

## THE INDIAN EPHEMEROPTERA (MAYFLIES).

### PART I.—THE SUB-ORDER EPHEMEROIDEA: FAMILIES PALINGENIIDAE AND POLYMITARCIDAE.

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(Plates VIII—X).

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#### INTRODUCTION.

Shortly before his lamented death Dr. N. Annandale, the late Director of the Zoological Survey of India, suggested to me the study of this interesting group of insects, with a view to publishing a memoir dealing chiefly with their taxonomy and bionomics. The work was started early in 1924, but owing to various interruptions of different sorts could not be continued for a considerable part of the last two years. The collection of mayflies in the Indian Museum, which was fairly large to start with, has in the meantime been growing rapidly by additions made by the officers of the Zoological Survey, and other outside workers, as well as by loans, for the purpose of examination and comparison, from various scientific institutions in India interested in insects. The result of this has been that the work has assumed much larger proportions than was originally contemplated either by me or by Dr. Annandale. My original intention was to publish my results in one comprehensive memoir, but as I now find that this would entail considerable delay and would mean the holding up of the earlier parts of the work for periods much longer than is generally desirable, I have decided with the permission of Major R. B. Seymour Sewell, Director, Zoological Survey of India, to publish my results piecemeal. The present contribution is the first of a series of papers that I hope to publish from time to time in the *Records of the Indian Museum*.

The collection of mayflies in the Indian Museum has for the most part been made at different times by the officers of the Zoological

Survey, chiefly by the late Dr. Annandale and Dr. S. W. Kemp and recently by my colleague Dr. S. L. Hora. Of outside collectors not directly connected with the Survey the name of Lt.-Col. F. C. Fraser, I.M.S., must be mentioned. At my request he made a special collection of the mayflies of Coorg in the Western Ghats and sent me very useful notes on the habits of some of them. For all this I owe him my best thanks.

Of the different scientific institutions in India interested in work on insects that have helped me by lending their named and unnamed collections I must first of all mention the premier entomological institution in India, namely the Agricultural Research Institute at Pusa in Bihar. Mr. T. Bainbrigge Fletcher, the Imperial Entomologist, attached to this Institute, placed his entire collection, named and unnamed, at my disposal, and also sent me a very useful list of references to Indian mayflies that he had prepared for his own use. My best thanks are due to Mr. Fletcher for all the help he has given me. I am also indebted to Dr. F. H. Gravely, Superintendent, Madras Museum, and Rao Sahib Y. Ramchandra Rao, Officiating Government Entomologist at Coimbatore (Madras) for lending me for examination the unnamed collections under their respective charge. The Entomologist attached to the Forest Research Institute at Dehra Dun has also recently sent me some unnamed mayflies.

From outside India also I have received valuable help. Dr. Walther Horn of the Deutsches Entomologische Museum at Berlin sent me a number of duplicates of Central European mayflies determined chiefly by Dr. Georg Ulmer. Drs. F. Maidl and H. Zerny of the Naturhistorisches Museum at Vienna also sent me a large number of named duplicate specimens chiefly from the Palaearctic Region. They also very kindly lent me for examination the type-specimen of Pictet's *Polymitarcys indicus*. The loan of this specimen has helped me a great deal in correctly identifying my Indian examples of this species and for this I owe these gentlemen my best thanks. Professor J. G. Needham of the Cornell University, Ithaca, New York, has helped me a great deal in the course of my work by making several valuable suggestions and also by sending me some duplicate specimens. He has also returned to me a large unnamed collection belonging to the Indian Museum that was sent to him for naming several years back, but which he had not so far been able to deal with on account of other engagements. This collection, partly on account of its being old and partly because of the severe shaking it has had during its journey to the United States of America and back, is at present in a very unsatisfactory condition of preservation and is not of much use. With this collection Professor Needham has sent me a number of slide-mounts that he had made at the time the collection was sent to him. I offer my sincere thanks to Professor Needham and all the other eminent entomologists mentioned above for the help that I have received from them.

The late Dr. Annandale took a great deal of personal interest in this work during the short time that he lived after it was started, and helped me by making several valuable suggestions. I owe him a great debt of gratitude for the encouragement that he gave me in all my work.

Dr. Bains Prashad, Superintendent, Zoological Survey of India, helped me in translating several passages from German into English, and for this I desire to express my thanks to him.

Major R. B. Seymour Sewell has kindly gone through the manuscript with me, and has made several valuable suggestions, for which my best thanks are due to him.

The drawings illustrating this paper have been made under my supervision by Babu D. N. Bagchi, one of the talented artists of the Zoological Survey. I am greatly obliged to him for the care that he has taken in this work, and for the fidelity of delineation that he has displayed.

Following the accepted arrangement, as also for purposes of convenience, I have divided mayflies into three groups, the Ephemeroidea, the Baëtoidea and the Heptagenoidea, giving each of these the rank of a sub-order. The present paper deals with the first-named sub-order. The plan of breaking up into parts a work of a monographic nature is often unsatisfactory in so far as repetitions are sometimes unavoidable, and some important points are often likely to be left out. I have tried to overcome the former difficulty in at least so far as references to literature are concerned, by omitting a complete bibliography from the present paper, and by giving only the most important references. I hope to be able to give a complete bibliography in my last paper.

Under the title "Indian Ephemeroptera" I have, for the most part, included mayflies from the territorial limits of India, including in it Burma and Ceylon. Two species from Mesopotamia have also been included, chiefly because they happen to be in an Indian collection, *viz.*, that of the Entomologist at Coimbatore. Another species from Borneo preserved in the Indian Museum collection has also been included. Though there is a large collection of mayfly nymphs in the Indian Museum, in the present paper I have restricted myself to imago and subimago only.

I have provided analytical keys wherever it has been practicable, but in most cases these have been wholly or partly adopted from the works of previous authors.

In the descriptive parts of the paper I have employed the most commonly used terms. In spite of the extensive work on wing venation by Comstock, Needham, Miss Morgan and Tillyard, the question of the nomenclature of the different veins of the Ephemerid wing is yet far from settled. The arrangement adopted by Eaton and earlier workers is perhaps more convenient for descriptive work than the system laid down by Comstock and Needham and amplified or amended by later writers, including Comstock himself, but the homologies with wing venation in other orders of insects that this arrangement represents are not generally accepted by the present-day entomologists. I have, therefore, thought it best to follow Comstock and Needham's system. I have gone into this question of wing venation somewhat more fully in another part of this paper.

In describing colouration I have used the names of different shades and tints as given and illustrated by Ridgway.<sup>1</sup> Unless standard

<sup>1</sup> Ridgway, Color Standards and Color Nomenclature: Washington (1912).

colour names referable to some easily obtainable standard work are used in describing insects the confusion now prevailing in systematic work on several orders of insects will continue as at present or perhaps become worse in course of time.

#### MATERIAL.

The major part of the collection dealt with by me is preserved in spirit, while insects in some of the older collections are pinned. Like several other workers I also find small insects like the mayflies, especially the smaller species, keep better in spirit than when pinned. In many old collections it is a common experience to find that many insects have vanished from the cabinets, only the pins and the labels or at most fragments of the body remaining behind. This is due either to the ravages of cabinet pests or to the shaking and handling that the collection receives. Professor J. G. Needham is also of the same opinion, for in one of his letters to me he writes "Mayflies should not be pinned, at least, the smaller ones should not. They vanish from the pins as if by evaporation, falling away bit by bit, and soon only the pins and labels remain. . . . When I went to Cambridge, Mass., to study Hagen's types of mayflies, I found them nearly all represented by bare pins. I keep my own in alcohol, and when prepared for study, on slides, with only a few pinned ones for comparison with the remnants in other conventional collections."

#### HISTORICAL.

Comparatively little work has been done on the Indian mayflies. Walker's descriptions (1853) of certain Indian and Cingalese species, in his "*Catalogue*," are, as is the case with most of his work, very meagre and it is difficult in many cases to recognize definitely the forms that he has described. Eaton's "*Revisional Monograph*" (1883) of the world species contains an account of all the then known Indian mayflies, and is to this day the standard work on the subject. In this monograph are included all of Walker's species, and in several cases the descriptions have been amplified. Some of Eaton's other papers also, notably those published in the *Transactions of the Entomological Society of London*, contain references to Indian mayflies. In 1892 this eminent entomologist (1892a) described in the *Journal and Proceedings of the Asiatic Society of Bengal* some mayflies belonging to the Indian Museum, which are still preserved in our collection. Prior to the publication of Eaton's famous monograph Hagen (1858, 1859) in a couple of papers published some notes and descriptions of some Cingalese mayflies. Needham in 1909 in his account of the Neuroptera of the Indian Museum included some Ephemeroidea also; in this paper he redescribed Walker's *Caenis perpusilla* that had been very inadequately described before. Banks in 1914 gave in the *Records of the Indian Museum* a short account of the mayflies that the Zoological party attached to the Abor Expeditionary Force had brought back; in the same year (1914b) he described in the *Proceedings of the Academy of Natural Sciences of Philadelphia* two Ephemeroidea from Ceylon, one of which *Anagnesia greeni* is believed

to be synonymous with Pictet's *Polymitarcys indicus*. In 1920 Gravely revised the Asiatic species of *Palingenia* (*s. l.*) and described a new species from Sarawak. Recently Lestage (1923) has revised the world-known species of the Palingeniidae, and has formed two new genera, one based on Morton's (1921) *Palingenia mesopotamica* from Mesopotamia, and the other to accommodate an insect from New Guinea. He gives in this paper good analytical keys for the identification of various genera and species of this family.

