—the only butterfly seen.

Jaluit, Marshall Group, June 19, 1883—butterfly abundant and larvae numerous.

Kusaie, Caroline Islands, June 28, 1883—butterfly plentiful at Kusaie and Ponapé.

Norfolk I., May 28, 1884—*bolina* present in a collection received from the island.

Apia, Samoa, June 20, 1884—many *bolina* : the females varied a good deal. Also at Pango Pango, June 26.

Tonga, July 7 and 8, 1884—*bolina* noted on both days, in great numbers on the 8th.

Ne afo, Vavua I., Tonga Group, July 18, 1884—*bolina* plentiful and the females varied excessively.

"For some of the islands visited I made no note as to whether it occurred or not, though I am pretty sure it did. —G.F.M."

Mr. Mathew has also kindly summed up his experience of *H. bolina* in the Pacific in these words :—"*Bolina* was the commonest and the most widely spread butterfly among the islands of the Pacific I visited. It was a great favourite of mine, and was a very fearless insect. In the heat of the day they were fond of hiding themselves on the

* These notes were in part published by Mr. G. F. Mathew in Trans. Ent. Soc., 1888, pp. 149–151, together with an account of the habits and life-history of the Polynesian *H. bolina*. It is there recorded that the egg is yellow and that the larva feeds on two species of *Sida* and "a convolvulus"; also, as Mr. Mathew believed, on "various species of *Portulaceae*."

undersides of leaves by the sides of the footpaths through the woods, and when one passed they would dash out almost into one's face. When sitting feeding on flowers the females were so tame they would almost allow one to stroke them—but the males were more wary."

Commander Walker, who has also had a very wide acquaintance with this butterfly in the Pacific and has published many notes on it in the Entomologist's Monthly Magazine, has read Mr. Mathew's account and tells me that it entirely describes his own experience. The habits, as observed by both naturalists, strongly suggest that the butterfly is specially protected, and that the *Euploea*-like female is a Müllerian mimic. This conclusion receives further support in the migration of the mimetic forms of *bolina* into areas far removed from their Euploeine or Danaine models and their rapid increase and predominance in these areas (pp. 641, 642).

Mr. G. F. Mathew was on H.M.S. "Espiegle" at Fiji, when he first found the larvae of *bolina* in a valley near Levuka, Ovalau, on June 13, 1882. He has kindly extracted the following note from his journal, referring to that date: "I noticed plenty of *D. erippus* [*plexippus*], together with their larvae; *D.* [*H.*] *bolina* and I believe their larvae, for I discovered a spiny larva somewhat similar to that of *A. aglaia* feeding in plenty upon an unknown shrubby plant."

On the following day Mr. Mathew observed that these larvae "seemed to be somewhat crepuscular in their habits, for I noticed that they ascended their food-plant and became much more conspicuous towards sunset. I boxed a couple of dozen of the largest ones and also 2 pupae which I found hanging low down on the plant." On June 22, at Aneiteum, in the New Hebrides, a male *bolina* emerged from a pupa of which the larva had been collected in Fiji, thus proving the correctness of Mr. Mathew's surmise.

The food-plant was "a common little shrubby-looking plant with yellow flowers which grew in clumps along the beach just beyond high-water mark." Mr. Mathew afterwards found the larvae feeding on allied plants with similar habits, at Funafuti, Matthew I., Pitt I., and Jaluit, Marshall Islands.

I submitted the coloured drawing of the plant, reproduced on Plate XLV, to my friend Dr. O. Stapf, F.R.S., of Kew.

He kindly wrote, October 20, 1923: "It is no doubt a *Malvacea* and very probably a species of *Sida*. Beyond that I would not go. There are very many species of *Sida* spread all over the tropics, and not a few are regular weeds which may turn up anywhere. There are few *Sidas* recorded from Fiji, and they are distinct from your plant; nor have I found any specimens in our Malayan and Indian covers to match the drawing."

The Botanical Department of the Natural History Museum was next consulted and, with the kind help of Dr. A. B. Rendle, F.R.S., and Mr. E. G. Baker, the plant was identified as *Sida fallax* Walp., although the herbarium specimen which agreed with the drawing was not from Fiji but another Pacific group. It appears that collectors of plants often adopt the same procedure as that of many entomologists, and neglect the most interesting and successful species, because they are the commonest! All my botanical friends agreed that the number of petals (which should have been five), shown on Pl. XLV, was due to inadvertence or to the fact that the drawing was made from an exceptional variety.

Commander Walker discovered the larvae at Fatouhiva, Marquesas Islands, March 10–11, 1883 (E.M.M., Vol. 20, 1883–4, p. 92), only a few months after Mr. Mathew, and he has kindly allowed me to make use of the unpublished description in his journal. It was written with the living larva before him within three months of his first sight of it. In this period he had also made its acquaintance in Tahiti and Eimeo (Societies) and in Aitutaki (Cook Is.).

"General aspect that of a *Vanessa* or *Argynnis* larva. Length from $1\frac{3}{4}$ to more than 2 inches: cylindrical, rather stout, a little attenuated in front. Head a little larger than 2nd segment, deeply bifid at top, and bearing, on each lobe, a long, blackish spine pointing upwards and a little forwards: colour light reddish-brown or burnt-sienna. Body deep brownish-black, with a rather well-defined, irregular, subspiracular, longitudinal stripe on each side, light burnt-sienna colour: legs and prolegs of the same tint. Segments 3 to 12 bear eight ochreous-orange, slightly branched spines about $\frac{1}{6}$ inch long, rigid and somewhat irritating when handled: segment 2 has only two short spines on either side. Spiracles black, surrounded with ochreous-yellow. Specimens from Aitutaki are much suffused with ochreous-brown.

" Feeds on a common weed (of the order Malvaceae), with nettle-shaped leaves and small yellow flowers.

" Pupa not very unlike that of *Vanessa io*, but larger and stouter: palpi-cases rather distinct, front of thorax very convex, with a strong, toothed, lateral crest. Abdomen very stout and rather abruptly truncated, bearing 5 longitudinal rows of sharp-pointed tubercles, the outer ones only distinct on the anterior segments. Anal appendage rather short and stout. Colour dark, dull, umber-brown, irregularly blotched with a lighter and more ochreous tint, especially on the wing-cases.

" It remains in the pupal state rather less than a fortnight."

Commander Walker at once recognised the Fijian larva, drawn by Mr. G. F. Mathew (Pl. XLV), as similar to the form in Aitutaki: those from further east in the Marquesas and Societies were much darker.

The colour differences between larvae from different localities is very interesting and has been insufficiently studied. Trusting to memory, I believe that the larvae of *Pyrameis atalanta* L., found feeding on Mallow as well as nettle at Tenerife in March 1888, were far more commonly of a cream-colour than they are in England—a difference perhaps analogous to that of *H. bolina* in different parts of the Pacific, the two butterflies being closely allied, as a glance at the larvae and pupae on Pl. XLV will suggest. The colour differences between the two pupae drawn by Mr. Mathew are probably due to a susceptibility to their surroundings, such as is known to exist in certain Vanessidae and at least one Argynnid.

Mr. H. W. Simmonds informs me that in Fiji the eggs are green or yellow, but not so deep a yellow as those of *Hypolimnas antilope*. Two females bred from green eggs taken on Vanua Balavu are male-like forms, with predominant white on the chief marks; two from yellow eggs found on the same island are the mimetic *euploeoides* form, with the chief mark of the hind-wing indicated by a blue iridescence. The association of the female forms with the colours of the eggs is probably accidental, but it would be interesting to repeat the experiment on a large scale.

(c) *Families of H. bolina, Bisexual and All-female, Bred from known Female Parents from different Fijian Islands, by Hubert W. Simmonds.*

Mr. Simmonds' notes on the number of the all-female families bred by him and the prevalence of females in the Suva district have been published in Proc. Ent. Soc., 1923, pp. ix–xii. Mr. G. F. Mathew has also written on the same subject:—

"I must have bred several hundred, and of course a number were given their liberty. I remember that the females were greatly in excess of the males, as they were in the various localities where they occurred."

The following extracts from Mr. Simmonds' letters describe his attempt to determine, for Taveuni, the proportions of the sexes and of the female forms, by the only really satisfactory method.

March 24, 1922.—"Whilst away I endeavoured in Taveuni, where *bolina* is abundant,* to pick up as many larvae as possible and breed them out, thus showing the average of the various forms to some extent, which cannot be done otherwise, as collecting is always selective. I am now breeding these, and hope to forward all males and females by the next mail."

April 10, 1922.—"I had bad luck in regard to my larvae of *H. bolina* which I had picked up in Taveuni, ants clearing off all that had not pupated (some 50 or 60) one night; so I now send the few that emerged, and all these are dark. Doubtless this is the prevailing type in Taveuni."

Before recording the families of *bolina* bred by Mr. Simmonds it is necessary to attempt to classify the female forms. All the forms included in the seven Fijian families appear in the table on pp. 652, 653, together with a reference to the figure or figures on the coloured plates by which each form is represented. Mr. Simmonds' success has been so great that I believe nearly every form in Fiji and Polynesia will be found figured on Plates XLVI–LIII. The exceptions are chiefly transitional forms, other than the many here represented, and also races distinguished, like that from the Societies, by the colour of the under surface.

In the western race of *bolina* from continental India the seasonal differences are well marked, and are retained by

* Mr. Simmonds also wrote on Jan. 2, 1922, of the abundance of *bolina* in this island.

the invaders into Madagascar (Proc. Ent. Soc., 1915, p. lxi; 1916, p. xxi). The dry-season specimens of both sexes are larger with the under surface pattern blurred and lacking the conspicuous white markings of the wet season. The markings exist, but in a very reduced and obscure form. Furthermore, on the male upper surface, the chief marks, especially of the hind-wing, are bluer, often entirely blue, in the dry season, while, in the wet, they consist of a large white patch which is merely encircled with blue. In Fiji and Polynesia these characters exist, but are not regularly correlated as they are, for example, in India. It is interesting, however, to note that of the male-like females (B) in the following table, one group (I) possesses this last-mentioned feature of the wet-season male, the other (II) that of the dry.

FIJIAN AND POLYNESIAN FEMALE FORMS OF H. BOLINA.

A. NON-MIMETIC (in Fiji and Polynesia).

I. *Nerina*-like (= *elliciana* Fruhst.). Resembling the ♂-like ♀ form B.I., but with the addition of a conspicuous red or orange patch in areas 1B, and 2 of F.W. (LIII,* 3); often also invading 1A (XLV, 2). Traces of this mark ("*nerina* red") often occur combined with other patterns (XLVI, 3, 4: LI, 4: LIII, 2).

II. Wings bright orange or yellow, dark at the bases.

(a) *Chief mark white and prominent on F. and H.W.* (= *pallescens* Butl.—L, 1, 2).

(b) *Chief mark obsolescent or absent* (L, 3).

III. Wings dusky orange, dark at the bases.

(a) *Chief mark of F.W. white* (XLVIII, 2; XLIX, 2, 3, 4; LI, 1, 2).

(b) *Chief mark of F.W. orange* (XLVIII, 1, 3; XLIX, 1; L, 4; LI, 3).

IV. Dark wings bordered with orange chiefly developed at apex of F.W.

(a) *Chief mark of F.W. white* (= *montrouzieri* Butl.—XLVII, 2).

(b) *Chief mark of F.W. orange* (XLVII, 1; LI, 4).

* "Pl." and "fig." are omitted from the references in this table.

B. MALE-LIKE.

I. White predominant in chief mark of H.W. Blue, if present, restricted to border (= *naresi* Butl.—XLVI, 4; XLVIII, 4; LIII, 4).

II. Blue strong or predominant in chief mark of H.W.

(a) *Chief mark of F.W. white and conspicuous* (= *thomsoni* Butl. *and moseleyi* Butl.—XLVII, 3; XLIX, 5; LII, 1).

(b) *Chief mark of F.W. obsolescent; pattern transitional to euploeoides* (p. 646 note—XLVI, 1, 3). Here also comes *murrayi* Butl. (XLVI, 2; LII, 2).

C. MIMETIC.

Dark and nearly patternless except for the submarginal white spots of F.W. The female form *euploeoides* (XLV, 3; XLVII, 4; XLIX, 6; LII, 3; LIII, 1, 2).

Before describing the bred families of *bolina* it will be convenient to give references to the descriptions of Brit. Mus. types included in the table, and to clear up, as far as possible, the uncertainty which prevails as to the locality of some of them.

Elliciana, described by Fruhstorfer as a "very small, melanotic form" from the Ellice Is. (Seitz, ix, 553), resembles LIII, 3. *Type:* ♀.

The ♀ type of *pallescens* is labelled "Solomon Islands," evidently in error. It is briefly described and figured, as a var. of *bolina* from the "South-sea Islands," by Butler in Brenchley's "Cruise of the Curaçoa," 1873, p. 468, pl. xlviii, figs. 3, 4. Two examples are stated to exist, in British and Maidstone Museums. The name *pallescens* first appeared, with a reference to the previous description and figures, in Butler's paper P.Z.S., 1874, p. 282, No. 47, where the erroneous locality is given. The cruise had included Polynesia and Fiji, and there is no doubt that the specimens came from either one or the other—almost certainly the latter.

Montrouzieri Butl. (P.Z.S., 1874, p. 281). *Types*: ♂, New Hebrides; ♀ "Navigators Island" (sic). The ♀ type, with three other ♀ *bolina* similarly labelled, was recorded in 1851 as part of a collection said to come from this locality, and received at some earlier unknown date; but the specimens certainly have nothing to do with the "Navigators' Islands," an old name for the Samoan

Group. The Samoan *bolina* are very small, and these very large for Polynesia. There is no doubt that they are correctly placed with specimens from the Cook Is. (Rarotonga, etc.) in Brit. Mus. Coll.

Naresi Butl. (Ann. Mag., Nat. Hist., Ser. 5, vol. xi, p. 414). *Types*: ♂ ♀, Tongatabu.

Thomsoni Butl. and *moseleyi* Butl. (Ann. Mag. Nat. Hist., Ser. 5, vol. xi, p. 414). *Types*: ♂ *thomsoni*, ♂ ♀ *moseleyi*, Tongatabu; ♀ *thomsoni*, Kandavu, Fiji. Both have ♂-like ♀♀ with differences of pattern which, for such a variable species, are very slight. *Thomsoni* stands, as it is described earlier on the same page. Fruhstorfer quotes this form, named in honour of the great naturalist of the "Challenger" who moved *Peripatus* into its true sub-kingdom,—*morseleyi!* (Seitz, ix, p. 553).

Murrayi Butl. (Ann. Mag. Nat. Hist., Ser. 5, vol. xi, p. 413). *Types*: ♂ ♀, Kandavu.

The following seven families are arranged in the order already adopted for the Fijian islands (pp. 611–627), beginning with Viti Levu.

FAM. 1.—*Small all-female family of female parent Z, captured at Suva, July* 1921.

(Plate XLVI. Nat. size.)

The female parent, which is much worn, especially in the fore-wings, resembles fig. 3. It is a dark form which still retains indications of the central blue iridescence of the hind-wing and the white submarginal spots of the fore. The under surface is also apparently very similar. The specimen shown in fig. 3 was marked "as parent" by Mr. Simmonds.

The family contained five females, one of which, resembling the parent and therefore like fig. 3, was retained by Mr. Simmonds.

Four out of the five—figs. 1–3 and the last-mentioned female—are the mimetic *euploeoides* form combined with elements from other patterns: fig. 1, with the chief markings blue, those of the hind-wing resembling the form *thomsoni*; fig. 2, with the added elements much obscured, resembles *murrayi*; fig. 3, with slight blue patch in hind-wing, also exhibits traces of "*nerina* red" in fore-wing. The female represented in fig. 4 is the male-like female *naresi* but with emphasised white patches and a trace of the "*nerina* red."

The specimens emerged in the following order :—

Aug. 5.—The female represented in fig. 4
„ 6. „ „ „ 3
„ 8. „ „ „ 2
„ 9. „ „ „ 1

It is noteworthy that the form represented in fig. 1 possesses the chief marks of the male dry-season form, fig. 4 the chief marks of the wet, but over-emphasised.

In the following families the offspring which most closely resemble the form of the female parent are placed first and the remainder in a series which departs further and further from her pattern, thus following the arrangement of Plates XLVII–LIII. Hence Patterns A, B, C, etc., do not correspond in the different families; for A always represents the nearest approach to the female parent, and these parents differ widely from one another. Each pattern is, however, brought into relation with the table on pp. 652, 653.

FAM. 2.—*All-female family of female parent Y, captured at Suva, July* 9, 1921.

(Plate XLVII. Nat. size.)