Of recent authors dealing with Oriental mayflies Ulmer and Lestage are perhaps the most prominent. During the last few years these two entomologists have written several valuable papers on this group of insects. Pictet's (1843) description of *Polymitarcys indicus* from the "East Indies" is about the oldest account of an Oriental mayfly. Walker, Hagen and Eaton, the last in his *Revisional Monograph*, have also described Oriental species.

Of publications not dealing exclusively with Oriental forms Eaton's memoir cited above is indispensable to all workers on mayflies. Ulmer (1920) in *Stettiner Entomol. Zeitung* has given very useful keys to the families and genera of mayflies, and has included references to all the known species that he considers valid. The keys are in most cases easy to work, and the references to species are reliable and accurate; the practical usefulness of this work cannot be too highly estimated. Lestage's revisions and notes are also very useful; his notes on Eaton's *Monograph* (1924b) bring the latter work up to date.

Comstock (1899 and 1918), Needham, Miss Morgan (1912) and Tillyard (1923) have done a great deal of work on the wing venation of mayflies and Miss Morgan's paper (1913) on the "Biology of Mayflies" is an interesting study of the habits and life-cycle of these insects. The last mentioned paper also includes a very useful bibliography of the biological, morphological and the more important systematic works dealing with mayflies. For descriptions of larvae and nymphs Eaton's *Revisional Monograph* is still the best work on the subject, while Needham (1905, 1917-18) and several other authors also have made useful contributions to this branch of study. Lestage (1921) in his paper in the series "Les Larves et Nymphes Aquatiques des Insectes d'Europe" has described all the European nymphs and has figured several of them. He has included in this paper keys for the identification of the European nymphs which are very useful.

#### WING VENATION.

Though a considerable amount of work has been done on the wing venation of mayflies the homologies of some of the veins with those in other orders of insects are far from definitely established. The earlier notation as adopted by Eaton (1883) and several other workers need not be considered in any detail, for the homologies of several important veins that this system represents are not accepted by any of the present-day entomologists. Leaving, therefore, Eaton's notation out of consideration, the system of vein nomenclature that has so far received the largest amount of recognition is the one originally expounded by Comstock and Needham (1899).

According to Comstock and Needham the "intercalary" veins which have been considered to be such a characteristic feature of mayfly wings are of course present. The radial sector (Rs) is well developed, and forms, after forking twice, four branches  $R_2$ ,  $R_3$ ,  $R_4$  and  $R_5$ . The radius (R) is a separate vein and its trunk forms the anterior  $R_1$ . The media (M) is supposed to be rather poorly developed and forks only once, and, with an intercalary vein lying in the fork, has three branches  $M_1$ ,  $M_2$ ,  $M_3$ . The cubitus (Cu) is a strong vein, often strongly curved and divides once. This has also an interpolated vein in its fork. The three anals (1A, 2A, 3A) are well developed and distinct. No account was taken by Comstock and Needham of the small veins lying behind the third anal, or of some of the intercalary veins lying in the complex radial sector system. The results, as briefly mentioned above, of these two American entomologists were based not only on an exhaustive study of the adult wing, but the tracheation of the nymphal wing-pad was also taken into account. In fact Comstock and Needham are the earliest workers who, in studying the wing venation of mayflies, took the tracheation in the larval wing-pads into consideration. Excellent as the results of these two eminent entomologists are, they, as pointed out by Miss Morgan (1912), unfortunately studied only those wing-pads in which the bases of the radial and medial (according to Miss Morgan, but radial sector according to these authors) tracheae were closely approximated. They were thus led to interpret as Rs a part of the complex media (as understood by Miss Morgan: *vide infra*).

I have given in the accompanying table and illustration (pp. 98, 99) a comparative statement of the different principal notations that have been used or are being used at present in describing mayfly wings.

Following upon Needham's discovery (1903) of the crossing over of the radial sector in certain dragonflies Miss A. H. Morgan (1912) took up the study of wing venation in mayflies. She studied in great detail the tracheation in the wing-pads of nymphs belonging to a large number of mayfly genera, and offered an interpretation which brought the venation of mayflies in a line with that of Anisopterous dragonflies, in so far as the crossing over of Rs is concerned. She believes that what Comstock and Needham considered to be Rs is really a part of the complex media. The latter vein is greatly developed and has four branches besides a large number of interpolated veins. The radius is unbranched; the radial sector is a small almost insignificant vein which has shifted its position and instead of being attached to the radius, as should be expected, it has been stranded on to the first branch of media ( $M_1$ ), thus altogether losing its connection with the parent stem—the radius. In no adult mayfly can one see this supposed Rs to be connected with  $R_1$  and only in some nymphs of one genus did Miss Morgan find this connection to be actually existing. It must, however, be pointed out that in most wings the supposed radial sector shows near its proximal end a strong upward curving thus suggesting that it may have once been connected to the radius. The cubitus and the three anals, according to Miss Morgan, are exactly as Comstock and Needham described them. The evidence in support of Miss Morgan's view regarding a shifting of the radial sector is, however, far from conclusive, and she herself no

doubt was fully aware of the weakness of her position for in describing this problematic vein she called it  $R_s$ ? In fact the fundamental principle which no doubt influenced Miss Morgan in arriving at these conclusions—the supposed shifting of the radial sector in certain dragonflies—is now strongly challenged by Tillyard and others. Whatever views one might hold regarding Miss Morgan's conclusions one cannot help admiring her painstaking and thorough work.

Comstock in his "Wings of Insects" (1918) and more recently in his "Introduction to Entomology" (1924) has agreed with Miss Morgan's conclusions. He has no doubt that Miss Morgan's  $R_s$ ? represents the true radial sector of other insect wings. He has also given names to some of the intercalary veins that Miss Morgan had left unnamed.

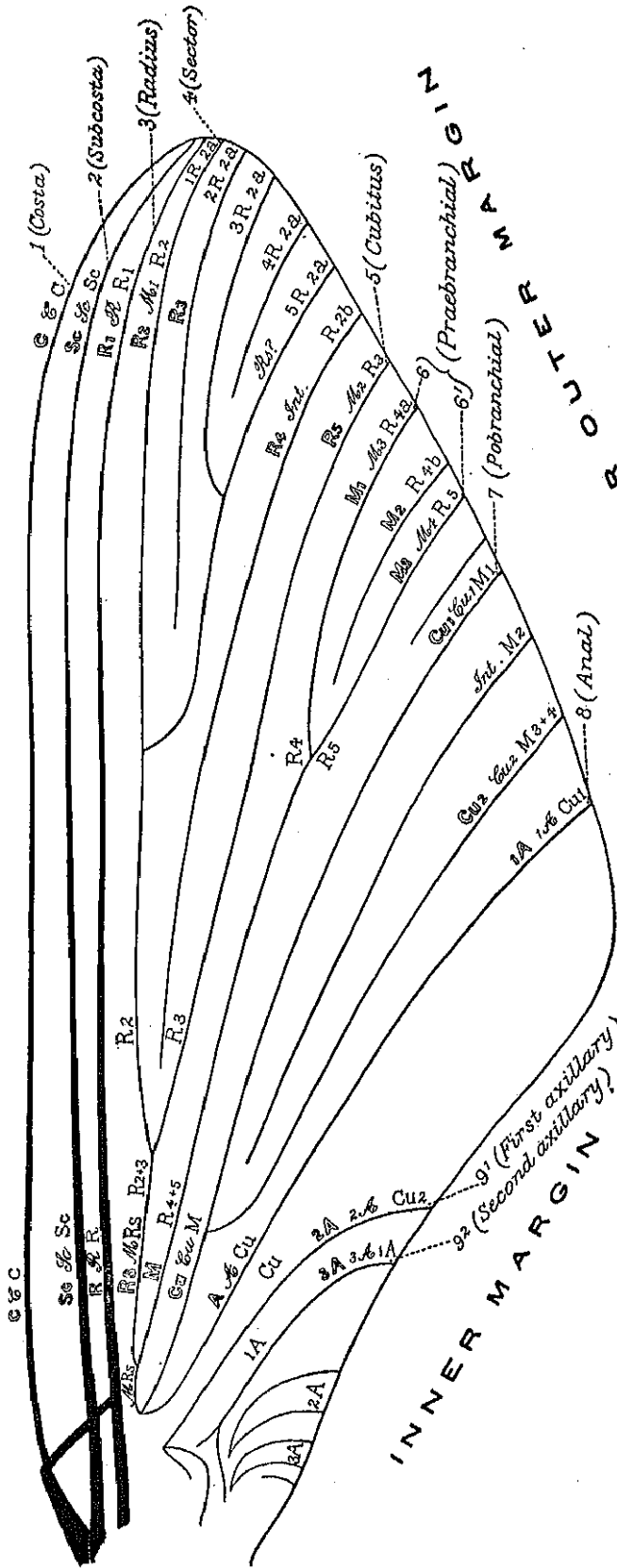
Tillyard (1923) in an admirable piece of work based on an exhaustive study of the fossil wing of the mayfly *Protoreisma* sp., as also that of some nymphal wing-pads, has recently expounded a new notation altogether different from any previously in vogue. From a study of dragonfly wings and by homologising the veins in the wing of mayflies to those of the dragonfly wing he has been able to lay down a plan which brings the wing venation of mayflies more or less in a line with that in other insects. In the first place Tillyard does not believe in the presence in the mayfly wing of any intercalary veins. In *Protoreisma* all the veins branch off from the main trunks, and Tillyard believes that the discontinuity of the so-called intercalary or interpolated veins has been brought about by absorption of the basal connections with the trunks, of which these are the true branches. In the second place the anal area or the clavus in mayfly wings is reduced almost to insignificance, and further the radial sector is enormously developed. What Miss Morgan calls the media and Comstock and Needham had considered the combined radial sector and media becomes, according to Tillyard, the complex radial sector having four branches  $R_2-R_5$ . The media of Comstock and Needham [Praebrachial of Eaton] has thus become a part of the radial sector forming  $R_4$  and  $R_5$ . The cubitus of Comstock and Needham, Miss Morgan and others [Pobrachial of Eaton] now becomes the media, and the first anal of everybody else is regarded by Tillyard as the cubitus, or rather its first branch  $Cu_1$ , the second anal becoming the  $Cu_2$ . The third anal of previous authors is Tillyard's first anal, and two small almost insignificant veins near the base of the inner margin, that everybody had so far ignored, are supposed to be 2A and 3A. From the comparative statement given in the accompanying table the profound changes introduced by Tillyard will be easily understood. The second radial ( $R_2$ ), as will be seen from the table and the illustration, is divided into five branches, which have been given distinct though rather perplexing names. Of these,  $5R_{2a}$  is Miss Morgan's  $R_s$ ? and Comstock's  $R_s$ .

For checking and confirming his results—as very briefly mentioned above—Tillyard combined three different and independent methods of study, viz.: (1) the study of the wings of fossil mayflies; (2) the study of the tracheation in some nymphal wing-pads; and (3) the application of the principle of convex and concave veins. I do not propose

| EATON.           |                                | COMSTOCK AND NEEDHAM. |                     | MORGAN.        |                 | COMSTOCK.      |                 | TILLYARD.        |                   |
|------------------|--------------------------------|-----------------------|---------------------|----------------|-----------------|----------------|-----------------|------------------|-------------------|
| Veins near base. | Veins at margin.               | Near base.            | At margin.          | Near base.     | At margin.      | Near base.     | At margin.      | Near base.       | At margin.        |
| Costa            | 1 Costa                        | C                     | C                   | C              | C               | C              | C               | C                | C                 |
| Subcosta         | 2 Subcosta                     | Sc                    | Sc                  | Sc             | Sc              | Sc             | Sc              | Sc               | Sc                |
| Radius           | 3 Radius                       | R                     | R                   | R              | R               | R              | R               | R <sub>1</sub>   | R <sub>1</sub>    |
| Cubito-sector    | 4 Sector                       | Rs                    | M <sub>1</sub>      | M              | M <sub>1</sub>  | M              | M <sub>1</sub>  | Rs               | 1 R <sub>2a</sub> |
|                  | Adventitious                   |                       | Omitted             | ?              | Omitted         | Omitted        | ?               | IM <sub>1</sub>  | 2 R <sub>2a</sub> |
|                  | Adventitious                   |                       | Omitted             | ?              | Omitted         | Omitted        | ?               | Omitted          | 3 R <sub>2a</sub> |
|                  | Adventitious                   |                       | Accessory Radial I. | ?              | Rs ?            | Rs ?           | ?               | Rs               | 4 R <sub>2a</sub> |
|                  | Adventitious                   |                       | R <sub>4</sub>      | ?              | Intercalary     | Intercalary    | ?               | IRs              | 5 R <sub>2a</sub> |
| Cubitus          | 5 Cubitus                      | R <sub>5</sub>        | M <sub>2</sub>      | M <sub>2</sub> | M <sub>2</sub>  | M <sub>2</sub> | R <sub>3</sub>  | R <sub>2b</sub>  |                   |
| Praebrachial     | 6 Praebrachial                 | M                     | M <sub>3</sub>      | ?              | M <sub>3</sub>  | ?              | M <sub>3</sub>  | R <sub>4</sub>   | R <sub>4a</sub>   |
|                  | Adventitious                   |                       | Omitted             | ?              | Omitted         | Omitted        | ?               | IM <sub>3</sub>  | R <sub>4b</sub>   |
|                  | 6 <sup>1</sup> Praebrachial    |                       | M <sub>4</sub>      | ?              | M <sub>4</sub>  | ?              | M <sub>4</sub>  | R <sub>5</sub>   | R <sub>5</sub>    |
| Pobrachial       | 7 Pobrachial                   | Cu                    | Cu <sub>1</sub>     | Cu             | Cu <sub>1</sub> | Cu             | Cu <sub>1</sub> | M <sub>1</sub>   | M <sub>2</sub>    |
|                  | Adventitious                   |                       | Intercalary         | ?              | Intercalary     | Intercalary    | ?               | ICu <sub>1</sub> | M <sub>2</sub>    |
| Anal             | 8 Anal                         | A                     | 1 A                 | A              | 1 A             | A              | 1 A             | M <sub>3+4</sub> | Cu <sub>1</sub>   |
|                  | 9 <sup>1</sup> First axillary  |                       | 2 A                 | ?              | 2 A             | ?              | 2 A             | Cu <sub>2</sub>  | Cu <sub>2</sub>   |
|                  | 9 <sup>2</sup> Second axillary |                       | 3 A                 | ?              | 3 A             | ?              | 3 A             | A                | 1 A               |
| Axillary         | Omitted                        |                       | Omitted             |                | Omitted         |                | Omitted         | 2 A              |                   |
| Axillary         | Omitted                        |                       | Omitted             |                | Omitted         |                | Omitted         | 3 A              |                   |



COSTAL MARGIN



INNER MARGIN

1(Costa), 2, 3 etc. ... Eaton's notation.  
 C, Sc, R<sub>1</sub>, etc. ... Tillyard's "  
 A.C. Chowdhary del.

EXPLANATION OF DIAGRAM.

Diagram of an archaic type of mayfly fore-wing to illustrate the different notations used in describing venation. Different types of letters represent different notations, those adopted by Eaton, Tillyard, Miss Morgan and Comstock and Needham being shown successively from margin inwards. For "Praebrachial" and "Pobrachial" read "Praebranchial" and "Pobbranchial".  
 A, anal trunk; 1A, 2A, 3A, first, second and third anal veins. Cu, trunk of cubitus; Cu<sub>1</sub>, Cu<sub>2</sub>, first and second cubitus veins. Int, intercalary veins of Miss Morgan. M, trunk of media; M<sub>1</sub>, M<sub>2</sub>, M<sub>3</sub>, M<sub>4</sub>, its four branches; MRS, combined trunk of media and radial sector. R, radius; R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>5</sub>, its five branches with 1R<sub>1</sub>, 2R<sub>1</sub>, 3R<sub>1</sub>, 4R<sub>1</sub>, 5R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>5</sub>, R<sub>6</sub>, R<sub>7</sub>, R<sub>8</sub>, R<sub>9</sub>, R<sub>10</sub>, R<sub>11</sub>, R<sub>12</sub>, R<sub>13</sub>, R<sub>14</sub>, R<sub>15</sub>, R<sub>16</sub>, R<sub>17</sub>, R<sub>18</sub>, R<sub>19</sub>, R<sub>20</sub>, R<sub>21</sub>, R<sub>22</sub>, R<sub>23</sub>, R<sub>24</sub>, R<sub>25</sub>, R<sub>26</sub>, R<sub>27</sub>, R<sub>28</sub>, R<sub>29</sub>, R<sub>30</sub>, R<sub>31</sub>, R<sub>32</sub>, R<sub>33</sub>, R<sub>34</sub>, R<sub>35</sub>, R<sub>36</sub>, R<sub>37</sub>, R<sub>38</sub>, R<sub>39</sub>, R<sub>40</sub>, R<sub>41</sub>, R<sub>42</sub>, R<sub>43</sub>, R<sub>44</sub>, R<sub>45</sub>, R<sub>46</sub>, R<sub>47</sub>, R<sub>48</sub>, R<sub>49</sub>, R<sub>50</sub>, R<sub>51</sub>, R<sub>52</sub>, R<sub>53</sub>, R<sub>54</sub>, R<sub>55</sub>, R<sub>56</sub>, R<sub>57</sub>, R<sub>58</sub>, R<sub>59</sub>, R<sub>60</sub>, R<sub>61</sub>, R<sub>62</sub>, R<sub>63</sub>, R<sub>64</sub>, R<sub>65</sub>, R<sub>66</sub>, R<sub>67</sub>, R<sub>68</sub>, R<sub>69</sub>, R<sub>70</sub>, R<sub>71</sub>, R<sub>72</sub>, R<sub>73</sub>, R<sub>74</sub>, R<sub>75</sub>, R<sub>76</sub>, R<sub>77</sub>, R<sub>78</sub>, R<sub>79</sub>, R<sub>80</sub>, R<sub>81</sub>, R<sub>82</sub>, R<sub>83</sub>, R<sub>84</sub>, R<sub>85</sub>, R<sub>86</sub>, R<sub>87</sub>, R<sub>88</sub>, R<sub>89</sub>, R<sub>90</sub>, R<sub>91</sub>, R<sub>92</sub>, R<sub>93</sub>, R<sub>94</sub>, R<sub>95</sub>, R<sub>96</sub>, R<sub>97</sub>, R<sub>98</sub>, R<sub>99</sub>, R<sub>100</sub>.  
 Some of these intercalary veins, as shown in the chart on page 98, have been named by Comstock as: IM<sub>1</sub>, intercalary vein media one; IM<sub>2</sub>, intercalary vein radial sector; IM<sub>3</sub>, intercalary vein media three and 1Cu<sub>1</sub>, intercalary vein cubitus one.