The female parent, which is much worn, resembles fig. 1. It is near the form *montrouzieri*, which, however, has the fore-wing oblique bar white and more extensive blue in the centre of the hind-wings, in both respects resembling fig. 2.

The family is divided into the forms represented on Pl. XLVII, as follows. The year 1921 is of course to be understood for the emergences.

FAMILY.

Pattern A.

1.—Female shown in fig. 1 : emerged Sept. 2, 1921 (omitted below).
2.—Female resembling fig. 1 : emerged Aug. 28. ("Y. 1.").
3. „ „ „ „ Aug. 29.
4. „ „ „ „ Aug. 30.
5. „ „ „ but without orange and nearly without blue in centre of hind-wing : emerged Aug. 28. ("Y. 1. Intermediate.")
6.—Female like No. 5 : emerged Sept. 2.

Pattern B.

7.—Female shown in fig. 2 : emerged Aug. 29. ("Y. 1.")
This is the form *montrouzieri*, but with less development of orange than in the type.

8.—Female resembling fig. 2 : emerged Aug. 27. ("Y. 1.")

Pattern C.

9.—Female shown in fig. 3 : emerged Aug. 30.
This appears to be the form *naresi* in the fore-wing, and *thomsoni* in the hind.

10.—Female resembling fig. 3 : emerged Aug. 30.

11. „ „ „ but with less blue in hind-wing centre : emerged Aug. 31.

Intermediate between C and D.

12.—Female resembling fig. 3, but oblique fore-wing bar clouded over with scattered dark scales : emerged Aug. 28. ("Y. 3.")
This approaches the form *murrayi*, but the markings are more reduced.

13.—Female like No. 12 : emerged Aug. 30.

Pattern D.

14.—Female shown in fig. 4 : emerged Aug. 30.
This also approaches the form *murrayi*, but with pattern still further reduced. It is seen to be the *euploeoides* mimetic form with traces of the *murrayi* pattern added.

15.—Female like No. 14 : emerged Aug. 28. ("Y. 3. As 2, but darker.")

Mr. Simmonds retained for breeding three females, one of each of the three types "Y. 1," "Y. 2," and "Y. 3" intended to be indicated on some of the specimens. Unfortunately "Y. 2" was accidentally lost in manipulation, or omitted, probably from Pattern B, "Y. 1" being inadvertently written on specimens of the latter. The fact that No. 5 is labelled "intermediate" supports this interpretation. It is possible, however, that "Y. 2" was intended for Pattern C. The label on No. 15 probably indicates that it was similar to the second specimen (No. 12) of Y. 3, but darker. We can only conclude that, of the three additional specimens, one had Pattern A or B, one Pattern B or C, one Pattern D or intermediate between it and C.

The family gives approximate equality between the presence and absence of the orange-brown colour.

One of the females retained by Mr. Simmonds laid sixty or seventy parthenogenetic eggs, but all were infertile.

This family was somewhat larger than the above numbers indicate, for Mr. Simmonds wrote on Sept. 10, 1921—"In the three biggest families I have retained the last few to emerge irrespective of which form they took." The two other families to which these words apply are apparently 6 (X) and 7 (W).

FAM. 3.—*Bisexual family of female parent K, captured in Ovalau, May* 6, 1922.

(Plate XLVIII. Nat. size.)

The worn female parent, represented in fig. 1, appears to be intermediate between the offspring represented in figs. 2 and 3.

The family, following the order of the female forms on Pl. XLVIII, is as follows :—

FAMILY.

Pattern A.

1.—Female shown in fig. 2 : emerged June 13, 1922 (omitted below).

2.—Female resembling fig. 2 : emerged June 9.

Pattern B.

3.—Female shown in fig. 3 : emerged June 9.

Pattern C.

4.—Female shown in fig. 4 : emerged June 11.
This is the form *naresi*, with emphasised white patches.

5.—Female resembling fig. 4 : emerged June 11.

6. „ „ „ „ „ 15.

7. „ „ „ „ „ 15.

8.—Male emerged June 14.

Three females of pattern A or B and one of C were retained by Mr. Simmonds for breeding.

It appears that the intermediate pattern of the female parent has split up into its constituents A and B; the two together give as near equality as possible with pattern C (6 to 5).

Fam. 4.—*All-female family of female parent O, captured in North Vanua Levu, Sept.* 18, 1922.

(Plate XLIX. $\frac{3}{4}$ Nat. size.)

The female parent, taken on the road from Naduri to the Dreketi (Ndrekati) River, in the Macuata district, is very much damaged, but evidently resembled fig. 1.

The female forms in the family are tabulated below. All emerged in November, 1922, the actual date of No. 5 being Nov. 5, and Nos. 1 and 7—Nov. 6.

Family.

Pattern A.

1.—Female form shown in fig. 1.

2, 3, 4.—Female forms resembling fig. 1.

B. Transition from A to D.

5.—Female form shown in fig. 2.

6, 7.—Female forms resembling fig. 2.

C. Further step to D.

8.—Female form shown in fig. 3.

Pattern D.

9.—Female form shown in fig. 4.

10. „ „ resembling fig. 4.

Pattern E.

11.—Female form shown in fig. 5.

Female form *naresi*, but with more blue near F.W. costa and rather larger H.W. patch.

12, 13.—Female forms resembling fig. 5.

14, 15. „ „ „ „ but with H.W. patch larger and the white more extended.

Pattern F.

16.—Female form shown in fig. 6. The *euploeoides* female costa with a trace of the *murrayi* pattern in F.W.

17, 18, 19, 20.—Female forms resembling fig. 6.

Mr. Simmonds retained six females—"2 dark, 2 yellow with white circles, and 2 without." We may therefore safely add two to Pattern A, two to C or D, and two to E or F.

There is here approximate equality between the female forms with orange invasion and those without; also fair equality between the four classes represented by fig. 1 (6),

figs. 2–4 (8), fig. 5 (6), and fig. 6 (6), respectively, allowing for the addition of two of the retained females to the first class, two to the second, and one each to the third and fourth.

The relation between the patterns is very different. There is a beautiful transition from A (fig. 1) to D (fig. 4), but a sharp break between D and E (fig. 5), and between E and F (fig. 6). The uniformity of F is very interesting. Nos. 16–20 all bear the mimetic *euploeoides* pattern, but all retain a blurred trace of the subapical oblique bar of the fore-wing.

FAM. 5.—*Bisexual family of female parent S, captured in Taveuni, Sept.* 4, 1921.

(Plate L. Nat. size.)

The female parent, represented in fig. 1, is the form *pallescens*. The family emerged in October 1921, during Mr. Simmonds' absence. No. 5, a bred specimen with the date of emergence Oct. 29, is included in the family, although it does not bear the letter "S," probably inadvertently omitted.

FAMILY.

Pattern A.

1.—Female form shown in fig. 2 (*pallescens.*)

2, 3.—Female forms resembling fig. 2.

4, 5. „ „ „ „ , but with smaller chief marks on F. and H.W.

Pattern B.

6.—Female form shown in fig. 3.

7, 8, 9, 10.—Female forms resembling fig. 3, but two (8, 9) have very slightly darker orange ground-colour, and another (10), with the dark basal areas emphasised in extent and depth, has a trace of a blue and white chief mark on H.W.

Pattern C.

11.—Female form shown in fig. 4.

12. „ „ resembling fig. 4 and like it with the faintest trace of the blue and white H.W. mark.

13.—Female form like fig. 4, but with a distinct blue and white H.W. mark, intermediate between that of figs. 2 and 4, and an emphasised F.W. oblique bar.

14–22.—Nine males.

The widespread orange ground-colour, seen in the whole of the female offspring, strongly suggests Mendelian heredity. The break between patterns A and B is sharp, although there is some slight indication of transition in No. 10. Patterns A and C are, as regards the pattern, connected by No. 13, but there is a wide difference in the ground-colour.

FAM. 6.—*Bisexual family of female parent X, captured in Kandavu, July* 25, 1921.

(Plates LI, LII. Nat. size.)

The female parent of this extremely interesting family is represented on Pl. LI, fig. 1, and, although much worn, clearly resembles the daughter shown in fig. 2.

FAMILY.

Pattern A.

1.—Female shown on Pl. LI, fig. 2: emerged Sept. 10, 1921 (omitted below).

2.—Female resembling Pl. LI, fig. 2: emerged Sept. 10.

Pattern B.

3.—Female shown on Pl. LI, fig. 3: emerged Sept. 11.

4. „ resembling Pl. LI, fig. 3: emerged Sept. 9.

Pattern C.

5.—Female shown on Pl. LI, fig. 4: emerged Sept. 11. This is near the form *montrouzieri*.

6.—Female resembling Pl. LI, fig. 4: emerged Sept. 12. Darker than fig. 4. Without H.W. patch, and the oblique F.W. orange bar is much obscured. Date believed to be Sept. 12, but the figures indistinct.

Pattern D.

7.—Female shown on Pl. LII, fig. 1: emerged Sept. 10. The female form *thomsoni*.

8.—Female resembling Pl. LII, fig. 1: emerged Sept. 9.

Pattern E.

9.—Female shown on Pl. LII, fig. 2: emerged Sept. 11. The female form *murrayi*.

Pattern F.

10.—Female shown on Pl. LII, fig. 3: emerged Sept. 11.
The female form *euploeoides* with orange and white marginal pattern.
11.—Female resembling Pl. LII, fig. 3: emerged Sept. 11.

12.—Male shown on Pl. LII, fig. 4: emerged Sept. 9.
13, 14.—Males resembling Pl. LII, fig. 4: emerged Sept. 9 and 10.

There is an extraordinary regularity about the female forms in this family, two examples of each pattern being present, except of E which is transitional between D and F. There is also as near equality as possible between the orange-suffused forms (Pl. LI) and the others (Pl. LII, figs. 1–3).

The family included five additional females.

FAM. 7.—*All-female family of female parent W, captured in Kandavu, July* 25, 1921.

(Plate LIII. Nat. size.)

The female parent, resembling fig. 1, is the *euploeoides* mimetic form.

FAMILY.

Pattern A.

1.—Female shown in fig. 1: emerged Sept. 13, 1921 (omitted below).
2.—Female resembling fig. 1: emerged Sept. 11.* Type of ♀*f. euploeoides.*
3. „ „ „ „ „ 12.

Pattern B.

4.—Female shown in fig. 2: emerged Sept. 12.
5. „ resembling fig. 2: emerged Sept. 13.
With slightly less of the "*nerina* red" on F.W.
6.—Female resembling fig. 2: emerged Sept. 11.
With slightly more of the "*nerina* red."

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* The date is written 11.x.1921, evidently intended for 11.ix.1921.

Pattern C.

7.—Female shown in fig. 3 : emerged Sept. 12.
The form *elliciana*—a *nerina* with reduced pattern.
8.—Female resembling fig. 3 : emerged Sept. 22.
9. ,, ,, ,, ,, ,, 12.
10. ,, ,, ,, ,, ,, 12.
11. ,, ,, ,, ,, ,, 12.
12. ,, ,, ,, ,, ,, 10.
13. ,, ,, ,, ,, ,, 13.
14. ,, ,, ,, ,, ,, 13.

Pattern D.

15.—Female shown in fig. 4 : emerged Sept. 11.
The female form *naresi*, with emphasised H.W. mark.
16.—Female resembling fig. 4 : emerged Sept. 13.

There is equality between Pattern C (fig. 3) and the other forms taken together. The transition of the "*nerina* red" of the fore-wing (fig. 3) through Pattern B, into the black mimetic form (fig. 1) is extremely gradual, one specimen out of the three having rather more red and one rather less than is shown in fig. 2.

This was the only family out of the seven in which the predominant female of the original invader from the west, made its appearance, and then in the reduced Polynesian form *elliciana* (fig. 3).

I. HYPOLIMNAS ANTILOPE CRAM. MAY PROBABLY SUPPLY EVIDENCE THAT DARK EUPLOEAS FORMERLY EXISTED IN WEST FIJI.

The short series of this species received from Mr. Simmonds suggests the probability of further evidence that West Fiji was inhabited by dark Euploeas in the recent past. Of the three females, beautiful mimics of an almost patternless *Euploea*, one was taken in Thithia on August 31, 1921, and two in Vanua Balavu on the following day. They are dark brown butterflies with a paler tint forming a wide border to the hind-wing, and over the site of the oblique subapical bar of the fore-wing. A submarginal series of small white spots is present on both wings. For these three females the *simmondsi* race of *Euploea boisduvalii* is a convincing model, especially the forms with white spots, like that represented on Pl. XXXI, fig. 3, of

which the original came from Vanua Balavu and was taken on the same day as the two female *antilope*.

Of the three males of this *Hypolimnas*, one was captured with the two females in Vanua Balavu, the second bred, December 19, 1921, from a larva found on the same island,* the third, taken at Vunilagi, on the north-east of Vanua Levu. The first-mentioned male is considerably lighter in tint than the females, this being true of the general surface as well as the paler areas. It closely resembles Butler's figure of the type of his *lutescens* (= *antilope*) from Ovalau, in P.Z.S., 1874, pl. xliv, fig. 3. In spite of its lighter tint, this form of *antilope* is an obvious *Euploea* mimic with an especially suggestive likeness to a worn and faded model. The second, the bred specimen, differs from the first in its rather deeper shade of brown and paler pattern, especially in the fore-wing, where the oblique bar is prominent, being white overspread with scattered brown scales. It is possible that artificial conditions may have had some effect upon this specimen.

The third male is exceptionally interesting, because it is the most strongly white-marked of the six examples, and it was taken at Vunilagi, between May 25 and 31, 1921, with the powerful association of three white-marked Euploeas shown on Pls. XXXIV and XXXV. This specimen of *antilope* was the only one seen by Mr. Simmonds at Vunilagi and he "took it for a different *Euploea*." He also observed in Vanua Balavu that "it is a perfect mimic in life of the large Euploeas."

Capt. Riley kindly informs me that, of three *antilope* from Mango in the British Museum, a male and one female are slightly paler than the type from Ovalau, and a second female considerably darker. The two females were taken on the same day—July 16, 1882. These, with the type, are the only Fijian examples of *antilope* in the British Museum.

The extremely interesting capture in Rarotonga (Cook Is.) by Commander Walker of a form of *antilope* precisely resembling that from Fiji has been mentioned before and its significance considered (p. 588).

* Mr. Simmonds wrote, January 2, 1922—"I found five larvae of *Hypolimnas* and bred out four. Two of these I enclose." It may be that the second specimen was the first-mentioned male, accidentally labelled as a capture, Sept. 1, 1921. It is a nearly perfect specimen and may well have been bred.

When in Vanua Balavu Mr. Simmonds observed that *antilope* "lays a yellow egg instead of the green one of *H. bolina* [see, however, pp. 647 n., 650], and the larvae feed on a big tree." Attempts to rear them on the food-plant of *bolina* were abortive. The larvae and food-plant were, I believe, unknown until Mr. Simmonds discovered them.

There can be no doubt about the mimicry by *antilope* of the dark Euploeas in East Fiji, and Mr. Simmonds' capture at Vunilagi proves that it also exists in the western islands. It will be of the greatest interest to study a long series from this latter part of the group and ascertain how far the *Hypolimnas* has followed the white-bordered Euploeas and how far retained its mimetic likeness to the dark models of the eastern islands. We are brought back, as often before, to emphasise the importance and interest of further collections from as many islands as possible, but in this case chiefly from West Fiji.

J. CIRCUMSTANTIAL EVIDENCE OF BIRD-ATTACKS ON MEMBERS OF THE EUPLOEINE ASSOCIATION AND OTHER BUTTERFLIES IN WEST FIJI AND FOTUNA ISLAND.

(Plate XLIV, all figs.)

Many naturalists have thrown doubt on the conclusion that butterflies are much attacked by birds, while some have thought that such attacks, if made at all, are so rare that they may be neglected as a selective agency. These doubts are, I believe, chiefly felt by keen collectors of insects who, in reviewing past experiences, found that their memories were without any record bearing on a subject to which no attention had been paid. Incredulity, based on the examination of birds' stomachs in the United States, has also been expressed by American naturalists.

The large amount of evidence already in existence, but for the most part overlooked by objectors, was brought together by Dr. G. A. K. Marshall, F.R.S. (Trans. Ent. Soc., 1909, p. 329), who had himself, by well-devised experiments and observations, direct and indirect, made important contributions to the subject. (Trans. Ent. Soc., 1902, pp. 340–375.) Then followed Mr. C. F. M. Swynnerton's great paper (Linn. Soc. Journ.—Zool., xxxiii, 1919, pp. 203–385), giving an account of experiments and observations carried on in S.E. Rhodesia from 1908 to 1913, the principal

results being published in a condensed form in Proc. Ent. Soc., 1915, pp. xxxii–xliii. In these papers he showed that the negative evidence supplied by American birds was explained by a rapid digestion, which, in a short time, leaves of a butterfly nothing recognisable except with the aid of a microscope. He also directed attention, I believe for the first time, to evidence based on the V-like impression of a bird's beak on the wings of butterflies (*ibid.* p. xxxix). In the year following this communication a beautiful V-mark was observed on a female *bolina* from Madagascar —so perfect indeed that Mr. W. R. Ogilvie Grant was able to suggest the probable species of bird from the impression of its beak—*Uratelornis chimaera* Rothsch. (Proc. Ent. Soc., 1916, p. xxi).