going into the details of his elaborate arguments, nor am I in a position to offer a criticism of Tillyard's conclusions, for besides studying the tracheation in the wing-pads in about half a dozen genera of Indian mayfly nymphs I have not studied the question of wing venation in mayflies from any of the three aspects from which Tillyard has approached it. My own observations, scanty though they are, agree more with Miss Morgan's conclusions than they do with Tillyard's. In no adult mayfly wing and in very few nymphal wing-pads does Tillyard's R<sub>s</sub> appear to form a connection with the radius. In some genera R<sub>s</sub> (as interpreted by Tillyard, or by Comstock and Needham as well) near its base lies very close to R but in no recent adult mayfly does it appear to branch off it. In the hind-wing this appears to be even more well marked than in the fore-wing. In the Permian mayfly *Protereisma*, however, the radial sector (Tillyard's) at its base lies so close to the radius that it appears to arise from it. The same is observable in the "nth" instar of *Ameletus ornatus*, as figured by Tillyard. But even in these cases it is very difficult to say whether the two merely lie close together or are really a part of one stem. In "(n + 1)th" and later instars of *Ameletus*, however, the radius and the radial sector lie apart from each other.

The triadic branching of the main vein stems by which, according to Tillyard, it is assumed that a positive vein, for instance in dividing, forms two positive branches and one negative between these is an ingenious way of explaining the alternating arrangement of convex and concave veins.

Tillyard's conclusions, though one may not entirely agree with them, are based on an intensive study of wing venation and are likely to rank always as a very important contribution to the question of the homologies of different veins in the mayfly wing. They have not been before the scientific world long enough to have evoked criticism or confirmation from many entomologists, though some workers on mayflies, notably Lestage (1924) among them, have already adopted them. In the succeeding pages I have followed Comstock and Needham's system originally expounded in their "Wings of Insects." I have done this not because I think that this system represents the correct or the most nearly correct homologies with other insect groups, but because I am unable to subscribe fully to either of the two later systems—Miss Morgan's or Tillyard's. Comstock and Needham's notation has at least one advantage over the other two systems, that it is older and has been extensively used in descriptive work. Until the homologies of veins in mayfly wings are definitely decided I think it will save further confusion if one sticks to an old and commonly used system.

#### SYSTEMATIC ACCOUNT.

The history of classification given by Eaton (1883) extends back to the days of Linnæus when all the known mayflies were arranged in a single genus "Ephemerus" with two sections, one for species with two caudal setae, and the other for those having three. In his most valuable paper entitled "Übersicht über die Gattungen der Ephemeropteren, nebst Bemerkungen über einzelne Arten" Ulmer (1920), besides giving

an up-to-date classification of the mayflies of the world, gives an interesting account of the classifications adopted by writers from the time of publication of Eaton's famous *Revisional Monograph* to his own day. At that time and even to a considerably later period mayflies were considered to constitute only a family of the composite order "Neuroptera." Even though some of the present writers, notably Needham among them, give mayflies a family rank only, most entomologists, however, are agreed that they form a distinct order separable on well-defined characters from other orders of Insecta. The order Ephemeroptera (sometimes called Ephemeroida), according to this view, is divided into three sub-orders, the Ephemeroidea, the Baëtoidea, and the Heptagenoidea, each having approximately the same position as "Group I," "Group II" and "Group III" of Eaton (1883) respectively. According to Eaton, however, "Potamanthus Type" (now the family Potamanthidae) was included in his "Group II"; it is now considered to be a family of the first sub-order Ephemeroidea and not of the second Baëtoidea. Further, Eaton placed the genus *Oligoneuria* in his "Palingenia Type" in "Group I"; now it is included in the family Oligoneuridae in the sub-order Baëtoidea. Except for these comparatively minor changes the classification of Eaton is followed, in its broad outlines at least, up to the present day. What Eaton called the "Types" have now become the families, and thus the order Ephemeroptera is now believed to consist of fourteen families (thirteen "Types" of Eaton, and the Oligoneuridae of later writers), four under the sub-order Ephemeroidea, six under Baëtoidea and four under Heptagenoidea.

In the following pages Ulmer's classification of the order, as given in the paper cited above, has been followed almost completely.

The three sub-orders of mayflies may be distinguished from one another with the help of the following key :

- A. In fore-wing cubitus (Cu) and first anal vein (1A) strongly divergent near base. [Hind-tarsus with only four (sometimes fewer) freely movable segments, fifth segment, if ever present, more or less completely united with tibia and immovable; venation never greatly reduced.] .. .. Ephemeroidea.
- B. In fore-wing cubitus (Cu) and first anal vein running more or less parallel near base, rarely weakly divergent
  - I. Hind-tarsus with only four freely movable segments, fifth segment, if ever present, more or less completely united with tibia and immovable. [Venation sometimes greatly reduced.] .. .. Baëtoidea.
  - II. Hind-tarsus with five freely movable segments. [Venation never greatly reduced.] .. .. Heptagenoidea.

#### Sub-order EPHEMEROIDEA.

The four families into which the sub-order Ephemeroidea is divided may be separated from one another as follows :—

- A. Subcoosta of fore-wing concealed in a fold of membrane under radius and not visible along costal margin except near base. [Both wings dull, at most translucent; legs of female weak and often functionless, those of male well developed.] .. .. Palingeniidae.

- B. Subcosta of fore-wing not concealed in a fold of membrane, fully developed and well displayed.
- I. Wings dull, at most translucent, sometimes slightly shining in male; legs weak, especially in female, fore-legs of male often long .. .. . Polymitarcidae.
- II. Wings shining, transparent; legs well developed in both sexes.
1. In fore-wing third anal vein not forked, but connected with inner margin of wing by many cross veins; genital forcep of male four-segmented, basal segment small, second longest .. .. . Ephemeridae.
2. In fore-wing third anal vein forked once, rarely connected with inner margin by cross veins; genital forcep of male three-segmented, basal segment longest .. .. . Potamanthidae.

In the synoptic key given by Ulmer (1920, pp. 100, 101) the family Ephemeridae is separated from the Potamanthidae on the character, among others, that in Ephemeridae "Im Vorderflügel ist Analader 1 nicht gegabelt, sondern durch mehrere bis zahlreiche Queradern mit dem Flügelrande verbunden," while in the other family the first anal vein in the fore-wing is described as being forked once, with the cross veins wanting. Fletcher<sup>1</sup> in his "Tentative keys to the Orders and Families of Indian Insects" has repeated the same statement. This, however, is obviously incorrect as the first anal vein in the fore-wing in both the families is not forked, and is connected in both to the inner margin by a number of small veins. It is the third anal vein that is forked in the Potamanthidae and is not forked in the Ephemeridae, and is connected with the wing margin in the latter family, while it is not so connected in the former.

#### Family PALINGENIIDAE.

In his "Étude sur les Palingeniidae" published in 1923 Lestage (1923a) gives an excellent account of the insects comprising this family. The historical sketch, the important features characterising these insects, their geographical distribution and their taxonomy are all so well treated that nothing need be added to them. In this paper the author has also described two new genera, one *Mortogenesisia* based on a Mesopotamian insect already described by Morton (1921) under the name of *Palingenia mesopotamica* and the other *Tritogenesisia* from New Guinea. All the world species are recorded and briefly characterised.

Gravely's "Notes on some Asiatic species of *Palingenia*" published in the *Records of the Indian Museum* also form a very useful contribution to the subject. In this paper all the then known Indian species (including one from Mesopotamia) are dealt with, and a new one from Borneo is described. Descriptions of nymphs of two species are also given for the first time.

Of the five genera into which this family has been divided by Lestage, viz., *Palingenia* (Burmeister) Eaton, *Anagenesia* (Eaton) Ulmer, *Pletho-*

<sup>1</sup> Fletcher, *Bull. Agric. Research Inst. Pusa*, No. 162, pp. 15--18 (1926).

*genesis* Ulmer, *Mortogenesis* Lestage and *Tritogenesis* Lestage, the first, second and fourth are met with in the Oriental Region, while the remaining two, *Plethogenesis* and *Tritogenesis*, are so far known to live in New Guinea only.