The convincing character of this last-mentioned evidence was conclusively proved by Capt. W. A. Lamborn who, in Nyasaland, observed a wild Weaver-bird capture a Pierine butterfly and remove its wings which, when collected, exhibited marks of the beak (Proc. Ent. Soc. 1920, pp. xxiv–xxix, lvii). He also shot a wild Weaver-bird barely two hours after it had eaten two Pierines, and found no recognisable " portions of them except with the aid of the microscope " (*ibid.*, pp. xxvi, lvii).

Direct evidence of bird-attacks has also been published in Proc. Ent. Soc. by the following observers in the Ethiopian Region :—Mr. Cecil N. Barker, recording an observation by Mr. Harold Millar (1919, xxxiii), Dr. G. D. H. Carpenter (1915, lxiv; 1917, lxii), Rev. G. Cecil Day (1921, lxxiv), Capt. Lamborn (1919, xxxiv), and Mr. E. E. Platt (1915, lxxii). Also in England by the following :—Mr. H. Britten (1917, xxix), Dr. Carpenter (1920, xxxiv), Prof. E. B. Poulton (1917, xxix), and above all by Mr. W. Parkinson Curtis in his papers on " Coloration Problems " (Ent. Record, vol. xxv, 1913, and later vols.)

Further circumstantial evidence based on the V-like beak-marks has accumulated since Mr. Swynnerton and Capt. Lamborn first directed attention to it. Mr. A. H. Hamm has, during the past summer (1923), captured two specimens of *Heodes phlaeas* L., near Oxford, with beautiful beak impressions on their wings, and I was delighted to find the same marks on a *Euploea* from Fotuna I. and on two members of the West Fijian Euploeine Association, sent by Mr. H. W. Simmonds. The attacked butterflies

are represented, of the natural size, on figs. 4, 5, and 6 of Pl. XLIV. Two species of *Euploea* and the one Danaine member of the Association are represented. Mr. C. Chubb, after kindly examining a photograph of the marks, expresses the opinion that they were most probably made by Fijian birds among the following genera—*Artamus* (Wood Swallows), *Pachycephala* (Thickheads), or *Lalage* (Cuckoo Shrikes). The marks appear to indicate birds of three species, or perhaps sex may explain some of the difference.

The attack of the bird with the slenderest bill, as shown by its mark in fig. 5, was most determined, for there are other impressions crossing the sharpest on the left hind-wing and others again on the right. Although not nearly so clear as the single one, examination of the specimen itself, especially upon the under surface, indicates that there is no doubt about their nature.

It will be noticed that the mark of the bird with the broadest bill (fig. 4) was made in Fotuna I., but that all the other figures on the plate represent attacks in West Fiji. The injury to the Danaine shown in fig. 7 is nearly as convincing as the V-like marks. The hind-wings could hardly have been shorn through cleanly and symmetrically, as they came together at rest or in flight, by any enemy except a bird. The injuries inflicted on the Nymphalines represented in figs. 1–3 were more probably caused by lizards attacking when the butterflies were at rest, in accordance with the observations of Dr. V. G. L. Van Someren (Journ. E. Afr. and Uganda Nat. Hist. Soc., No. 17, Mar. 1922, p. 18 and plate; Proc. Ent. Soc. 1922, pp. xlix, xcv).

It was of great interest to find in material collected for another purpose by Mr. Simmonds, this convincing evidence of the presence in Fiji of the only selective agency which has hitherto been suggested as likely to have modified or maintained the Müllerian Associations of these islands.

APPENDIX.

On the Numerical Aspect of Reciprocal Mimicry (*Diaposematic Resemblance*), by Prof. H. H. Turner, M.A., D.Sc., F.R.S.

1. In considering the numerical * relations of two groups of distasteful insects it becomes necessary to make some simple assumptions, but it is curious to find (to all appearance) contradictory assumptions being made by the advocates of different theories. Thus in the brief and illuminating paragraphs in which the Müllerian view is stated (Proc. Ent. Soc. Lond., Feb. 3, 1915, p. xxiii) we read :—

" There are in a certain district two unpalatable species, the one numbering 10,000 individuals, the other 2,000. If the foes inhabiting the same district destroy annually 1,200 individuals of an unpalatable species before learning to avoid it,

(*a*) this number would be lost by each species if they were different;

(*b*) but if they were so similar that the experience with one serves for the other, then the first would lose 1,000, the other 200 individuals."

2. The division and the letters (*a*) and (*b*) have been introduced in reproduction, and do not occur in the original. They serve to compare the two extreme forms of assumption liable to be made, which are both given by Müller, who, however, proceeds to neglect (*a*) and consider chiefly (*b*). In Dr. Guy Marshall's paper, however, he insists on directing attention chiefly to (*a*) : thus in Trans. Ent. Soc., 1908, p. 98, top—

* It must be borne in mind that, in the evolution of Reciprocal Mimicry, there are other important relationships in addition to the numerical. The relative variability and unpalatability of the species in a developing association must also be taken into account. But these and probably other relationships can only be dealt with one at a time, although the ultimate object must be to combine all the results in a common curve. Prof. Turner deals with the relationship considered by Fritz Müller and by Dr. Marshall. It happens, too, that in the Euploeines and the Danaine treated in this memoir—nearly related and all members of the same distasteful family or subfamily—the numerical relationship is by far the most important. It is otherwise with *H. bolina*, which is undoubtedly far less distasteful and is probably the most variable butterfly in the world.—E.B.P.

" . . . education of young birds . . . necessitates the destruction of approximately 1,000 *individuals in each group* of distinctive patterns."

3. Now an outsider intervenes in such matters with obvious risks: the only contribution of value I can hope to make is by inquiring whether in this (as in other instances in my experience) a very human dislike of the complexities of mathematics has not embarrassed the argument; and whether it is not desirable to re-examine it with a little more of a mathematical procedure? I hope I shall not deter any reader at the outset. I promise to use the minimum of symbolic procedure—little more than a simple diagram; but if it happens to throw light on the essence of the matter I hope it may be excused.

4. For it does not seem to me possible to treat adequately any question of " survival of the fittest " without *some* reference, however elementary, to the " distribution curve," or the " error curve," which represents some graded feature in the horizontal direction and numbers of individuals in

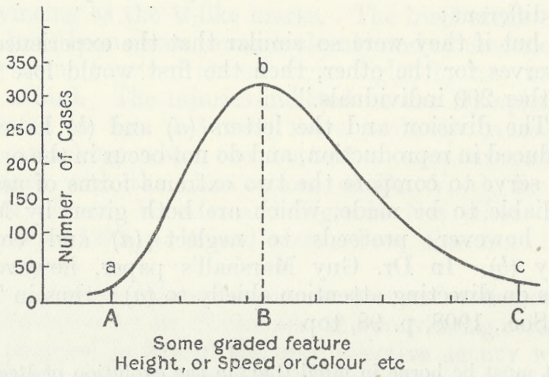


Fig. 1.

the vertical. The majority, represented by the large ordinate Bb, have the feature in a standard measure B, while A represents a measure of it in defect (say), which only a few individuals, Aa, possess, C represents an excess (say) possessed by Cc individuals.

5. The words " excess " and " defect " are too particular and suggestive; we want more colourless ones representing departures from the average in opposite directions. But no suitable ones occur to me.

6. To simplify procedure, we can retain the essential idea without using a curve (which rather suggests an elaborate formula) so long as we retain the idea of 3 groups

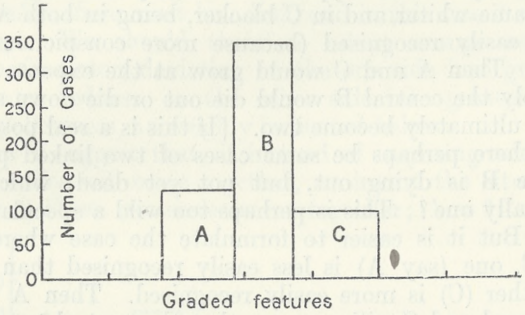


FIG. 2.

—B a large central group, A and C smaller groups (not necessarily equal to one another) deviating from B in opposite directions.

7. Now before proceeding to consider another group of individuals, let us visualise what will happen to this one under different possible conditions of "avoidance."

(*a*) The groups A and C deviate from B, on which the lessons of avoidance are chiefly learnt. The deviations may be such as to *nullify* the lesson. Thus suppose B represented a nearly circular marking ○, and A and C represented deviations from it by elongation in opposite directions.

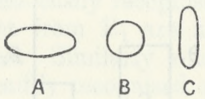


FIG. 3.

It might well happen that the lessons learnt on B were practically useless for A and C, so that destruction would proceed on A and C at a greater relative rate (almost according to alternative (*a*) in § 1): A and C would thus be gradually eliminated, and the central type B would become stable. Reversing the argument, we may infer that IF a type has become stable, the deviations from it were both *less* easily recognised than the type which has become stable.

(β) Now imagine the other extreme case, when both A and C are *more* easily recognised than B, though at the moment a good example does not occur to me. But as a bad example let us suppose for B a grey marking, which in A became whiter and in C blacker, being in both A and C more easily recognised (because more conspicuous) than in B. Then A and C would grow at the expense of B—possibly the central B would die out or die down and the series ultimately become two. [If this is a real possibility, may there perhaps be some cases of two linked patterns (where B is dying out, but not yet dead) which were originally one? This is perhaps too wild a speculation.]

(γ) But it is easier to formulate the case where, of A and C, one (say A) is less easily recognised than B and the other (C) is more easily recognised. Then A will be destroyed and C will grow, so that the central type B will move in the direction of C. This must surely be quite common in practice? In general terms we may use "excess" and "defect" here: a marking may be very *strong* or very *weak*. The weak will be destroyed and the strong avoided.

8. We may now consider two characters which are ultimately to show "mimicry." I venture to suggest that

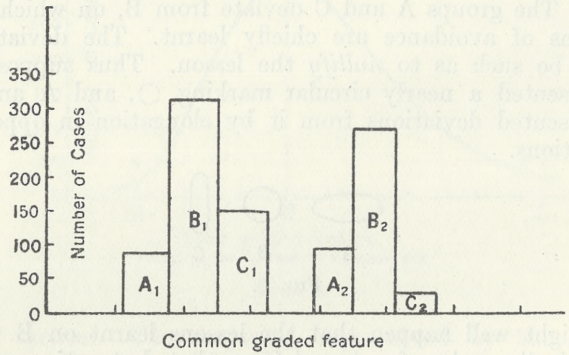


FIG. 4.

we have almost all the machinery for sound conclusions in what has been said. We require in addition only the assumption that there is *some* character which may be regarded as *qualitatively* common to the two, varying only *in degree*, so that there is a definite line of approach which we may adopt for the horizontal line in the diagram. It

may require some little consideration to specify this character in definite terms, but it must be there. Thus type (1) may be *red* in some feature, type (2) may be *yellow*; and these may seem to offer no link. But *if they come together*, there must be a link, and in this case it would be *orange*. We should therefore adopt orange as the common character, deviating on the one side into greater and greater redness, on the other side into greater and greater yellowness, as roughly indicated below.

9. Now I suggest that, if instead of inquiring whether the two series will come together, we invert the situation and say, "These two series came together; how?" then

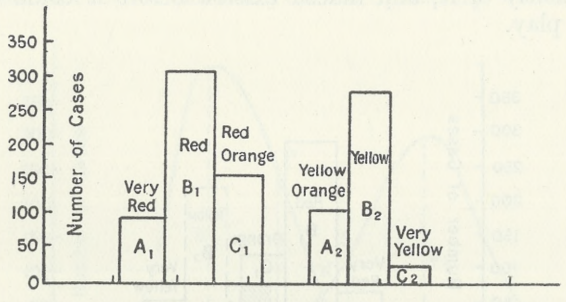


FIG. 5.

we have obtained the reply already in what precedes. No (1) series travels to the right; this must be by elimination of A_1, and growth of C_1. We conclude that *very great redness* (A_1) is less easily recognised than *redness* B_1: *i. e.* the lessons learnt from B_1 are not applied, and A_1 is gradually destroyed. Similarly with *very great yellowness* (C_2)—it is not readily recognised as being like B_2 and is attacked whenever met.

10. On the other hand C_1 and A_2 must *for some reason* be more easily recognised and therefore avoided. I underline the words *for some reason* because it seems to me that there may be more than one. The reason may be a merely numerical one, which can only happen when there is a definite overlap of C_1 and A_2. But presumably the two sets were approaching one another before this, while C_1 and A_2 were still separate; in which case the reasons for approach cannot have been founded on any *numerical* or *combined* argument, but must have been essential to

types, each separately. There must have been some reason why orange red (C_1) was more easily recognised than red (B_1) and was therefore more avoided than red: so that set (1) would move to the right—quite apart from the existence of set (2). Similarly there must have been some entomological (or "inimical") reason why A_2 should be avoided more than B_2. If we admit this, then it is natural to suppose that the same reasons would still be effective after the junction or overlap. Hence without in any way denying the effectiveness of the Müllerian (numerical) reason, which still remains to be considered, we may fairly suppose that it is reinforced by reasons which exist independently of it, and indeed existed before it could come into play.

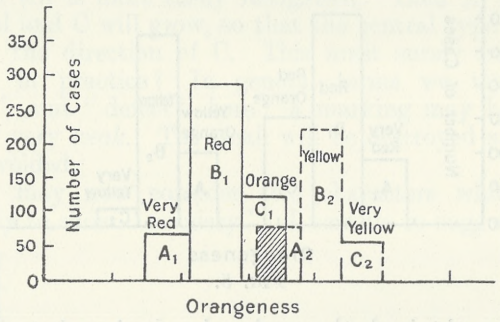


FIG. 6.

11. Reflecting on what has gone before, I venture to propound these suggestions before proceeding to the numerical relationships.

There seems to be room in the vast diversity of animal life and change for all three alternatives (α), (β) and (γ) considered in § 7.

(α) Both extreme forms may be eliminated as *less* recognisable than the average, in which case the central type is stabilised.

(β) Both extreme forms may be *more* easily recognised and therefore avoided. The extremes will grow relatively to the mean, and two types may be formed out of one.

(γ) But it must surely often be true that one extreme form is *more* easily, the other less easily recognised, in which case the mean type will "march" towards the more easily recognised extreme.

12. We now proceed to deal with the numerical interrelations of two groups. We have seen that either or both may "march" toward the other for inherent reasons, and thus we have at any rate a possible machinery for bringing them within reach of each other, so to speak; *i. e.* so that some of the extreme forms overlap. With the crude method of representation hitherto adopted, we should have to say that A_2 and C_1 overlapped; as in the shaded portion of Fig. 6.

Even with this crude representation we see that the numerical argument will depend, *not* on the relative numbers of the whole classes, or even of the majorities B_1 and B_2, but on those of the small classes C_1 and A_2, which may

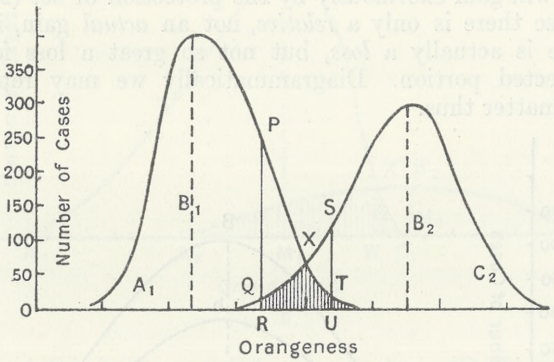


FIG. 7.

be very different from either of the above relations or ratios. But it will be important in what follows to return to a closer representation of nature, which has many grades, so that the distribution can only be properly represented by a curve as in Fig. 7, and the overlap is a piece of triangular shape.

13. Now it seems to me that this notion is very important. If we take the total numbers in the two groups, then (1) may be much more numerous than (2). The total numbers would be represented by the whole areas of the curves. But near the tip T, the members of the first group are represented by the short ordinate TU, while those of the second are represented by the much larger ordinate SU. For this particular shade of orangeness the second group is much more numerous than the first. In

fact, we easily see that in the overlapping portion of the two curves the ratio of individuals in the two sets has no relation to the ratio of the totals. Beginning with a shade near R (the tip of the second curve) set (1) is much more numerous. Proceeding to the right, set (2) grows in relative importance: at the point X (where the curves cross) it reaches equality with set (1), and after that it is in excess, the ratio becoming larger and larger as we get nearer to T, the tip of the first set.

14. Hence I propose to apply Müller's beautiful rule, *not* to the numbers in the groups as a whole, but to successive equivalent shades. Let us consider the shade near one of the tips, say T. Here set (1) is much less numerous, and will gain enormously by the protection of set (2). Of course there is only a *relative*, not an *actual* gain, indeed there is actually a *loss*, but not so great a loss for the protected portion. Diagrammatically we may represent the matter thus.

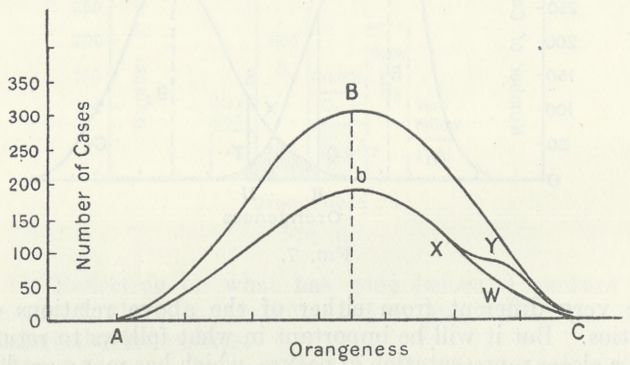


Fig. 8.

Suppose ABC the distribution curve that *would* have existed at the end of a season with no destruction, and AbWC the actual curve after destruction in which every ordinate has been reduced in about the same ratio. Then owing to the protection of set (2) the actual curve will be like AbXYC, with a slight hump near the tip. Fewer of the individuals near the tip will have been destroyed, owing to the protection of the other group.

15. I presume that, by mating, this hump XYC will presently be absorbed so as to give a smoother form to the curve; but its absorption will tend to displace the whole

curve to the right. The amount of the displacement will clearly depend on the ratio of the hump to the whole curve. If the hump is small compared with the whole curve the displacement of the group will be small—perhaps negligible.

16. Now it is easy to see how, though each of two groups must affect the other by the creation of a hump near the tip, the hump may be large for one and very small for the other, if the numbers of the whole groups are very different. Let us take two groups with the same variations (*i. e.*

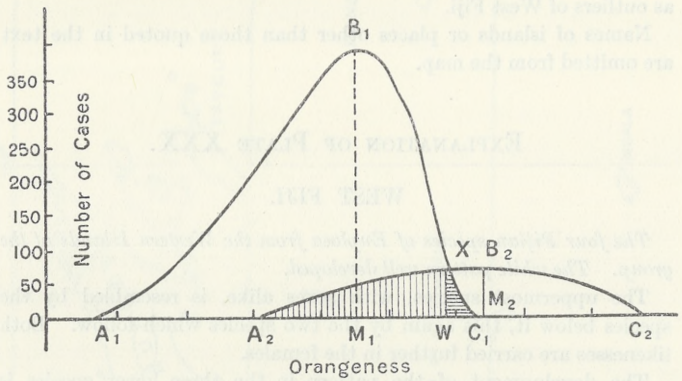


FIG. 9.

$A_1C_1 = A_2C_2$) but very different numbers (B_1M_1 much larger than B_2M_2). Then it is easily seen how much bigger the "tip" XWA_2 of the second must be than that of the first XWC_1. Both tips are protected, but the gain to the less numerous class is obviously much greater. The point is essentially Müller's point, but perhaps the diagrammatic form helps to make it clearer to the eye. In such a case as that drawn we can well imagine that the second set would grow rapidly towards the first, while the first would scarcely be affected at all. There must theoretically be some influence, but it is clearly very slight.

Explanation of Plate XXIX.

Map of the Fiji Islands.

A line drawn from Taveuni to Kandavu will separate West Fiji on the left from East Fiji on the right, the two islands being regarded as outliers of West Fiji.

Names of islands or places other than those quoted in the text are omitted from the map.

Explanation of Plate XXX.

WEST FIJI.

The four Fijian species of Euploea from the Western Islands of the group. The white pattern well developed.

The uppermost species, with sexes alike, is resembled by the species below it, this again by the two species which follow. Both likenesses are carried further in the females.

The development of the pattern in the three lower species is probably the direct and indirect effect of invasion, from the west, by the uppermost species.

Fig. 1. *Euploea helcita eschscholtzi* Feld., ♂—Ovalau: May 12, 1921. Also represented on Pl. XXXIX, fig. 2.

Fig. 2. Female of above species—N.E. coast of Vanua Levu, Vunilagi: May 25–31, 1921. Also on Pl. XXXIV, fig. 9.

Fig. 3. *Euploea boisduvalii* Luc., s.-sp. *proserpina* Butl., ♂,—Ovalau: Apr. 30, 1922. Also on Pl. XXXVII, fig. 2.

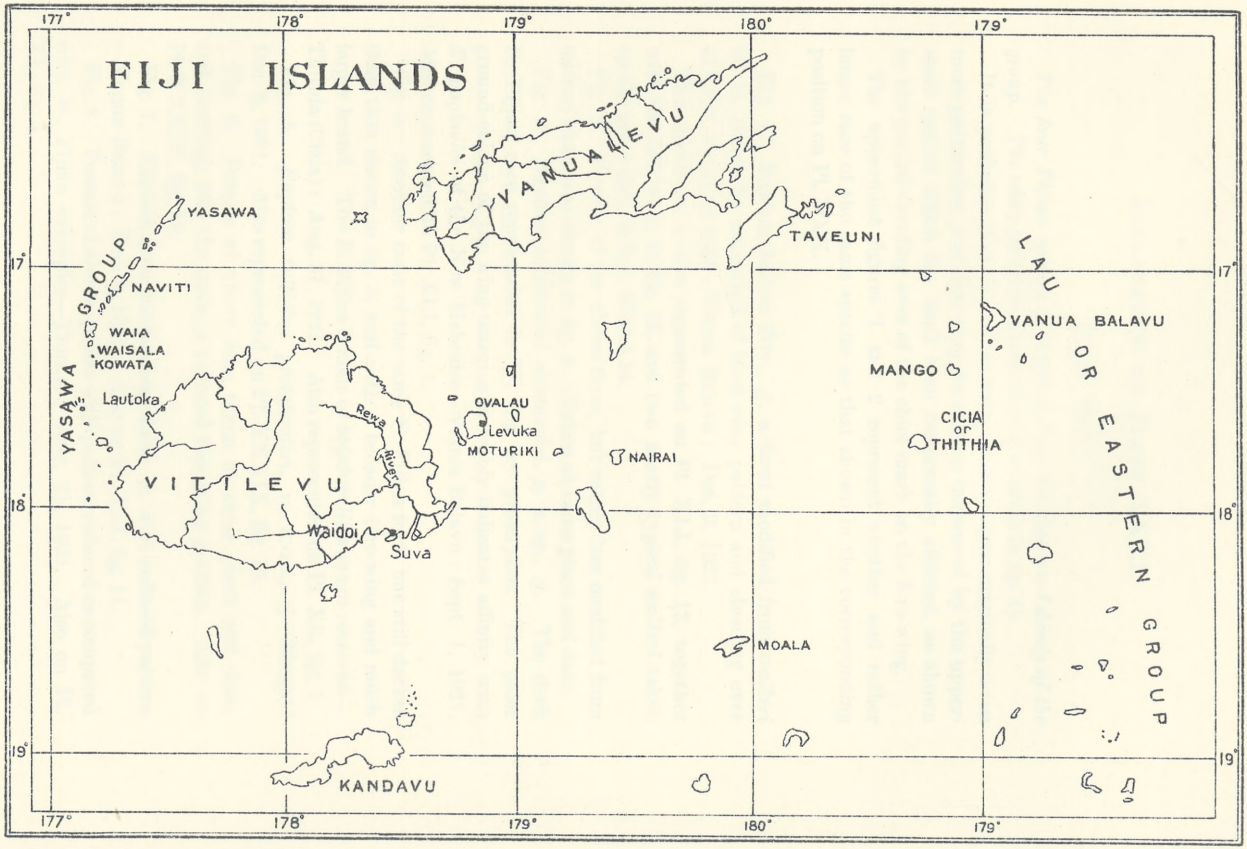
Fig. 4. Female of above species—Ovalau: Apr. 27, 1922. Also on Pl. XXXVII, fig. 5.

Fig. 5. *Euploea tulliolus forsteri* Feld., ♂. Data as in fig. 2. Also on Pl. XXXV, fig. 9.

Fig. 6. Female of above species with same data. Also on Pl. XXXV, fig. 18.

Fig. 7. *Euploea nemertes macleayi* Feld., ♂. Data as in fig. 4. Also on Pl. XXXVII, fig. 6.

Fig. 8. Female of above species. Data as in fig. 3. Also on Pl. XXXVII, fig. 12.



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Trans Ent. Soc. Lond., 1923. Plate XXIX

Explanation of Plate XXXI.

EAST FIJI.

The four Fijian species of Euploea from the Eastern Islands of the group. The white pattern reduced (almost wanting in fig. 4).

It is probable that the three lower species were originally even more patternless, but that they have been influenced by the uppermost species which has itself been reciprocally affected, as shown by the partial clouding over of the chief mark on the fore-wing.

The uppermost figures 1 and 2 represent another and rather larger race of the same species as that shown in the corresponding position on Pl. XXX.

Fig. 1. *Euploea helcita* Bdv., ♂, a form modified from *walkeri* H. H. Druce by reduction of hind-wing pattern and clouding over of chief fore-wing spot—Vanua Balavu : Dec. 9, 1921.

This specimen is also represented on Pl. XLI, fig. 12, together with the following, in fig. 15, and two nearly typical *walkeri* taken on the same day, in figs. 13 and 14.

Fig. 2. Female of the above form, but rather less modified from *walkeri* than that shown in fig. 1. Taken at same place and date.

Fig. 3. *Euploea boisduvalii simmondsi*, n. s.-sp., ♂. The dark E. Fijian race represented in W. Fiji by *proserpina*. The paler ground-colour of the wing-margins probably indicates affinity with *E. paykullei* of the New Hebrides—Vanua Balavu : Sept. 1, 1921. Also represented on Pl. XLI, fig. 1.

Fig. 4. Another male of the same E. Fijian form but still darker than that shown in fig. 3, and with a broader fore-wing and much larger brand. The E. Fijian female of *boisduvalii* was not received—Thithia (Cicia) : Aug. 31, 1921. Also represented on Pl. XL, fig. 1.

Fig. 5. *Euploea tulliolus protoforsteri*, n. s.-sp., ♂—Mango : Dec. 8, 1921. Also represented on Pl. XXXIX, fig. 15.

Fig. 6. Female of above race taken at same place and date, and showing, like the male, a reduced fore-wing pattern. Also on Pl. XXXIX, fig. 18.

Fig. 7. *Euploea nemertes macleayi* Feld., ♂, with reduced pattern —Vanua Balavu : Dec. 9, 1921. Also on Pl. XLI, fig. 11.

Fig. 8. Female of above species with pattern reduced as compared with W. Fijian examples—Thithia : Aug. 31, 1921. Also on Pl. XL, fig. 4.

Explanation of Plate XXXII.

YASAWA IS., VITI LEVU.

Three of the Fijian species of Euploea (and one Danaine) from the small westernmost islands (the Yasawa Group), and two from South Viti Levu.

All Euploeas and Danaines received from the Yasawa Group are here figured.

All the Euploeas on this plate have the white or bluish pattern well developed.

Figs. 1–5. From Waisala I., S. end of Yasawa Group: Oct. 16, 1921.

Fig. 1. *Euploea helcita eschscholtzi* Feld., ♂.

Figs. 2, 3. *Euploea boisduvalii proserpina* Butl., ♂♂.

Figs. 4, 5. *Euploea tulliolus forsteri* Feld., ♀ (fig. 4); *protoforsteri* ♂ (fig. 5).

Figs. 6–10. From Naviti I., towards the centre of the Yasawa Group: Oct. 13, 1921.

Fig. 6. As fig. 1, ♂.

Fig. 7. As figs. 2, 3, ♀.

Figs. 8, 9. As fig. 4, ♀♀.

Fig. 10. *Danaida melissa neptunia* Feld., ♂. The pattern closely resembles that of Pl. XLIII, fig. 5, and is thus intermediate between the most patterned (*protoneptunia*) and the most patternless (*neptunia*) forms of this Fijian race. The specimen is No. 11 of Table A, p. 632.

Figs. 11, 12. From Yasawa I., at the N. end of group Oct. 14, 1921.

Fig. 11. As fig. 1, ♂.

Fig. 12. As fig. 5, ♂.

Fig. 13. As fig. 1, ♂. From Kowata I., at S. end of Yasawa Group: Oct. 11, 1921.

Figs. 14–25. From the Waidoi Valley, near Navua, S. Viti Levu, a very wet area: May and June, 1919.

Fig. 14. As fig. 1, ♀. May 27.

Fig. 15. This form of *Euploea helcita eschscholtzi*, a ♂, resembles, in the submarginal series of H.W., the race *walkeri* H. H. Druce, from Tahiti, etc. June 4. It appears to be a very rare form in the W. Fijian islands.

Figs. 16–25. As figs. 2, 3. Males in left column, females in

right: each pair taken on same day. Figs. 16, 21—May 28; figs. 17, 22—June 1; figs. 18, 23—June 2; figs. 19, 20, 24, 25—June 4.

The five pairs of this species show well the greater development of white, the more dyslegnic pattern and the paler ground-colour of the females.

Explanation of Plate XXXIII.

VITI LEVU.

Three species of Euploea and one Danaine species from S.E. and (figs. 13 and 14 only) N.W. Viti Levu.

All Euploeas show the strongly-marked W. Fiji pattern and the Danaines a transition from a patterned to patternless inner half of fore-wing.

Figs. 1 to 9—Jan. 9, 1920; figs. 10 to 12 and 15 to 18—Apr. 10, 1921. All from S.E. Viti Levu, Lower Rewa River district, Nasinu.

Figs. 13 and 14—Aug. 15, 1922. From N.W. Viti Levu (dry side of island), Vitoga River, near Lautoka.

Figs. 1 to 4 and 10. *Euploea helcita eschscholtzi* Feld., all ♂.

Figs. 5 to 9 and 11. *Euploea boisduvalii proserpina* Butl. All ♂ except fig. 9, which shows well the stronger development in the female of the chief fore-wing marking, in mimicry of *eschscholtzi*.

Figs. 12 to 14. *Euploea tulliolus forsteri* Feld., ♂♂♀. These, the only examples of this species sent by Mr. Simmonds from Viti Levu, all exhibit a well-developed fore-wing pattern.

Figs. 15–18. *Danaida melissa neptunia* Feld., all ♂. The series, all captured at the same time and place, well illustrates the gradual loss of the ancestral markings on the inner half of the fore-wing and reduction of those on inner part of the hind, in mimicry of the Euploeas.

Figs. 15 and 16 represent a transitional stage between *proto-neptunia* and *neptunia*; figs. 17 and 18 are the latter form.

Figs. 15 and 16 are both No. 6 in Table A on p. 632; fig. 17 is No. 15, and fig. 18 is No. 17 in the same table.

Explanation of Plate XXXIV.

VANUA LEVU.

Two of the Fijian Euploeas from Vunilagi on the N.E. coast of Vanua Levu. All captured May 25–31, 1921. A third species is figured on Pl. XXXV.

Figs. 1 to 7 males, 8 to 14 females, of *Euploea helcita eschscholtzi* Feld.

The male represented in fig. 6 is transitional towards the race *walkeri*.

Figs. 15 to 18 males, 19 to 22 females of *Euploea boisduvalii proserpina* Butl.

The females, as usual, exhibit a stronger development of the white pattern than the males. The fore-wing brand represented in fig. 15 is exceptionally small.

Explanation of Plate XXXV.

VANUA LEVU.

A third Fijian species of Euploea, making, with the two represented on Pl. XXXIV, the complete series of Euploeas captured May 25–31, 1921, at Vunilagi, N.E. coast of Vanua Levu.

Figs. 1 to 15 males, 16 to 21 females of *Euploea tulliolus forsteri* Feld.

The figures are arranged to show the transition from the greatest to the least development of pattern in both males and females. The greater variability of the latter sex is well shown by the fact that the males are out-distanced at both ends of the series, fig. 21 representing the weakest, and fig. 16 the strongest pattern on the plate. The average development of the female pattern is, of course, much higher than that of the males.

Figs. 14, 15, and 21 are the form *protoforsteri*.

Explanation of Plate XXXVI.

MOTURIKI, TAVEUNI.