The three Oriental genera of this family may be distinguished from one another with the help of the following key :—

- A. Media (M) of fore-wing forked well beyond middle of wing ; more than one subsidiary vein present in fork of first anal vein ; fore-tarsus of male  $2\frac{1}{2}$  times as long as femur. [ Genital forcep of male 6-7 segmented, basal segment very long, others short ; hind-tarsus with a double claw.] .. *Palingenia*.
- B. Media of fore-wing forked before middle of wing ; only one subsidiary vein in fork of first anal vein ; fore-tarsus of male about as long as femur.
- I. Hind-tarsus with a single claw ; media of fore-wing usually forked before forking of radial sector (Rs) ; genital forcep of male three-segmented, basal segment long, others short .. .. *Anagenesia*.
- II. Hind-tarsus with a double claw ; media of fore-wing forked later than forking of radial sector ; genital forcep of male seven-segmented, basal segment very long, others short .. .. *Mortogenesis*.

The remarkable absence of the members of this family from America has already been noted by Lestage.

#### Genus *Palingenia* (Burmeister) Eaton.

1839. *Palingenia*, Burmeister, *Handbuch d. Entomol.* II, p. 803 (*partim*).  
 1863. *Palingenia*, Eaton<sup>1</sup>, *Trans. Linn. Soc. London* (2) III, pp. 23-26.  
 1920. *Palingenia*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.  
 1923. *Palingenia*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, pp. 107, 108.

According to Eaton the genus *Palingenia*, as restricted by him occurs in the "Eastern N. Temperate region" only, the two species known to him having been met with in Central Europe and the Caucasus respectively. The range of the genus is now known to extend considerably eastwards ; the Central European species has been found in Mesopotamia also and another has been described from Seistan in Persia.

The genus, as now understood, consists of three species only ; *P. longicauda*, the genotype, from Central Europe and the near East ; *P. fuliginosa* from the Caucasus and *P. orientalis*, sp. nov., from Seistan in Persia. The last named species was first described by Needham (1909) as *P. sp.* (probably *Anagenesia robusta* ?), and was later confused by Gravely (1920) with the Central European *P. longicauda*. The reasons that have led me to set up a new species for the insect from Seistan are given in their appropriate place.

The history of this genus has been fully described by Lestage in the paper cited above and nothing need be added to it.

<sup>1</sup> For earlier references to this genus see the synonymy given by Eaton in this paper under *Palingenia longicauda*.

**Palingenia longicauda** (Oliver).

1791. *Ephemera longicauda*, Oliver, *Encyclopedie Methodique* VI, p. 418.  
 1839. *Palingenia longicauda*, Burmeister, *Handb. d. Entomol.* II, p. 803.  
 1883. *Palingenia longicauda*, Eaton, *Trans. Linn. Soc.* (2) III, p. 24, pl. i, fig. 1a.  
 1920. *Palingenia longicauda*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.  
 1920. *nec Palingenia ? longicauda*, Gravely, *Rec. Ind. Mus.* XVIII, pp. 138-140.  
 1923. *Palingenia longicauda*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 107.

A single specimen of this cosmopolitan Central European form is in the collection of the Madras Government Entomologist at Coimbatore. It was collected at Karradah, on the Tigris River in Mesopotamia by Mr. Y. R. Rao on 24th May, 1920. The species is perhaps fairly common in Mesopotamia, though Gravely's reference to "large Mayflies on the Euphrates at about the beginning of April" point to those insects being *Mortogenesia mesopotamica* rather than the present species. As will be seen from Morton's account of his *mesopotamica*, as also from my notes on it (*vide infra*, p. 122), this species appears in large numbers in the beginning of April; *P. longicauda* is not known to emerge so early.

Through the courtesy of the authorities of the Vienna Museum I have been able to examine a specimen of this species from Central Europe, and find that it agrees exactly with mine from Mesopotamia. The Mesopotamian example is a pinned male, about 18 mm. long. The colour is very slightly faded, but agrees closely with Pictet's coloured picture of this species, as also with the Central European specimen. The forcep limb of one side is broken, but the other is like that shown by Eaton. In all respects the Mesopotamian example conforms with the published accounts of the species. My specimen is, however, somewhat smaller than the usual size of the species in Europe.

The occurrence of this species in Mesopotamia considerably extends its geographical range. It was hitherto thought to be confined to "the large rivers of middle Europe from Rotterdam to Hungary," and the present record from Mesopotamia extends its range eastwards a great deal. Further, it is interesting to note that the species emerges in Central Europe in the latter half of June or beginning of July, while in Mesopotamia it seems to come out considerably earlier.

**Palingenia orientalis**, sp. nov.

(Plate VIII, figs. 1-3).

1900. *Palingenia (Anagenesia)* sp.? (*robusta* ?), Needham, *Rec. Ind. Mus.* III, p. 191, pl. xx, fig. 8.  
 1920. *Palingenia (s. str.) ? longicauda*, Gravely, *Rec. Ind. Mus.* XVIII, pp. 138-140, pl. xviii, fig. 1-4 (nymph), pl. xx, figs. 21-23 (imago).  
 1923. *Palingenia* sp. ? *longicauda*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 108.

I have based this new species on a number of pinned male specimens from Scistan preserved in the collection of the Indian Museum. There are nine specimens in the collection and they are all in a poor state of preservation. The legs and the caudal setae are missing in most of the examples, the forcep limbs are broken, and the wings in most cases are all but fragmentary. There is another male specimen in the Indian

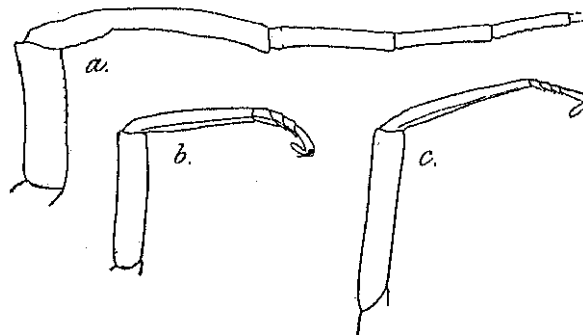
Museum collection preserved in spirit. This specimen also is in very poor condition and the head and a part of the thorax are altogether missing. It was sent probably along with other specimens to Professor Needham and was returned by him named as *P. sp. (? robusta)*.

Imago ♂ (dried).—The general colouration of the body is a dirty white varying to a shade of ochraceous buff. The head is black, but the area between the eyes is in most specimens fuscous. The pronotum is of the general ground tint, but the mesonotum and metanotum are warmer. In one specimen the notum is considerably suffused with smoke gray. The dorsum of the abdomen is ochraceous buff to ochraceous tawny, with light annulations at the segmental joints. The last two segments are considerably warmer than the rest and are almost tawny. The venter is dirty white.

The legs and setae are missing in most of the specimens; they are dirty white to cream in colour. The wings are transparent and somewhat dull, and have no prominent colour markings. They are a very light shade of ochraceous buff, with opaque warm buff neuration.

In the fore-wing the arrangement of veins, as illustrated in Gravelly's figure quoted above, corresponds more or less closely with that in the wing of *P. longicauda*, as given in Eaton's figure of it. The small intercalary and even the cross veins are more or less similarly disposed. The media forks well beyond the middle and there are, as emphasised by Eaton, two sets of longitudinal nervures proceeding in pairs to the terminal margin. There are several longitudinal nervures contained in the fork of the first anal.

The hind-wing is also like that of *P. longicauda*. The subcosta is well displayed and all the other veins are well developed. The media forks well in advance of the middle, and the intercalary vein ( $M_2$ ) enclosed between the two branches extends almost up to the forking point. There are two subsidiary veins on either side of  $M_2$ . The cubitus and the anals are also well developed. As in the fore-wing there is a large



TEXT-FIG. 1.—*Palingenia orientalis*, sp. nov.

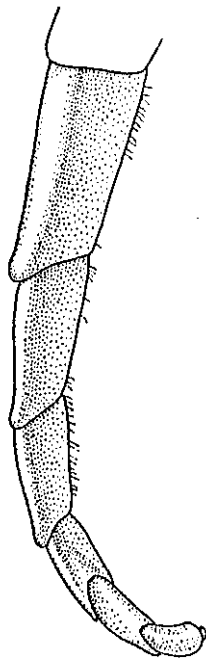
Legs of male, all drawn to same magnification:  $\times 6$ .

a. 1st leg (incomplete). b. 2nd leg. c. 3rd leg.

number of small intercalaries along the terminal margin and the cross veins are plentiful.

The legs are broken in most of the specimens, and the fore-tarsus is missing or incomplete in all. The fore-leg is the longest and the second is the shortest of the three. In the first leg the femur is considerably shorter than the tibia, and the tarsus appears to be the longest part. The latter is probably formed of four distinct and one rudimentary joint. In no specimen are more than three tarsal joints, exclusive of the rudimentary one, now present, and of these the first is slightly longer than the second, while the third is considerably shorter than either of these. In the second leg the tibia is somewhat longer than the tarsus; the latter is four-segmented, the proximal three segments being subequal, and the terminal much longer than any other. In the hind-leg the tarsus is much shorter than the tibia; the first three tarsal segments are in this case also subequal, and the fourth is longer than any other two put together. The claw is strongly developed and is biunguiculate, the two ungues being markedly unequal.