Two of the Fijian species of Euploea from Moturiki, a small island E. of Viti Levu, and near the S.W. corner of Ovalau; and three species from Taveuni, S.E. of Vanua Levu.

Figs. 1 and 2. Moturiki: Aug. 11, 1920. The only Euploeas received.

Fig. 1. *E. helcita eschscholtzi* Feld., ♀.

Fig. 2. *E. boisduvalii proserpina* Butl., ♀.

Figs. 3 to 12. Taveuni: dates as given. In addition to the specimens figured three more male *proserpina* (taken December 19, 1921, and March 9 and 18, 1922), with patterns transitional between those shown in figs. 5 and 6, were received. Fig. 7 shows an extremely interesting male *proserpina* transitional towards the E. Fijian forms with still more reduced pattern. Nothing like this

specimen was seen in the large numbers received or studied from islands W. of Taveuni except a single male from the outlying southern island Kandavu (Pl. XXXIX, fig. 5).

Fig. 3. *E. helcita eschscholtzi*, ♂: Dec. 11, 1921.
Fig. 4. „ „ , ♀: Dec. 17, 1921.
Fig. 5. *E. boisduvalii proserpina*, ♂, : Dec. 21, 1921.
Fig. 6. „ „ , ♂, : Dec. 19, 1921.
Fig. 7. „ „ , ♂: Mar. 18, 1922.
Fig. 8. „ „ , ♀: Dec. 11, 1921.
Fig. 9. „ „ , ♀: Dec. 18, 1921.
Fig. 10. *E. tulliolus forsteri* Feld, ♂: Mar. 18, 1922.
Fig. 11. „ „ , ♂: Dec. 18, 1921.
Fig. 12. „ „ , ♀: Dec. 11, 1921.

All these three are near the border line between *forsteri* and *protoforsteri*.

Explanation of Plate XXXVII.

OVALAU.

The four Fijian Euploeas from Ovalau, the island in which the white pattern reaches its highest development. The figured specimens, together with the far greater numbers received from Ovalau, are tabulated on p. 617.

Fig. 1. *E. helcita eschscholtzi*, ♀: Apr. 27, 1922. The figured example was the only Ovalau specimen with the H.W. of *walkeri*; the others, tabulated on p. 617, are all typical *eschscholtzi*.

Figs. 2 to 4. *E. boisduvalii proserpina*, ♂♂♀: Apr. 30, 1922.
Fig. 5. „ „ , ♀: Apr. 27, 1922.
Figs. 6 and 9. *E. nemertes macleayi* Feld., ♂♀: Apr. 27, 1922.
Figs. 7 and 10. „ „ , ♂♀: Apr. 28, 1922.
Figs. 11 and 13. „ „ , ♀: Apr. 29, 1922.
Figs. 8 and 12. „ „ , ♀: Apr. 30, 1922.
Figs. 14 and 15. *E. tulliolus forsteri*, ♂: Oct. 22, 1921.
Fig. 16. „ „ , ♂: May 3, 1922.
Fig. 17. „ „ , ♂: May 9, 1922.

Explanation of Plate XXXVIII.

(Natural size.)

OVALAU.

Members of mimetic association captured within two minutes of one another on a hill, Levuka, Ovalau: Sept. 9, 1920. *A second bred example of one member.*

Fig. 1. *E. helcita eschscholtzi*, ♀.

Fig. 2. *E. boisduvalii proserpina*, ♂.

Fig. 3. *Hypolimnas bolina* L., ♀ form which, on the wing, resembles the above Euploeas.

Fig. 4. *H. bolina*, ♀ form similar to fig. 3, but with stronger external and weaker internal pattern: probably as good a mimic as fig. 3, or even better. Bred Nov. 2, 1920, from larva found at Levuka. This form resembles *murrayi* Butl.

Explanation of Plate XXXIX.

OVALAU, KANDAVU, MANGO.

Fijiau Euploeas of western, mixed and eastern patterns from Ovalau, Kandavu, and Mango, respectively.

Ovalau: May 12, 1921. Compare Pls. XXXVII and XXXVIII.

Figs. 1 to 3. *E. helcita eschscholtzi*, ♂.

The specimen represented in fig. 3 has the chief marking of the fore-wing clouded over—the only example of this kind received from West Fiji and perhaps due to interbreeding with a more eastern form. It will be observed that the specimen closely resembles the forms of *helcita* from Wallis I. (Pl. XLII, figs. 8–12).

Kandavu: July 24, 1921. The mixed and intermediate patterns, the latter very obvious in the form of *boisduvalii* (fig. 5), are consistent with the supposition that the invading *helcita* (fig. 4) reached this rather remote southern island much later than the other less isolated western islands.

All the Euploeas received from Kandavu are figured on this plate, and all were captured on the same day.

Fig. 4. *E. helcita eschscholtzi*, ♂. Typical pattern: specimen large like *walkeri* (fig. 10).

Fig. 5. *E. boisduvalii*, ♂, intermediate between *proserpina* and the eastern patternless or nearly patternless race *simmondsi*, and rather nearer the latter than the Taveuni specimen (Pl. XXXVI, fig. 7).

Figs. 6–8. *E. nemertes macleayi*, ♂♀♀. Compared with the Ovalau series on Pl. XXXVII (figs. 6–13), it is seen that two out of the three Kandavu specimens are less patterned, especially in the hind-wing markings.

Fig. 9. *E. tulliolus forsteri*, ♂. This specimen is western in pattern and shows no approach towards the darker forms from Mango represented on the same plate (figs. 12–18).

Mango : all Dec. 8, 1921, except fig. 11—July 18, 1882.

E. helcita is represented by a single example of the race *walkeri*, unchanged by the presence of two dark Euploeas which are themselves nearly or perhaps completely unaffected. It appears probable that *walkeri* is a comparatively recent arrival in the island, although some specimens in other collections have the chief mark of the forewing more or less clouded over (pp. 626, 627).

It is unfortunate that *E. boisduvalii* was not taken with the other Euploeas.

Fig. 10. *E. helcita walkeri*, ♀.

Fig. 11. *E. nemertes macleayi*, ♀, a British Museum specimen captured by C. M. Woodford. It is slightly darker than the two females received from Thithia (Pl. XL, figs. 3, 4).

Figs. 12 to 18. *E. tulliolus protoforsteri*, 5 ♂ 2 ♀—a very dark series, as will be realised when compared with Pl. XXXV. The British Museum series from Mango, of about equal length, resembles this, so that the comparison rests upon a fair amount of material. Fig. 12 represents the darkest example of this species received from Mr. Simmonds, although one from Vanua Balavu closely approaches it (Pl. XLI, fig. 5).

Explanation of Plate XL.

THITHIA (CICIA).

The four Fijian Euploeas from Thithia (Cicia), with eastern, intermediate, and western patterns.

The plate shows all the Euploeas received from this island—figs. 1–13 captured Aug. 31, 1921; figs. 14, 15 captured Dec. 8, 1921.

Figs. 1, 2. *E. boisduvalii simmondsi*, ♂. The specimen represented in fig. 1 is, next to that on Pl. XLI, fig. 3, the darkest and most patternless example of this species received from Fiji. Fig. 2, on the other hand, represents a specimen well advanced towards *proserpina*, and very similar to some of the males from the western islands, *e. g.*, to those shown on Pl. XXXIII, figs. 5, 6, from Viti Levu.

Figs. 3, 4. *E. nemertes macleayi*, ♀, both somewhat dark eastern forms, although less dark than the single specimens from Mango and Vanua Balavu. The stronger western patterns are evident in the six Ovalau females (Pl. XXXVII, figs. 8–13).

Figs. 5–8 and 14. *E. tulliolus forsteri*, all ♂ except figs. 7, 8. These specimens are, except that shown in fig. 8, near the borderline between *forsteri* and *protoforsteri*. Fig. 8 is a strongly marked

western form of the female. This species is much darker in Vanua Balavu and still more so in Mango.

Figs. 9–13, and 15. *E. helcita walkeri*, typically E. Fijian except fig. 11, in which H.W. is transitional towards *eschscholtzi*, all ♂ except fig. 13. The principal fore-wing marking is partially obscured in fig. 9, slightly in 10, while the dyslegnic edge more or less evident in the same part of the border of the remaining specimens probably indicates the origin and direction of the cloudy growth.

Explanation of Plate XLI.

VANUA BALAVU (BAVATU).

The four Fijian Euploeas, on the whole of the darkest type, from the most eastern island visited—Vanua Balavu.

All Euploeas received from the island are represented on the plate—figs. 1, 2, 4–7 captured Sept. 1, 1921; figs. 3, 8–15 captured Dec. 9, 1921.

The darkness of the three indigenous Euploeas and the effect produced on the invading *helcita* are very evident.

Figs. 1–3. *E. boisduvalii simmondsi*, ♂. All of the dark eastern type and fig. 3 the most patternless Fijian specimen received. The paler borders evident in figs. 1 and 3 are also seen in the same form from Wallis I. (Pl. XLII, figs. 1–7), and suggest that these and *E. paykullei* Butl., from the New Hebrides, are closely related forms of the same species.

Figs. 4–10. *E. tulliolus protoforsteri*, all ♂ except fig. 10. The patterns are, on the whole, more reduced than in any island except Mango (Pl. XXXIX).

Fig. 11. *E. nemertes macleayi*, ♂. In spite of its poor condition it is obvious that this is the darkest example received from Fiji. The traces of a pattern on the right hind-wing are much fainter, and the fore-wing markings more reduced than in any other specimen.

Figs. 12–15. *E. helcita walkeri*, ♂, except fig. 15. The pattern of H.W. of fig. 15 is transitional towards *eschscholtzi*, and that of fig. 12 still more so. All four specimens show a reduction or clouding over of the chief mark of F.W. This, which is especially evident in figs. 12 and 13, is shown, by comparison with Plate XLII, to be due to the influence of the dark-winged Euploeas, nearly all of which show the effects of reciprocal mimicry in the more or less distinct traces of a marginal pattern.

Explanation of Plate XLII.

WALLIS AND FOTUNA IS., BETWEEN FIJI AND SAMOA.

Euploea helcita walkeri captured in Wallis I. with, in Fotuna I. without, the dark Euploea—E. boisduvalii simmondsi. Indications of Reciprocal Mimicry in Wallis I.

All the Euploeas received are figured, *E. helcita* being of the strongly-patterned form *walkeri* on Fotuna I., 178 miles from the N.E. tip of Vanua Levu and 296 from the centre of the Fiji Group, but with greatly reduced pattern where it is accompanied by a dark *Euploea*, on Wallis I., 322 and 430 miles from the same points, and 150 miles from Fotuna I.

Fotuna I. : May 25–26, 1922 (figs. 13–19).

Wallis I. : May 30, 1922 (figs. 1–12).

Figs. 1–7. *Euploea boisduvalii simmondsi*, all ♀ except figs. 1, 2. The extremely close resemblance to the Vanua Balavu form is obvious. Compare especially fig. 2 on this plate with fig. 1 on Pl. XLI.

The pale margins of both these males appear to have been derived from *paykullei* of the New Hebrides. One male (fig. 2) and two females (figs. 6, 7) appear to show reciprocal approach towards the reduced pattern of the race of *helcita* on the same island (figs. 8–12).

Figs. 8–12. *Euploea helcita* with reduced pattern, all ♀ except fig. 10. These specimens, taken with the above dark *Euploea*, are similar to a form from the Ellice Is., named *distincta* Butl. in the British Museum.

Figs. 13–19. *Euploea helcita walkeri*, ♂♂—13 to 15, 19; ♀♀—16 to 18. This form is well-known from the Society Is. and is also shown by Mr. Simmonds' captures to be characteristic of E. Fiji.

The comparison between this series of *helcita* and that from Wallis I., only 150 miles distant, is very striking.

The distinct impression of a bird's beak will be seen near the apex of the right fore-wing in fig. 19. The same specimen is shown of the natural size on Pl. XLIV, fig. 4.

Explanation of Plate XLIII.

The gradual reduction of the internal pattern of a Fijian Danaine butterfly, in mimicry of the white-bordered Euploeas.

Figs. 1–3 show the ancestral pattern, essentially similar to that found in allied races over a wide range. This is the form *proto-neptunia.*

Figs. 4–6 show the loss of the principal marking in the cell of the fore-wing and the increasing reduction of the three more basal markings. Transitional forms.

Figs. 7–9 show the still further reduction and final disappearance of these three markings and the great reduction in the internal pattern of the hind-wings. This is *neptunia* Feld.

All the figured specimens are ♂ except 9.

Fig. 1. *Danaida melissa neptunia*, n. f. *protoneptunia*—Taveuni: Dec. 20, 1921. The ♂ Type of *protoneptunia*.

Fig. 2. The same—Taveuni, Ura: Mar. 18, 1922.

Fig. 3. ,, Ovalau: Apr. 27, 1922.

Fig. 4. Transitional between *protoneptunia* and *neptunia*—Ovalau: May 12, 1921.

Fig. 5. The same—Ovalau: Apr. 27, 1922.

Fig. 6. ,, ,, May 3, 1922.

Fig. 7. *D. m. neptunia*—S.E. Viti Levu, Lower Rewa Riv. district, Nasinu: Apr. 29, 1921.

Fig. 8. The same—Ovalau: May 18, 1922.

Fig. 9. ,, S.E. Viti Levu, 5 miles from Suva on Waidoi rd., Lami: Aug. 28, 1920.

Explanation of Plate XLIV.

(Natural size.)

Injuries inflicted by birds, or in some instances probably by lizards, on Fijian butterflies and one from Fotuna I.

Figs. 1, 2. *Issoria egista* Cram., ♂—N.E. coast Vanua Levu, Vunilagi: May 25–31, 1921, and Mar. 8, 1922.

Fig. 3. *Doleschallia bisaltide* Cram., f. *vomana* Fruhst., ♂—Ovalau: Oct. 27, 1921.

These injuries to both hind-wings were evidently inflicted when they were closed—possibly during flight, but almost certainly when the insects were at rest. They are probably due to the attacks of lizards.

Fig. 4. *Euploea helcita walkeri*, ♂—Fotuna I.: May 26, 1922. The mark of a bird's beak near the apex of the right fore-wing is remarkably distinct.

Fig. 5. *Euploea boisduvalii proserpina*. ♂—S. Viti Levu, near Navua, Waidoi: Apr. 22, 1919. The impression of a narrower beak is equally clear on the left hind-wing. Other less clear impressions can also be made out on both hind-wings.

Fig. 6. *Danaida melissa neptunia*, ♂—S.E. Viti Levu, near Suva, Lami: Aug. 28, 1920. The beak-mark on the right fore-wing is

equally distinct. The male scent-pockets on the hind-wings of this specimen have been attacked, probably by house-ants. The injuries can be partially seen by comparing this figure with 7, and with 1–8 on Pl. XLIII. The specimen represented in fig. 6 is No. 21 of Table A (p. 632).

Fig. 7. As above, ♂—S. Viti Levu, Waidoi: June 6, 1919. The cleanly shorn hind-wings suggest the attack by a bird upon the butterfly in the position of rest. The specimen represented in fig. 7 is No. 9 of Table A (p. 632).

Explanation of Plate XLV.

Fijian *Hypolimnas bolina* (nearly $\frac{2}{3}$ natural size.)

Male, two forms of female, pupa, larva, and food-plant, from a coloured drawing by G. F. Mathew.

Figs. 1, 1a.—Upper and under surface of the male.

Figs. 2, 2a.—Upper and under surface of a female form with a somewhat reduced *nerina* pattern. Typical *nerina* is the prevalent form in the S. and E. Malay Archipelago, Australia, and the West Pacific islands. It occurs reduced, and also transitional towards other forms over the whole of Polynesia. Compare the more reduced patterns (*elliciana*) represented in Pl. LIII, fig. 3.

Figs. 3, 3a.—The female form *euploeoides*, mimicking a dark and nearly patternless *Euploea*. Its existence in West Fiji, where the Müllerian Association is conspicuously white-bordered, is evidence that this part of the group was inhabited in the recent past by dark Euploeas such as still persist in East Fiji.

The larva resembles the form in Aitutaki, Cook Islands. In the Marquesas and Societies it is much darker.

The different tints of the pupa may have been caused by response to lighter and darker surroundings. Allied species are known to possess this power.

The food-plant *Sida fallax* (Malvaceae). The drawing of the flower may have been made from a variety instead of the usual five-petalled form, or the number of petals may have been due to inadvertence.

Explanation of Plate XLVI.

Fijian *Hypolimnas bolina* (natural size).

Fam. 1.—*Female Forms in small All-female Family of Female Parent Z, from Suva.*

The much-worn Female Parent Z, taken July, 1921, resembles fig. 3.

Forms of Female Offspring present in Family.

Fig. 1. This female and that represented in fig. 3 are the dark mimetic form *euploeoides* with the addition of elements from other patterns.

Fig. 2. This mixture of the mimetic with other elements in a reduced condition approaches the form *murrayi*.

Fig. 3. Another combination of the mimetic form with other elements, including a trace of the "*nerina* red" on F.W.

Fig. 4. A male-like female of the form *naresi*, but with larger white patches and a trace of the "*nerina* red" on F.W.

The family included a fifth female which resembled fig. 3, and the female parent.

Explanation of Plate XLVII.

Fijian *Hypolimnas bolina* (natural size).

Fam. 2.—*Female Forms in All-female Family of Female Parent Y, from Suva.*

The much-worn female parent, taken July 9, 1921, resembles fig. 1.

Forms of Female Offspring present in Family.

Fig. 1. Six females of this form, two of them with no orange in H.W. centre and only a trace of blue. Fig. 1 approaches *montrouzieri*, the differences being apparent when fig. 2 is compared.

Fig. 2. Two females of this form, which only differs from the type of *montrouzieri* in the less development of orange, especially at F.W. apex.

Fig. 3. Three females of this form, one of them with less blue in H.W. centre.

Two other females differ from fig. 3 in the clouding over of the F.W. chief mark with scattered scales, thus approaching the form *murrayi*.

Fig. 4. Two females of this form—*euploeoides*, with the addition of traces of chief mark in F. and H.W.

One additional female retained by Mr. Simmonds resembled fig. 1 or 2; 1—fig. 2 or 3; 1—fig. 4, or came between 3 and 4.

This family was somewhat larger than the numbers indicate, as the last few to emerge were retained, as also in families 6 and 7.

Explanation of Plate XLVIII.

Fijian *Hypolimnas bolina* (natural size).

Fam. 3. *Female Forms in Bisexual Family (including one Male, received), with their Female Parent, K, from Ovalau.*

Fig. 1. Female parent K, taken May 6, 1922. It is seen to be of a form intermediate between the offspring represented in figs. 2 and 3, but probably nearer to the latter.

Forms of Female Offspring present in Family.

Fig. 2. Two females of this form.
Fig. 3. The only example of this form.
Fig. 4. Four females of this form.

The family contained 4 additional females—3 like fig. 2 or 3; 1 like fig. 4. One male was received.

Explanation of Plate XLIX.

Fijian *Hypolimnas bolina* ($\frac{3}{4}$ natural size).

Fam. 4.—*Female Forms in All-female Family of Female Parent O, from North Vanua Levu.*

The much-damaged female parent, taken Sept. 18, 1922, evidently resembled fig. 1.

Forms of Female Offspring present in Family.

Fig. 1. Four females of this form.
Fig. 2. Three females of this form.
Fig. 3. One female of this form.
Fig. 4. Two females of this form.
Fig. 5. Three females of this form, and two with the H.W. chief mark larger and with more extensive white.
Fig. 6. Five females of this form.

It is interesting to note the stability of this combination of the *euploeoides* form with an evanescent chief mark in F.W. All 5 females were similar in this respect.

Of 6 females retained by Mr. Simmonds, 2 resembled fig. 1; 2—fig. 3 or 4; 2—fig. 5 or 6. The 2 like fig. 1 have been added to the above 4 in the legend of Pl. XLIX.

Explanation of Plate L.

Fijian *Hypolimnas bolina* (natural size).

Fam. 5.—*Female Forms in Bisexual Family (including 9 Males), with their Female Parent S, from Taveuni.*

Fig. 1. Female parent S (*pallescens*), taken Sept. 4, 1921.

Forms of Female Offspring present in Family.

Fig. 2. Five females of this form (*pallescens*), 2 of them with smaller chief marks on F. and H.W. One of these latter is a bred specimen which probably, but not certainly, belongs to this family (see p. 659).

Fig. 3. Five females of this form, 2 of them with rather darker orange ground-colour and 1 with basal dark areas emphasised in depth and extent, and a trace of blue and white chief mark on H.W.

Fig. 4. Three females of this form, 1 of them with a very faint trace of blue and white H.W. mark, and 1 intermediate between figs. 2 and 4, and with an emphasised F.W. oblique bar.

Explanation of Plate LI.

Fijian *Hypolimnas bolina* (natural size).

Fam. 6.—*Female Forms (continued on Pl. LII), in Bisexual Family (including 13 Males), with their Female Parent X from Kandavu.*

Fig. 1. Female parent X, taken July 25, 1921. Allowing for its worn and faded condition it is seen to be of the form represented in fig. 2.

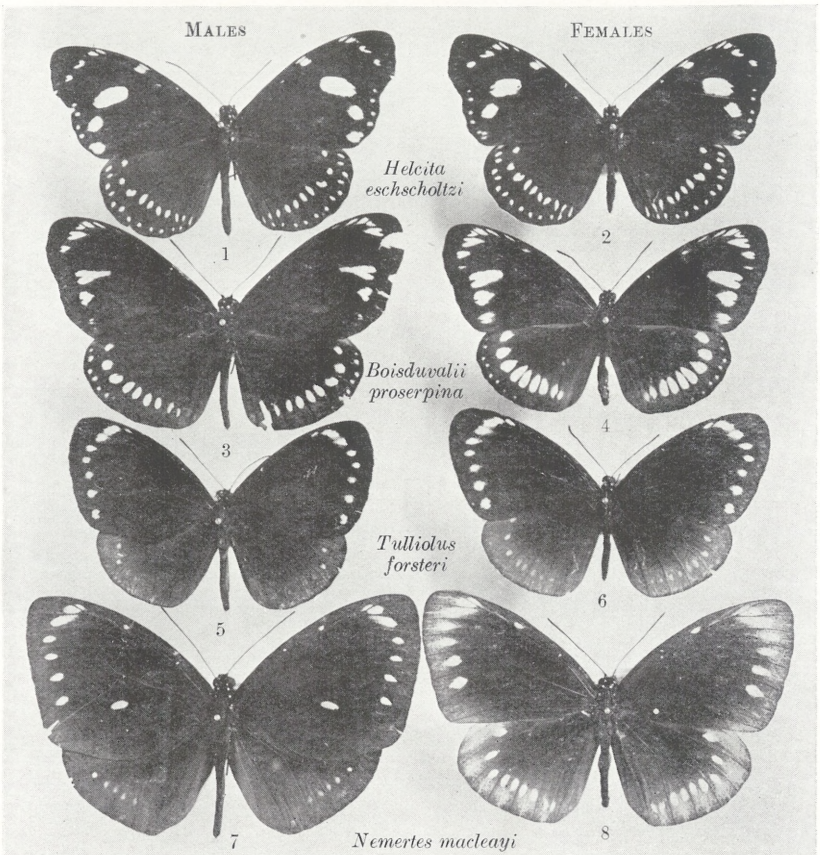
Forms of Female Offspring present in Family.

Fig. 2. Two females of this form.

Fig. 3. Two females of this form.

Fig. 4. Two females of this form, one of them with reduced orange markings in F.W., but emphasised in H.W., and without the blue and white mark in H.W.

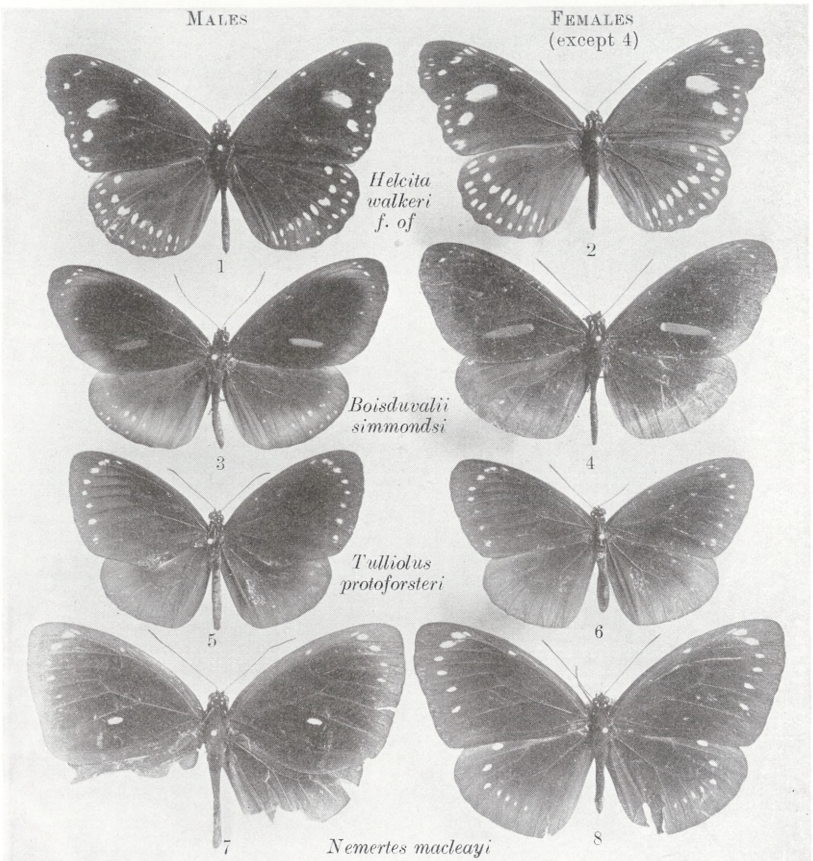
(Family continued on Pl. LII.)



A. Robinson, Photo. *Vaus & Crampton.*

All the figures are rather over $\frac{3}{5}$ nat. size.

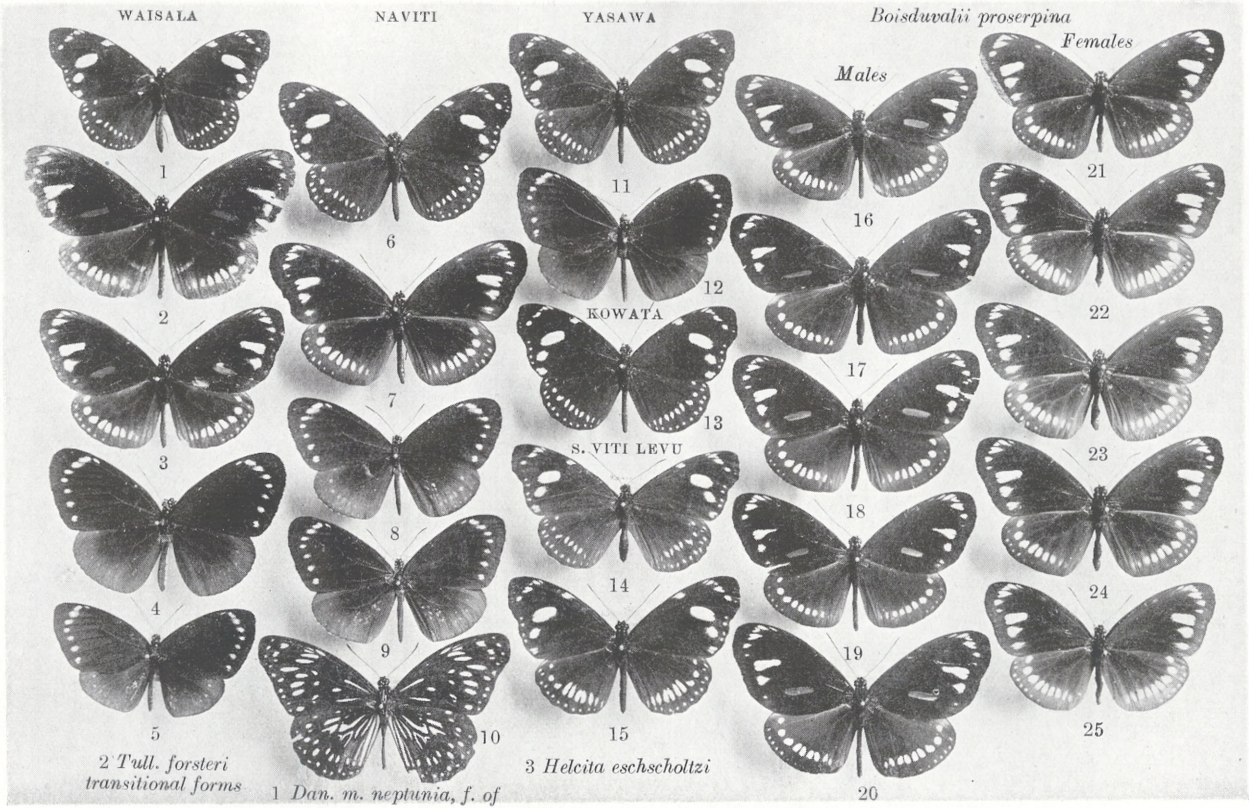
THE FOUR FIJIAN SPECIES OF EUPLOEA FROM THE WESTERN ISLANDS OF THE GROUP. THE WHITE PATTERN WELL DEVELOPED.



A. Robinson, Photo. *Vaus & Crampton.*

All the figures are rather over ½ nat. size.

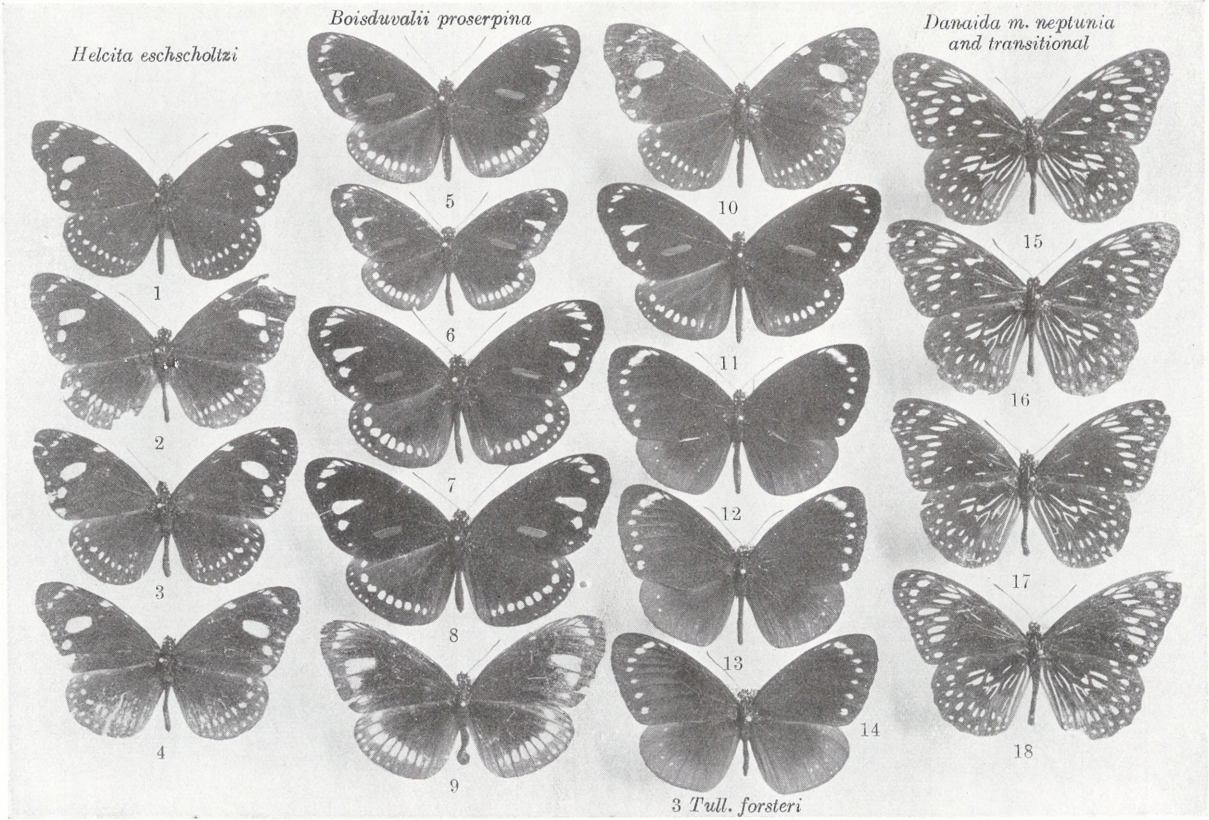
THE FOUR FIJIAN SPECIES OF EUPLOEA FROM THE EASTERN ISLANDS OF THE GROUP. THE WHITE PATTERN REDUCED.



A. Robinson, Photo. *All the figures are rather over $\frac{2}{3}$ nat. size.* *Vaus & Crampton.*

THREE OF THE FIJIAN SPECIES OF EUPLOEA (AND ONE DANAINE) FROM THE YASAWA GROUP, EXTREME W. OF FIJI, AND TWO FROM S. VITI LEVU.