The genital apparatus of the male has been figured by Gravely, and his illustration shows the various parts clearly. The genital forceps



TEXT-FIG. 2.—*Palingenia orientalis*, sp. nov.  
Genital forcep of male,  
terminal region only:  
x77.

are concolorous with the posterior abdominal region and each is formed of a long grooved basal joint and about six or seven terminal ones, of which the most distal are minute. The basal joint on its inner side near the base has a small rounded projection—not shown in Gravely's figure—like that shown in Eaton's illustration of *P. longicauda*. In most of my specimens the forceps are missing or broken, but in two or three they are fairly complete. As will be seen from the accompanying figure (Plate VIII, fig. 3) the basal joint is about three times as long as all the others put together, is distinctly grooved and seems to have fine hairs along both sides of the groove. Besides the long basal segment there are six well-developed joints and another extremely reduced one. This is clearly shown in the accompanying text-figure (fig. 2). The penis lobes, as shown by Gravely, are fairly long and are only slightly narrower at the apex than near the base. Their shape, etc. is exactly as seen in Gravely's figure.

The setae are present in a broken condition in only a few of the specimens. They are like narrow ribbons, finely pubescent throughout their length.

The ♀ is not known.

Length of body, ♂ 22-26; wings up to 25 mm.

The nymphs have been described and figured by Gravely in detail.

*Type-specimen*.—9417/14, Zoological Survey of India (*Ind. Mus.*).

*Locality*.—The nine pinned male specimens preserved in the Indian Museum were collected in Seistan, Persia, by Col. A. H. McMahon of the



Seistan Boundary Commission. The exact locality in Seistan where the specimens were collected is not known.

As will be seen from the synonymy given above the specimens on which I have based this new species were erroneously referred by Needham in 1909 to the genus *Anagenesia*. That the specimens do not belong to this genus is evident from a study of the wing venation and the genital forceps of the male. As shown in Gravely's figure of the fore-wing, quoted above, the media forks well beyond the middle; in *Anagenesia* it always divides before the middle. Similarly the genital forceps are formed of a long basal segment and six or seven terminal ones; in *Anagenesia* there are never more than three segments present. Gravely correctly placed the specimens in the genus *Palingenia* (*s. str.*), but provisionally referred them to the European *P. longicauda*. They, however, differ from the latter species in having a duller and more uniform colouration. The colour of the Seistan specimens has no doubt been greatly affected by poor preservation, but it is hardly likely that it was ever anything like that of *P. longicauda*. The wings are also considerably lighter in colour and instead of being dull brownish or medium sepia in colour are almost dirty whitish. Further the penis lobes in the European species are markedly constricted near the tip, while in *P. orientalis* they are more or less of a uniform thickness, showing only a very slight constriction near the apex.

The type-specimen seems to have been examined by Professor Needham and bears a label in his hand-writing "Palingenia sp. subgenus *Anagenesia* Eaton."

#### Genus *Anagenesia* Eaton.

1893. *Anagenesia*, Eaton, *Trans. Linn. Soc. London* (2) III, pp. 25-28.

1920. *Anagenesia*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.

1923. *Anagenesia*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, pp. 108, 109.

As mentioned by Eaton the genus *Anagenesia* occurs in the "Indo-Malayan region and Irkutzk." All the species so far known are from the same region.

In all 8 species have been definitely included by Lestage in this genus, out of which only three occur in India. Of these *A. lata* can be easily recognized by its dark brown wings and body, and by the fact that the two terminal joints of the male genital forcep are subequal. *A. robusta* is of about the same size as *A. lata*, but the body and wings have a very light colour and the last segment of the genital forcep is longer than the one preceding it. The third, *A. minor*, is a distinctly smaller insect and has a light colour more or less like that of *A. robusta*, but the posterior abdominal tergites have a characteristic clouding of gray, which is better seen in the female than in the male. *A. picta*, a Bornean species described by Gravely from specimens preserved in the Indian Museum, is also large, and has the body coloured reddish brown (slightly comparable to the warm sepia of *A. lata*), but the wings are dirty whitish with the costal margin infuscate.

With the help of the key given by Lestage, in the work quoted above, these species can be easily distinguished from one another as also from other species of the genus.

Of the three Indian species, *A. lata* and *A. robusta* are so far known from Assam only, while *A. minor* seems to be "very widely distributed over the Indian Empire,"<sup>1</sup> examples of this form having been met with in Bengal, Bihar, Burma and Karachi (?).

### *Anagenesia lata* (Walker).

(Plate VIII, figs. 4—6).

1853. *Palingenia lata*, Walker, *Brit. Mus. Catal. Neuropt.*, part III, p. 550.  
 1871. *Palingenia lata*, Eaton, *Trans. Ent. Soc. London*, p. 63, pl. iii, fig. 18.  
 1883. *Palingenia (Anagenesia) lata*, Eaton, *Trans. Linn. Soc. London* (2) III, p. 26, pl. i, fig. 1b.  
 1892. *Palingenia lata*, Eaton, *Journ. As. Soc. Bengal* LX, p. 407.  
 1920. *Palingenia (Anagenesia) lata*, Gravely, *Rec. Ind. Mus.* XVIII, p. 140, pl. xx, fig. 17.  
 1920. *Anagenesia lata*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.  
 1923. *Anagenesia lata*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 108.

This species is known from Sylhet and Sibsagar in Assam and is represented in the Indian Museum collection by a number of pinned male specimens from the latter locality. All the specimens have been examined and named by Eaton and are in a good state of preservation.

Eaton's descriptions of the species (1871, 1883 and 1892) are adequate for its proper determination, and his figures, as also one by Gravely (1920), illustrate the different parts quite accurately.

The species is easily recognized by the brownish colour of the body and wings. The thorax and parts of the head are vandyke-brown to warm sepia, but the wings are considerably lighter. At the present time they are more snuff brown than light vandyke-brown as described by Eaton. In the fore-wing the costal region is considerably warmer, and the first three longitudinal veins and the great cross vein are vandyke-brown. The remaining longitudinal nervures and the cross veins in the basal half of the disc of the fore-wing are lighter in colour. The cross veins in the distal half of the disc are almost whitish. The venation is like that figured by Eaton, though the small veins near the terminal margin seem to be somewhat reduced.

The eyes (Plate VIII, fig. 4) of the male are somewhat distantly placed and are blackish in colour; the ocelli are brownish encircled with black.

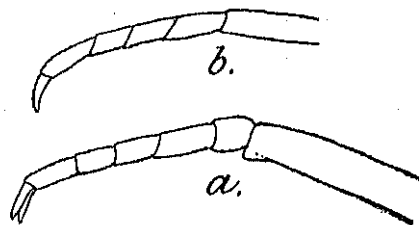
The abdomen is russet, with the posterior ends of the segments vandyke-brown. The last three segments are considerably warmer in colour than the rest of the abdomen. The venter is light tawny.

The legs are exactly like those described by Eaton, and the hind tarsus, as in other species of the genus, has a single claw. The proportion of the different segments forming the fore- and the hind-tarsi is clearly seen in the accompanying text-figure 3.

The genital forceps are light brown in colour and are composed of a large ventrally grooved basal joint, about three times as long as the two terminal ones put together, and have a fairly prominent projection at the inner side of the proximal end. The two terminal joints are

<sup>1</sup> Gravely, *Rec. Ind. Mus.* XVIII, p. 143 (1920).

subequal in length and the ultimate one tapers somewhat distally. The penis lobes have the usual shape, are rather short and thick set,



TEXT-FIG. 3.—*Anagenesia lata* (Walker).  
a. Fore-tarsus of male :  $\times 16$ . b. Hind-tarsus of male :  $\times 16$ .

triangular in shape, broad at the base, and narrow at the apex, where a constriction marks off the terminal portion.

The setae are as described by Eaton, and the median seta is rudimentary and very small.

The ♀ is not known.

The largest specimen from Sibsagar is slightly over 22 mm. long, with the wings and setae of the same proportionate length as given by Eaton.

The nymphs of this species are not known.

The species is so far known to occur in Assam only, and has been collected at Sylhet and Sibsagar. The specimens collected at the latter locality by the late Mr. S. E. Peal are preserved in the Indian Museum.

As remarked by Eaton, this is the only dark-winged species of *Anagenesia* so far found in India. *Anagenesia picta* Gravely (*vide infra*, p. 119), a Bornean species, has the costal margin of the fore-wing infuscate, but the general surface is whitish.

### *Anagenesia robusta* (Eaton).

(Plate VIII, figs. 7—10).

1892. *Palingenia robusta*, Eaton, *Journ. As. Soc. Bengal* LX, pp. 467, 468.

1920. *Anagenesia robusta*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.