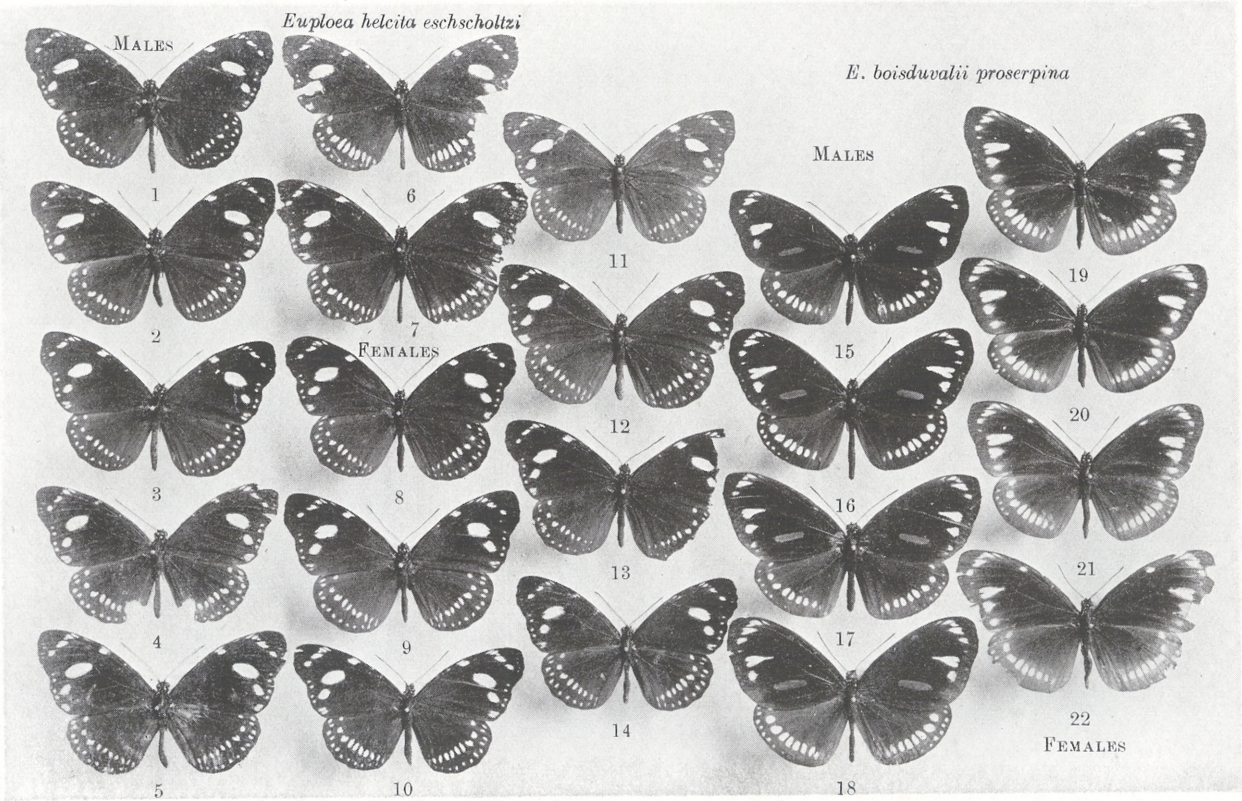
Trans. Ent. Soc. Lond., 1923, Plate XXXII.



A. Robinson, Photo. *All the figures are rather over ½ nat. size.* *Vaus & Crampton.*

THREE OF THE FIJIAN SPECIES OF EUPLOEA AND ONE DANAINE SPECIES FROM S.E. AND (Figs. 13 and 14 only) N.W. VITI LEVU.

Trans. Ent. Soc. Lond., 1923, Plate XXXIII.



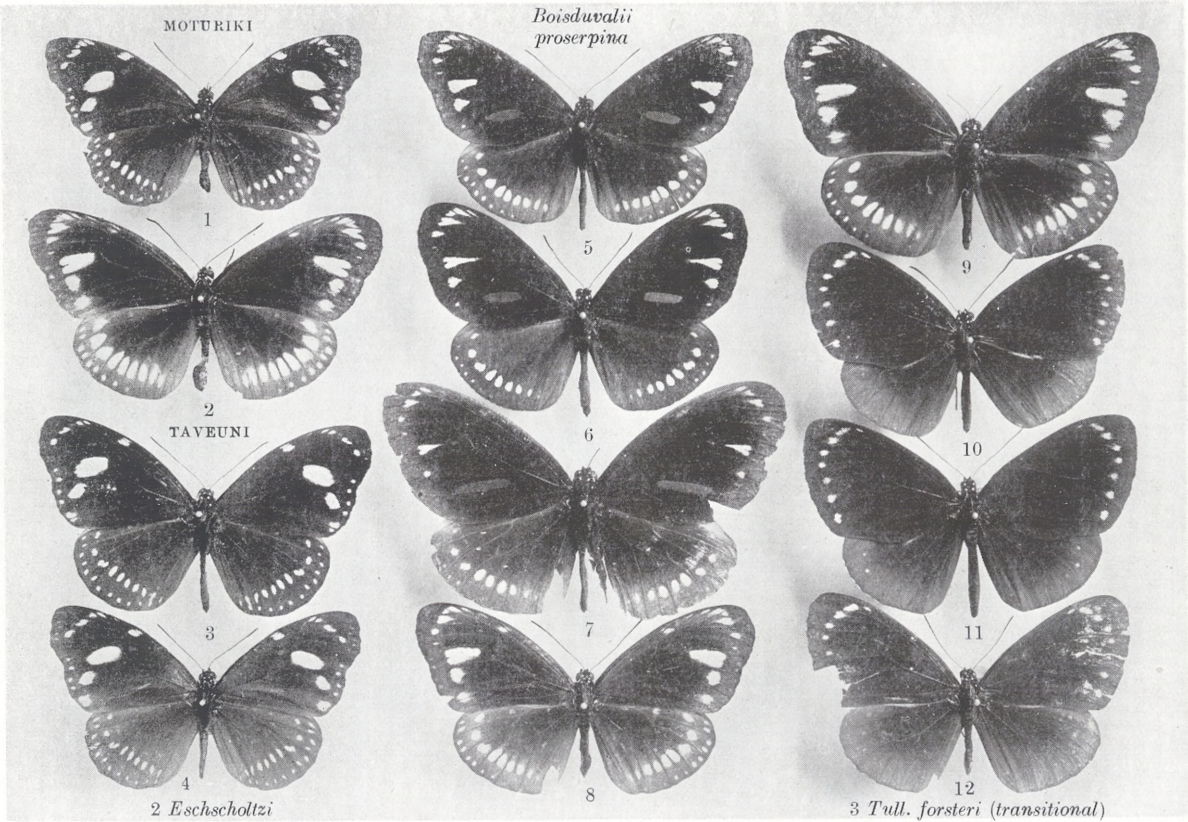
A. Robinson, Photo. *All the figures are rather under ½ nat. size.* *Vaus & Crampton.*

EUPLOEA HELCITA ESCHSCHOLTZI (Figs. 1–14) AND E. BOISDUVALII PROSERPINA (Figs. 15–22).
FROM N.E. VANUA LEVU: May 25–31, 1921.

Trans. Ent. Soc. Lond., 1923, Plate XXXIV.

A. Robinson, Photo. *All the figures are rather under ½ nat. size.* *Vaus & Crampton.*

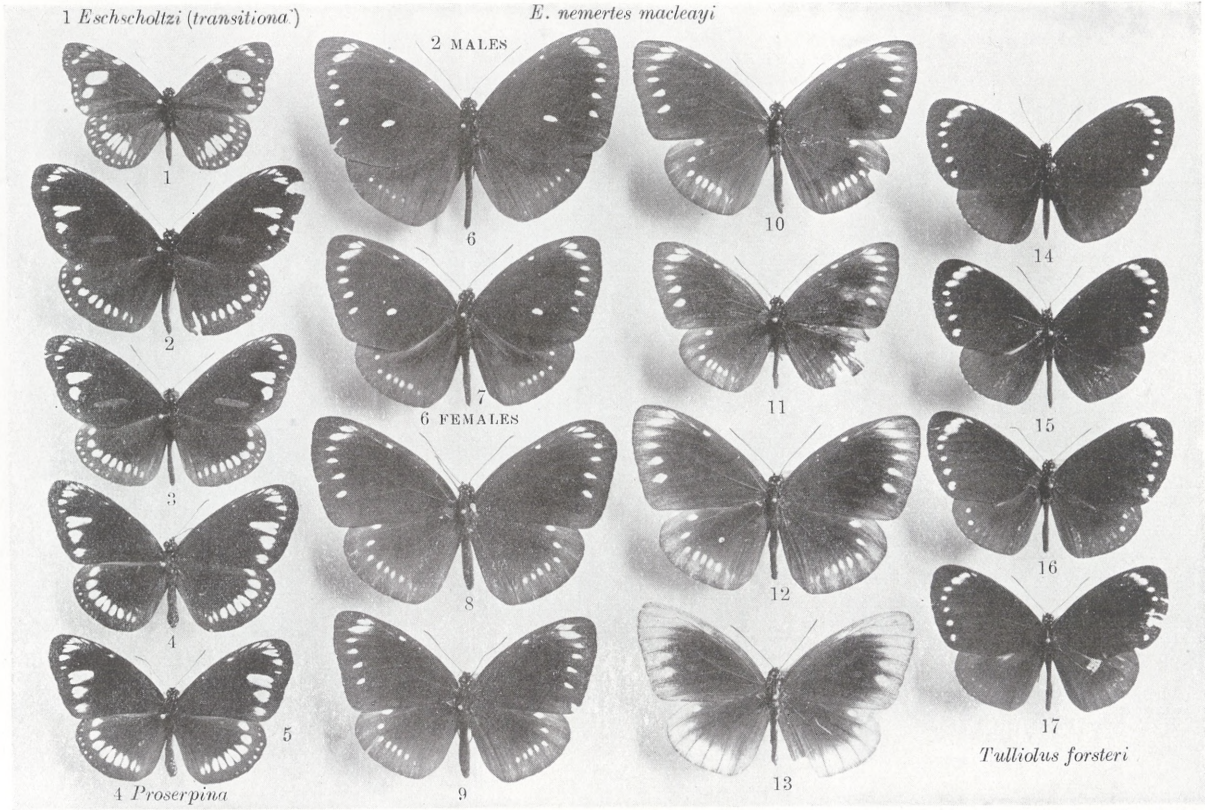
EUPLOEA TULLIOLUS FORSTERI FROM N.E. VANUA LEVU: May 25-31, 1921. The females (Figs. 16–21) show a stronger average development of pattern than the males (1–15). Figs. 13–15 and 21 are the form *protoforsteri*.



A. Robinson, Photo. *All the figures are rather over $\frac{3}{5}$ nat. size.* *Vaus & Crampton.*

TWO FIJIAN EUPLOEAS FROM MOTURIKI AND THREE FROM TAVEUNI.

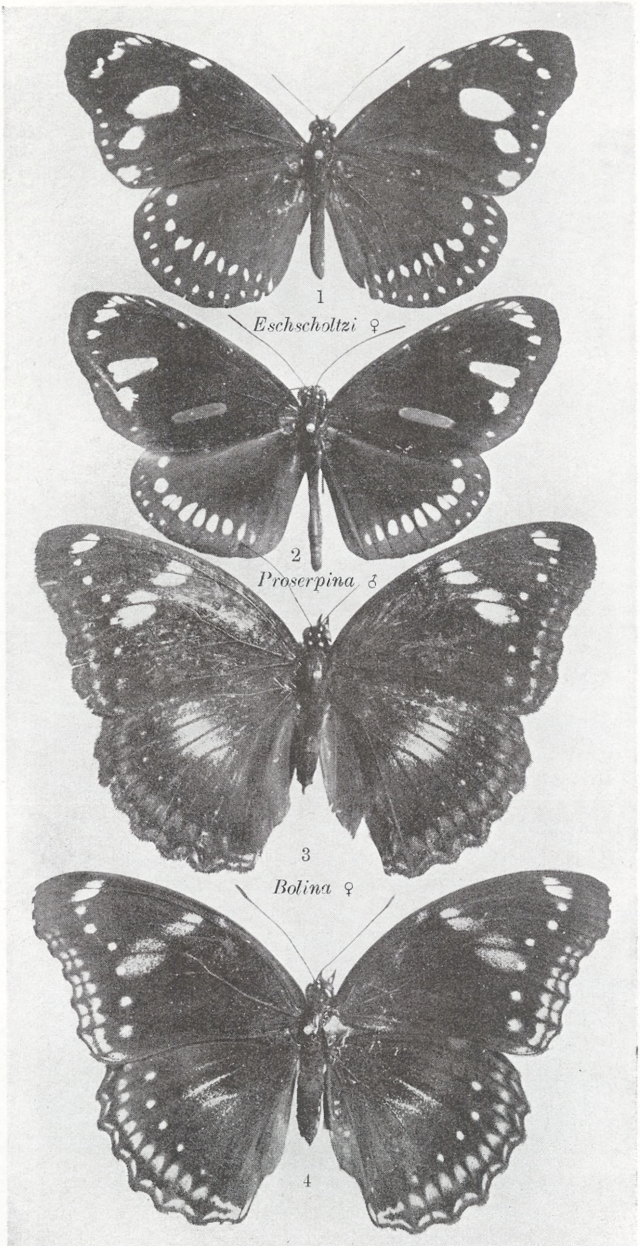
The male *E. boisduvalii proserpina* in Fig. 7 is transitional towards the E. Fijian form *simmondsi* with pattern almost or entirely absent.



A. Robinson, Photo. *All the figures are ½ nat. size.* Vaus & Crampton.

THE FOUR FIJIAN EUPLOEAS FROM OVALAU. WHITE PATTERN STRONGLY DEVELOPED.

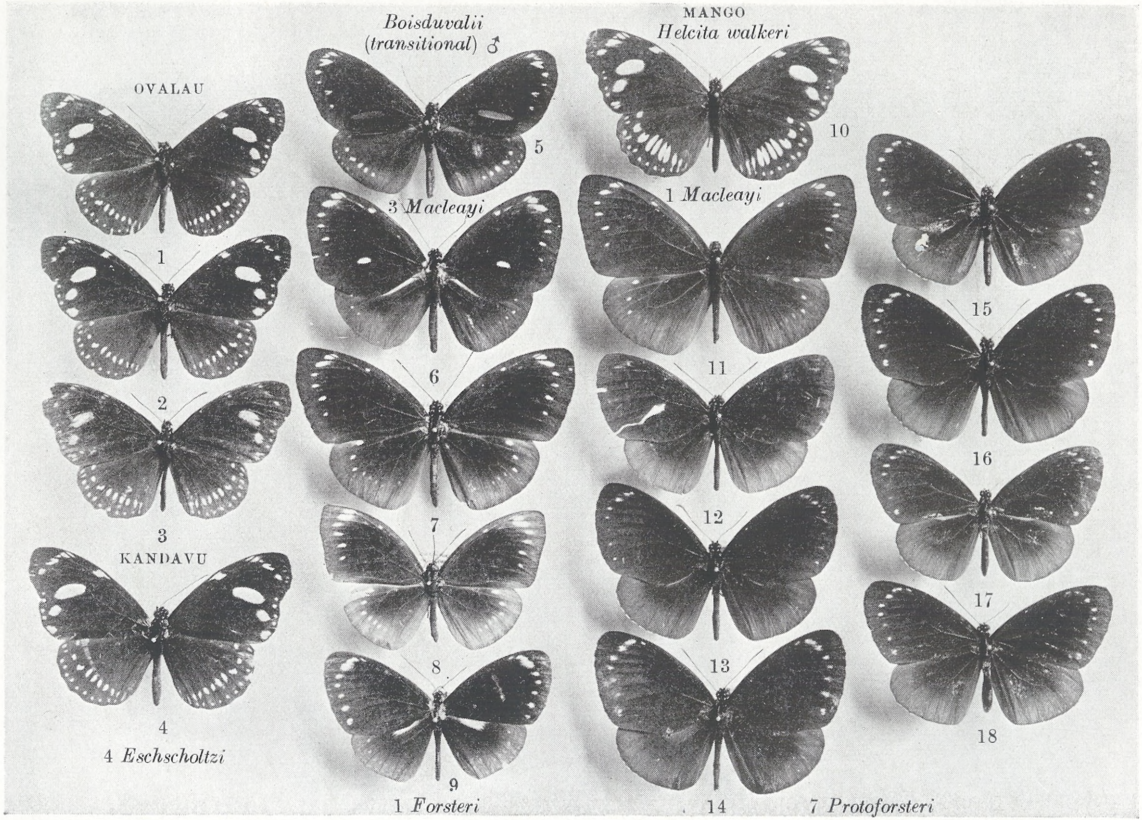
Trans. Ent. Soc. Lond., 1933, Plate XXXVII.