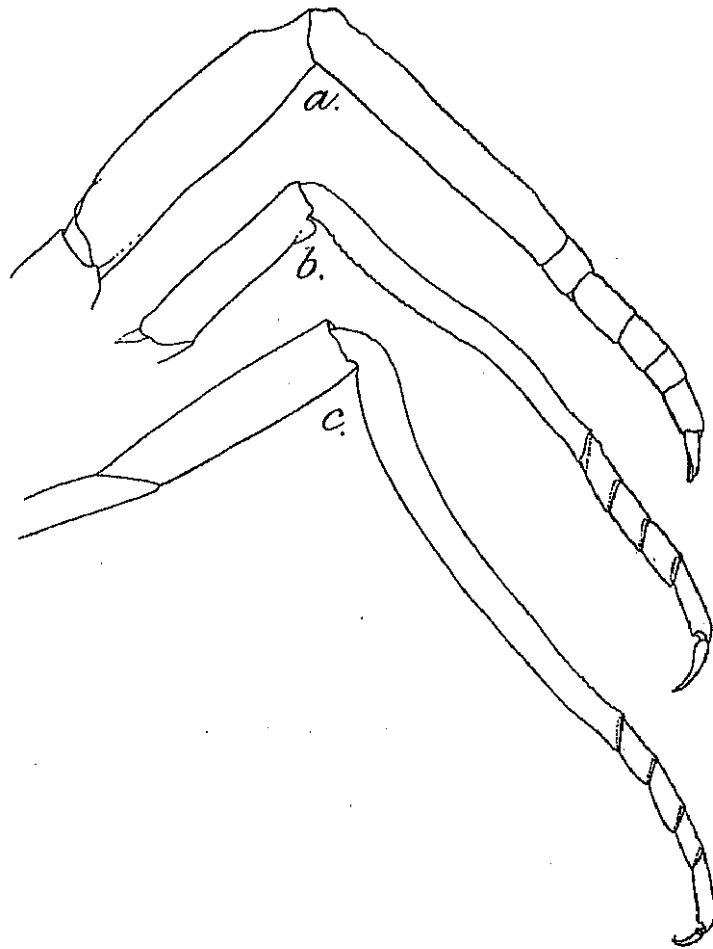
1920. *Palingenia (Anagenesia) robusta*, Gravely, *Rec. Ind. Mus.* XVIII, pp. 140—143, pl. xx, figs. 19, 20.

1923. *Anagenesia robusta*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 108.

Like the preceding species *Anagenesia robusta* is so far known to occur in Assam only. The two specimens on which Eaton based his original description were collected in Cachar, and one of these is still preserved in the Indian Museum collection. This specimen is at present in an imperfect condition, the abdomen being altogether absent, and the legs and wings broken. Besides this there are two pinned males, and a number of males and females in spirit in the Indian Museum collection. All these specimens are in good condition.

The colouration of the male has been accurately described by Eaton and nothing need be added here. The eyes are almost pitch black and are placed somewhat remote from one another. The ocelli are encircled with black. The wing venation is more or less like that of *A. lata*, but the

smaller subsidiary veins and the cross veins near the terminal margin are almost transparent, so that in transparent slide mounts the wing membrane near the terminal margin appears to be almost entirely devoid of small veins. In pinned specimens, however, there are clearly seen to be a large number of veins in this area. In the hind-wing the costal projection is not very prominent, and the venation is ample. The media forks quite close to the wing base, and the anal area is rather poorly developed.



TEXT-FIG. 4.—*Anagenesia robusta* (Eaton).  
Legs of male, all drawn to same magnification:  $\times 12$ .  
a. 1st leg. b. 2nd leg. c. 3rd leg.

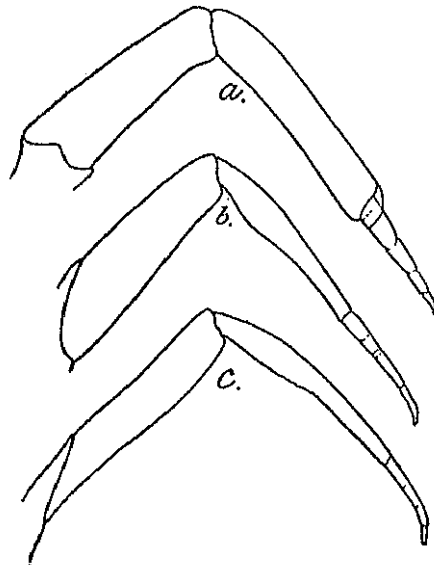
The legs are poorly developed in both sexes, but in the female they are far more reduced than in the male. In the male fore-tarsus the segments are as described by Eaton, but in the second and third tarsi the first segment is almost entirely suppressed, the second, third and fourth are more or less subequal, while the fifth is the longest. All the tarsi

are shorter than their respective tibiae, the first and the second tarsi being only slightly so, while the hind-tarsus is about half as long as the hind-tibia. The first leg is biunguiculate, the two unguis being nearly of equal length; the second and the third legs each have only a single unguis.

The male genital apparatus is like that of the preceding species. The genital forceps are slightly darker in colour than the venter, and have the usual shape. They are formed of a large ventrally grooved basal segment, having a prominent projection near the base, and two small terminal joints about two-fifths as long as the basal. Of the terminal segments the last is distinctly longer than the one preceding it, and, as shown in the figure (plate VIII, fig. 10), is sometimes subdivided in two. Of the two secondary segments thus formed the proximal one is distinctly shorter than the distal. This fact has also been mentioned and illustrated by Gravely (*op. cit.*, p. 141, pl. xx, fig. 20). The penis lobes are like those of *A. lata*.

The caudal setae are long and ribbon-like and are densely pubescent. The rudimentary median caudal seta is much better developed than in most other species and is easily visible.

The female imago of *A. robusta* is considerably darker in colour than the male. The head is much warmer in colour, and is almost bistre brown. The eyes are blackish-slate and the ocelli are whitish encircled with black. The notum is raw umber, and the mesonotum has a number



TEXT-FIG. 5.—*Anagenesia robusta* (Eaton).  
Legs of female, all drawn to same magnification:  $\times 12$ .  
a. 1st leg. b. 2nd leg. c. 3rd leg.

of dark dusky streaks. The dorsum of the abdomen is extensively suffused with light dusky brown, and the last three segments are coloured almost uniformly in that shade. The sides, venter and the wings are as in the male.

The legs are greatly reduced. The comparative atrophy of the legs in the two sexes is clearly brought out in the accompanying text-figures 4 and 5, where legs of a male and a female imago of about the same size are drawn on the same scale. The part most reduced in the female leg is the tarsus, and the reduction has gone so far that even the segments composing it are hardly demarcated. In the fore-tarsus the segments are more or less distinct, but in the hinder tarsi most of the lines of demarcation are to some extent obliterated. The claw is very poorly developed in all the tarsi, and appears to be uniunguiculate. The tarsi are considerably shorter than their corresponding tibiae.

The wings and the setae are as in the male.

*A. robusta* is a large species, some of the males being as much as 28 mm. long with the caudal setae about 70 mm. The wing is about 24 mm. long. The female appears to be somewhat smaller, the body and wing in the specimens I have seen not generally exceeding 25 and 21 mm. respectively. The setae in all the three females appear to be broken, but they are considerably shorter than those of the male insect.

The nymphs have been described and figured by Gravely.

*Type-specimen*.—5941/14, Zoological Survey of India (*Ind. Mus.*).

*Locality*.—The species is so far known to occur in Assam only; Eaton's type-specimens were collected in Cachar, and those described by Gravely come from Nazira on the bank of the Dikho River near Sibsagar. The exact locality in Cachar where the type-specimens were collected and the name of the collector are not known. The Dikho River examples, two pinned and six spirit males, three spirit females and a number of nymphs of both sexes, were collected by Mrs. E. S. Maxwell at about the end of October in 1918 and 1919. All the specimens collected by Mrs. Maxwell as adults were males; the females were caught as nymphs and hatched in captivity. The type-specimen is, as already mentioned, in a fragmentary condition.

*A. robusta* is easily recognized from the remaining large-sized species of the genus by the light colour of its body and wings. The preceding species, as also *A. picta* (*vide infra*, p. 119), are of about the same size as *A. robusta*, but both are of a distinctly warmer colour. This species is further distinguished from the other two on account of the last joint of the male forcep being longer than the penultimate; in *A. lata* the two joints are subequal, while in *A. picta* the last segment is shorter than the one preceding it.

Gravely's notes on the biology of the species, based chiefly on information supplied by Mrs. Maxwell, are very interesting. Large numbers of individuals are said to "emerge annually at about the end of October, and for three or four days float down the river in countless millions. The natives say that they also appear on other rivers, such as the Desoi, Desang and Dihing, and that they come out at and under the edge of the water in the shallows after the rivers have left the hills and where they run through silt only; but Mrs. Maxwell says that so far as she knows they do not occur on rivers actually rising in flat districts. The natives believe that until they have appeared there is always a chance of further floods and consequently it is no use building the temporary bamboo bridges which they put up every cold weather until

these 'pani-pooka' (water insects) have gone. The caudal appendages of the males were 3 inches long and semi-transparent when fresh. The insects are so light and hollow that they cannot be kept under water; when just out they are white and creamy and look like foam when blown together by the wind."

**Anagenesia minor (Eaton).**

(Plate VIII, fig. 11, plate IX, figs. 1—4).

1892. *Palingenia minor*, Eaton, *Journ. As. Soc. Bengal* LX, p. 408.

1920. *Anagenesia minor*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.

1920. *Palingenia (Anagenesia) minor*, Gravely, *Rec. Ind. Mus.* XVIII, p. 143, pl. xx, fig. 18.

1923. *Anagenesia minor*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 109.