A. Robinson, Photo. *Vaus & Crampton.*

Figures are nat. size.

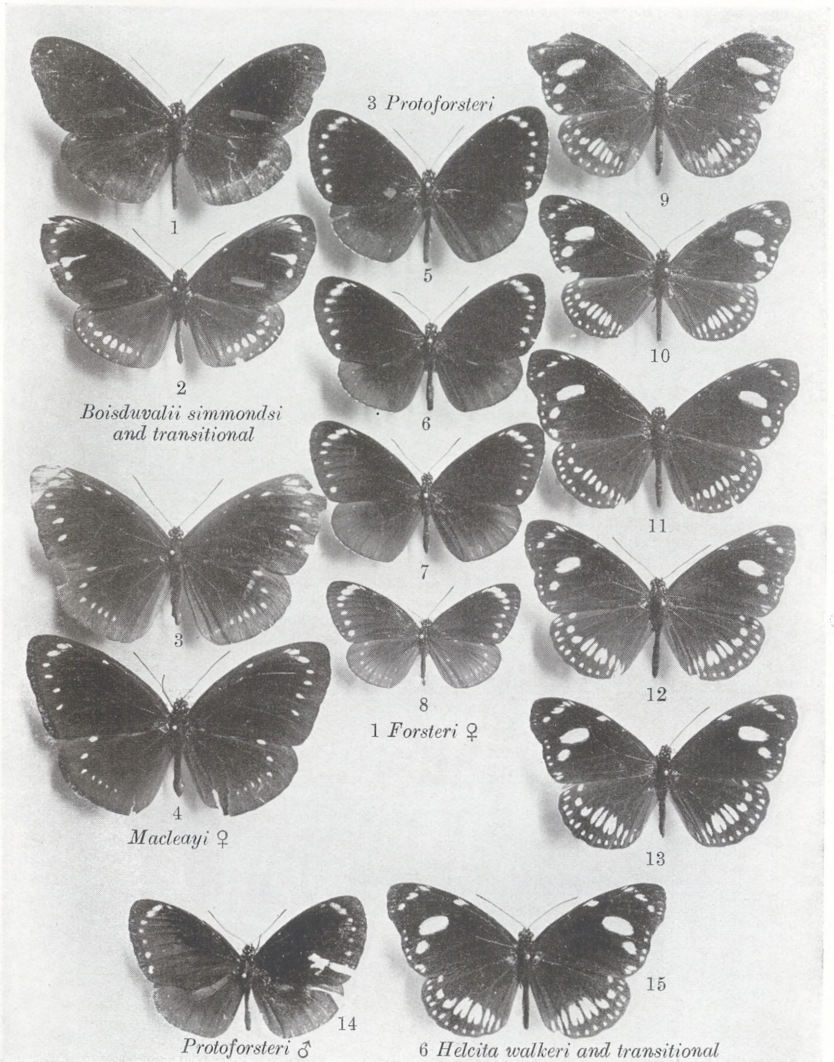
MIMETIC ASSOCIATION (Figs. 1–3) TAKEN WITHIN TWO MINUTES: OVALAU. BRED ♀ H. BOLINA (4) FROM SAME ISLAND.



A. Robinson, Photo. *All the figures are rather under ½ nat. size.* *Vaus & Crampton.*

FIJIAN EUPLOEAS OF WESTERN PATTERN, FROM OVALAU (1–3); OF MOSTLY INTERMEDIATE PATTERN, FROM KANDAVU (4–9); OF EASTERN PATTERN, FROM MANGO (10–18).

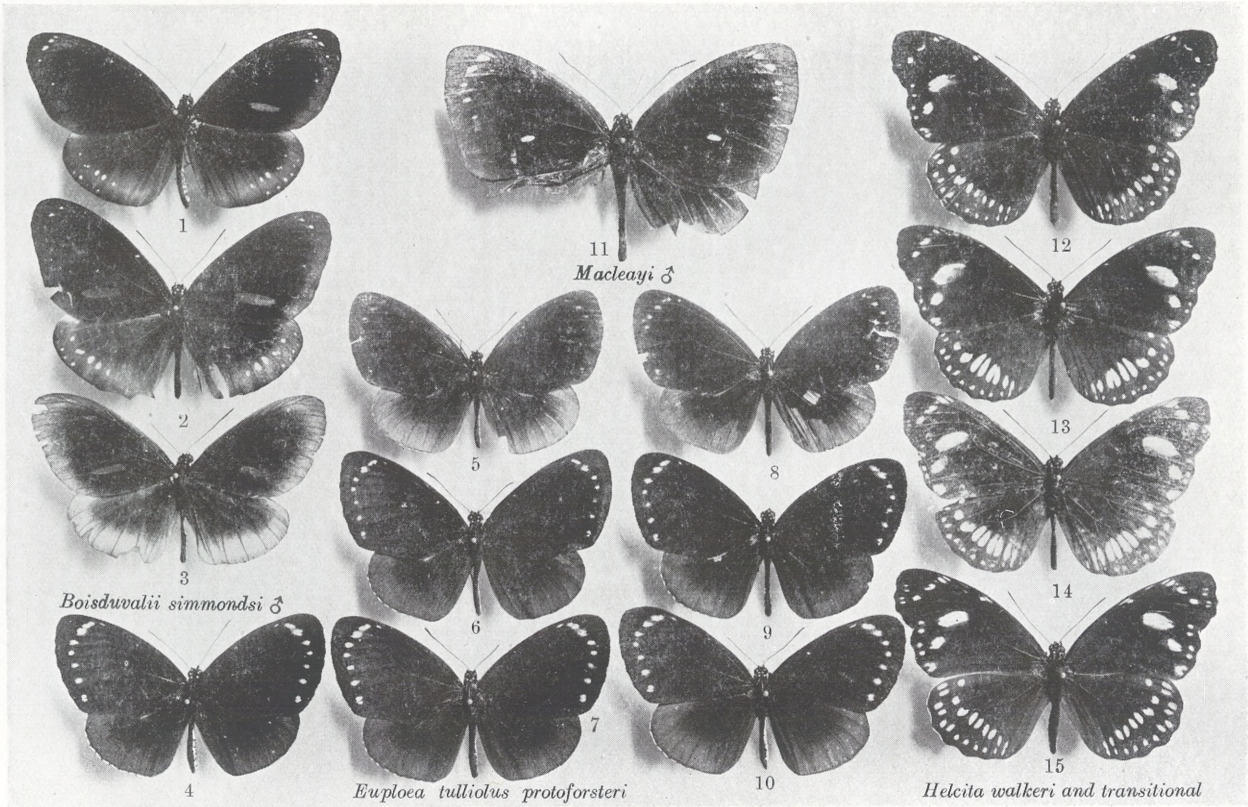
Trans. Ent. Soc. Lond., 1923, Plate XXXIX.



A. Robinson, Photo. *Vaus & Crampton.*

All the figures are rather under ½ *nat. size.*

THE FOUR FIJIAN EUPLOEAS FROM THITHIA (CICIA); WITH EASTERN, INTERMEDIATE AND WESTERN PATTERNS.



A. Robinson, Photo. *All the figures are rather over ½ nat. size.* *Vaus & Crampton.*

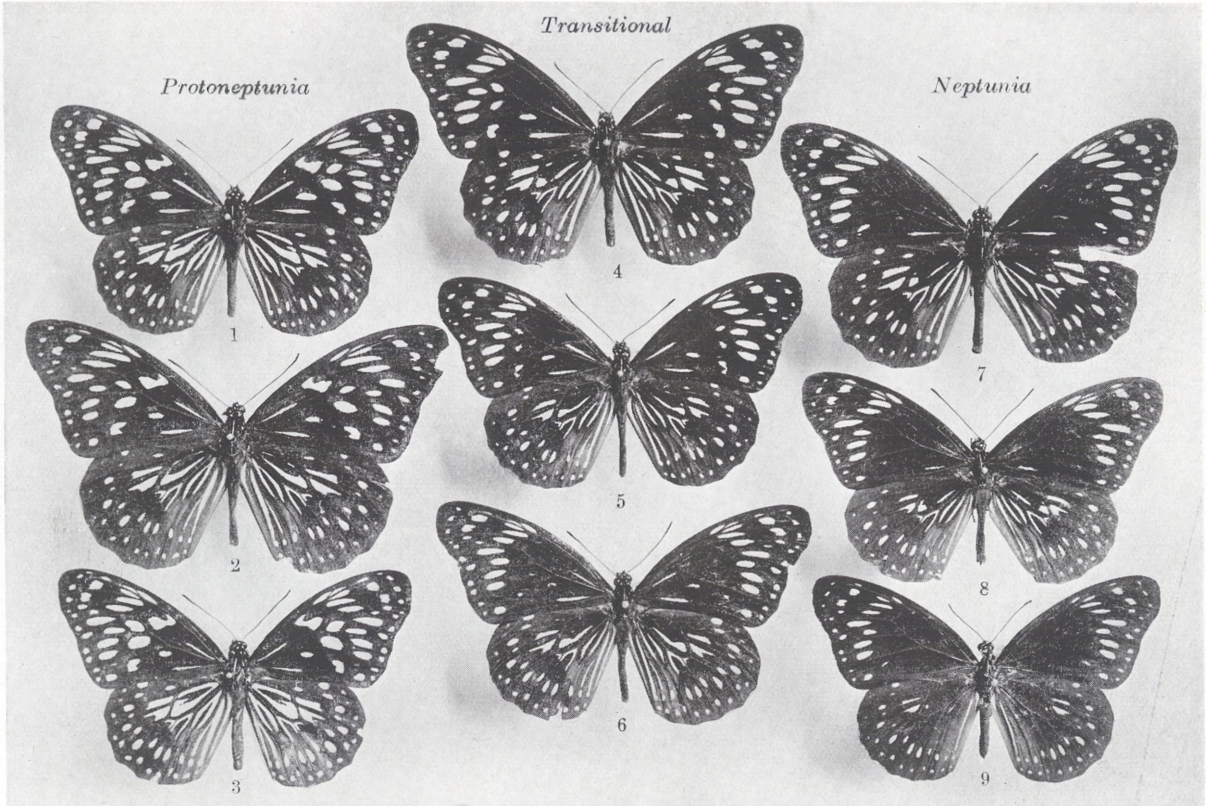
FOUR FIJIAN EUPLOEAS, ON THE WHOLE OF THE MOST EASTERN TYPE, FROM THE MOST EASTERN ISLAND VISITED—VANUA BALAVU.

Trans. Ent. Soc. Lond., 1923, Plate XLI.

A. Robinson, Photo. *Vaus & Crampton.*

All the figures are rather under ½ nat. size.

EUPLOEA HELCITA WITH REDUCED PATTERN (8–12) TAKEN WITH A DARK EUPLOEA (1–7) ON WALLIS I., BUT OF THE FORM WALKERI (13–19) ON FOTUNA I.



A. Robinson, Photo. *All the figures are rather over $\frac{2}{3}$ nat. size.* *Vaus & Crampton.*

GRADUAL REDUCTION OF INTERNAL PATTERN OF A FIJIAN DANAINE IN MIMICRY OF THE WHITE-BORDERED EUPLOEAS.

Trans. Ent. Soc. Lond., 1923, Plate XLIII.

A. Robinson, Photo. *Vaus & Crampton.*

All the figures are slightly under nat. size.

INJURIES INFLICTED BY BIRDS OR LIZARDS ON FIJIAN AND FOTUNA I. BUTTERFLIES. BEAK-MARKS DISTINCT ON 4–6.

FIJIAN HYPOLIMNAS BOLINA.

G. F. Mathew, pinx. *Vaus & Crampton, Ltd.*

All the figures are nearly $\frac{3}{5}$ of the natural size.

Male (1, 1A), two forms of female (2, 2A, 3, 3A), pupa, larva, and food-plant, from Suva.

O. F. Tassari, pinx. *All the figures are of the natural size.* *Vaus & Crampton, Ltd.*

Small All-Female Family of Female Parent Z, captured at Suva (July, 1921). Parent much worn but is the same Form as fig. 3. The Family included a fifth Female like the Parent.

O. F. Tassart, pinx. *All the figures are of the natural size.* *Vaus & Crampton, Ltd.*

Female Forms in All-Female Family of Female Parent Y, captured at Suva (July 9, 1921). Parent similar to fig. 1. Five more Females resemble fig. 1 ; 1 more—fig. 2 ; 2 more—fig. 3 ; 2 more—between figs. 3 and 4 ; 1 more—fig. 4. One additional Female resembled fig. 1 or 2 ; 1 more—fig. 2 or 3 ; 1 more—fig. 4, or came between 3 and 4.

Trans. Ent. Soc. Lond., 1923. Plate XLVII.

♀ Parent K

1 2 3 4

O. F. Tassart, pinx. Vaus & Crampton, Ltd.

All the figures are of the natural size.

Female Forms in Family (including 1 Male received) of Female Parent K (fig. 1), captured in Ovalau (May 6, 1922). One more Female resembles fig. 2; 3 more—fig. 4. The Family included 7 additional Females, 3 resembling fig. 2 or 3; 1—fig. 4.

Trans. Ent. Soc. Lond., 1923. Plate XLVIII.

Eleanor Stoll-Bailey, pinx. *Vaus & Crampton, Ltd.*

All the figures are ¾ of the natural size.

Female Forms in All-Female Family of Female Parent O, captured in North Vanua Levu (Sept. 18, 1922). Parent much damaged but probably like fig. 1. Five more Females resemble fig. 1; 2 more—fig. 2; 1 more—fig. 4; 4 more—fig. 5; 4 more—fig. 6. Two additional Females resembled fig. 3 or 4; 2—fig. 5 or 6.

Trans. Ent. Soc. Lond., 1923. Plate XLIX.

♀ Parent S

1 3

2 4

Trans. Ent. Soc. Lond., 1923. Plate I.

O. F. Tassari, pinx. *Vaus & Crampton, Ltd.*

All the figures are of the natural size.

Female Forms in Family (including 9 Males) of Female Parent S (fig. 1), captured in Taveuni (Sept. 4, 1921). Three, probably 4, more Females resemble fig. 2; 4 more—fig. 3; 2 more—fig. 4, but see explanation of plate for further details.

♀ Parent X

1 2 3 4

O. F. Tassart, pinx. Vaus & Crampton, Ltd.

All the figures are of the natural size.

Female Forms in Family (including 13 Males) of Female Parent X (fig. 1), captured in Kandavu (July 25, 1921). One more Female resembles fig. 2; 1 more—fig. 3; 1 more—fig. 4, but darker. The Family is continued on the next plate.

Trans. Ent. Soc. Lond., 1923. Plate LII.

O. F. Tassart, pinx. *Vaus & Crampton, Ltd.*

All the figures are of the natural size.

Continuation from pl. LI. of Female Forms, also 1 Male (fig. 4), in Family of Female Parent X (pl. LI., fig. 1). One more Female resembles fig. 1; 1 more—fig. 3. The Family included 5 additional Females.

Like ♀ Parent W

1 3

2 4

O. F. Tassart, pinx. Vaus & Crampton, Ltd.

All the figures are of the natural size.

Female Forms in All-Female Family of Female Parent W, captured in Kandavu (July 25, 1921). Parent similar to fig. 1. Two more Females resemble fig. 1, and 1 more is transitional to fig. 3 ; 11 more resembles fig. 2 ; 7 more—fig. 3 ; 1 more—fig. 4.

Explanation of Plate LII.

Fijian *Hypolimnas bolina* (natural size).

Fam. 6.—*Female Forms (continued from Pl. LI) and Male, in Bisexual Family (including* 13 *Males) of Female Parent X, from Kandavu.*

For female parent X see Pl. LI, fig. 1.

Forms of Female Offspring (continued from Pl. LI) present in Family (with One Male).

Fig. 1. Two females of this form (*thomsoni*).
Fig. 2. One female of this form (*murrayi*).
Fig. 3. Two females of this form (*euploeoides*).
Fig. 4. One of the 3 males (out of 13) received.

The family included 5 additional females.

Explanation of Plate LIII.

Fijian *Hypolimnas bolina* (natural size).

Fam. 7.—*Female Forms in All-female Family of Female Parent W, from Kandavu.*

The female parent W, taken July 25, 1921, is of the form *euploeoides*, resembling fig. 1.

Forms of Female Offspring present in Family.

Fig. 1. Three females of this form (*euploeoides*).
Fig. 2. Three females of this form. One of them has slightly more and one slightly less of the "*nerina* red" on F.W. All are the same form as that shown in fig. 1, with this slight addition.
Fig. 3. Eight females of this form (*elliciana*, a *nerina* with reduced pattern).
Fig. 4. Two females of this form (*naresi*, with emphasised H.W. mark).