*Anagenesia minor* was described by Eaton from one specimen collected at Nattor in Eastern Bengal, and two labeled "Karachi Mus.", but the provenance of which is not known. Gravely later referred two more specimens to this species, one from Sara Ghat in Bengal and the other collected in Upper Burma. Eaton's "Karachi Mus." specimens, which I regard as the types, are in the Indian Museum collection, and are in rather a poor state of preservation. They were in a "much damaged" condition at the time Eaton described them, and age has in no way improved them. The wings and legs in both the specimens are fragmentary and in one the abdomen is altogether missing. The Nattor specimen is not in the Indian Museum.

I refer to this species a large number of specimens of both sexes, pinned as well as in spirit, collected in different places in Bihar. I have compared these specimens with Eaton's types and have no doubt of their identity. The clouding of the posterior segments of the dorsum with gray, as described by Eaton, seems to be a characteristic feature of the species. This character, though not visible in Eaton's specimens now, nor clearly in Gravely's, is very well marked in the Bihar examples.

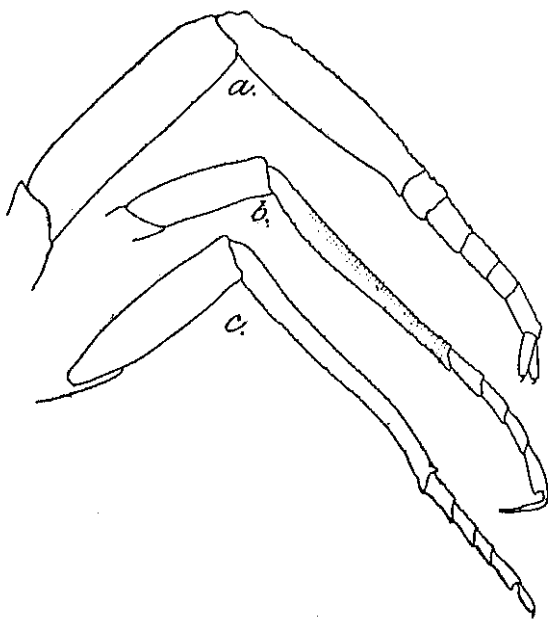
From an examination of the fresh material now available it has been possible for me to redescribe the male in greater detail than could hitherto have been done, and to describe the female for the first time.

Imago ♂.—In the pinned examples the general colour of the body varies between warm buff and cinamon buff, with the notum and parts of the head considerably warmer. In some specimens in which the segments are strongly telescoped the colour appears to be almost tawny. The head as described by Eaton is ochre brown with the area around the ocelli blackish. The eyes are not closely approximated and are black, and the ocelli are white encircled with black. The pronotum is of the ground colour with warmer patches of colour near the sides, and has a longitudinal depression in the middle line with a shallow circular pit in the centre. The mesonotum is considerably warmer than the pro- and metanotum, being more or less concolorous with the head. The dorsum of the abdomen is warm buff, with the segmental margins somewhat darker. The last two or three segments are considerably warmer in tint than the anterior ones, being ochraceous buff, and segments 7-9 are perceptibly clouded with gray. The gray colour is confined to a small area about the middle of the posterior half in the 7th segment,

but extends almost throughout the back in segments 8 and 9. This clouding, which appears to be a characteristic feature of the species, is better seen in spirit specimens than in the pinned ones. The venter and sides are slightly lighter in colour than the dorsum, being very light ochraceous buff. The legs are concolorous with the venter and have conspicuous markings, and the setae are light buff to light ochraceous buff. The wings are dull whitish, with opaque neuration, except in the costal region where the principal veins are light buff.

In the spirit material the colour of the insects is considerably lighter than in the pinned examples. The general colour varies from light ivory to cream buff, sometimes almost varying to light ochraceous buff. The mesonotum is warmer than the pro- or metanotum, being almost ochraceous buff. The dorsum of the abdomen is light buff, with the posterior segments warmer. The clouding of segments 7-9 with gray is better seen in these specimens than in the pinned ones. In some examples the 6th segment is also very faintly clouded, and in one or two the clouding extends even up to the 5th. The venter, sides, legs and setae are slightly lighter than those of the dry specimens.

In both the type-specimens the wings are broken, and it is impossible to see much of the venation. In Gravely's specimens the wings are intact, and seem to be identical with those of the Bihar examples. The wing venation is ample, and there is a large number of small veinlets along the terminal margin. As described by Eaton the venation is



TEXT-FIG. 6.—*Anagenesia minor* (Eaton).  
Legs of male, all drawn to same magnification:  $\times 15$ .  
a. 1st leg. b. 2nd leg. c. 3rd leg.

fairly comparable to that of *A. ampla* Eaton, as figured by him, but the veinlets ending in the posterior half of the terminal margin are not

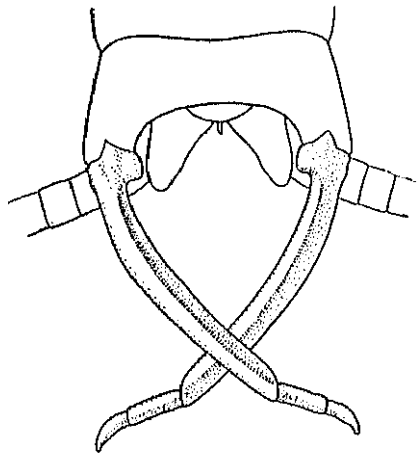


appreciably shorter in the Indian species. There also appear to be a larger number of veinlets along the terminal margin. The fork of the first anal, as usual in the genus, contains a single longitudinal nervure, and a large number of cross veins on both sides of it.

In the metathoracic wing the costal projection near the humeral angle is not very prominently developed. The forking of the three large veins Rs, M and Cu is not well marked, and the venation along the inner margin is somewhat poor.

The legs are well developed. The fore-tarsus is of about the same length as the tibia and is slightly shorter than the femur. The tarsus is made up of five distinct segments, of which the fifth is the longest, being only very slightly longer than the second. The first and the third are subequal and are somewhat longer than the fourth. The two ungues of the claw are well developed. In the hind-leg the tarsus is only a little more than half as long as the tibia, while the femur is also considerably shorter than the latter. The tarsus is formed of only four segments, of which the first is slightly longer than the second, the third is shorter than the second, while the last is of about the same length as the first. There is only a single claw. As described by Eaton the tibiae and tarsi are finely rugose transversely.

The sternite of the last segment forms a deep cup posteriorly to accommodate the genitalia. The penis lobes are short and broad, triangular in shape, with broad bases and rounded distal ends. There is no constriction near the tip as seen in *A. robusta*. The genital forceps are formed of the usual three segments. The long ventrally grooved basal segment has a prominent, somewhat blunt, projection on its inner side near the base, and is finely pubescent along the inner margin. The two last segments are about a fourth of the total length of the forcep,



TEXT-FIG. 7.—*Anagenesia minor* (Eaton).  
Genitalia of an abnormal specimen, showing the terminal joint of the forcep shorter than the one preceding it:  $\times 15$ .

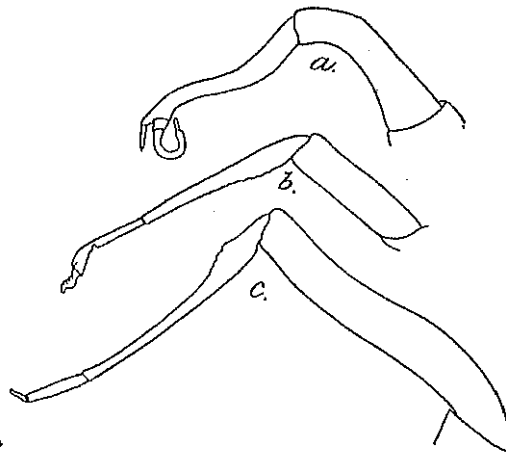
and the terminal one is distinctly longer than that preceding it. One of the Digha Ghat specimens differs remarkably from all the others in

so far as it has the penultimate segment of its forcep limb distinctly longer than the ultimate one. This is clearly seen in the accompanying text-figure 7. The specimen is, however, normal in all other respects.

The two lateral setae are very long and are uniformly pubescent throughout, except at the joints, where the hairs seem to be longer. The median seta, though not quite as well developed as that of *A. robusta*, is fairly distinct.

Imago ♀.—The female is much warmer in colour than the male. In the dry examples the general colour of the body is ochraceous-tawny to tawny. The head is fuscous, and the eyes are black. The ocelli have black rings surrounding the central white part. The pronotum is tawny, and is a little lighter than the mesonotum. The latter has some blackish streaks running longitudinally on it. The dorsum of the abdomen is tawny, with the posterior segments warmer, and considerably clouded with dark gray. This clouding with gray is present on all the tergites, but is best seen in the last three segments. The anterior five or six segments have each a small patch of gray on the middle of the tergite, that in the first two segments being almost insignificant. In the eighth segment the gray occupies the whole of the posterior half of the tergite, while in the last two segments almost the whole of the tergite is clouded with dark gray. These gray markings appear to be characteristic of the species and are very prominent. The venter and the sides are lighter in colour than the dorsum and are ochraceous-tawny. The legs are concolorous with the venter and the setae are dirty whitish. The wings are much warmer than those of the male and are very light ochraceous buff.

In specimens preserved in spirit the colour is considerably lighter than that in pinned examples. The general colour of the body is dirty whitish



TEXT-FIG. 8.—*Anagenesiu minor* (Eaton).

Legs of female, all drawn to same magnification:  $\times 15$ .

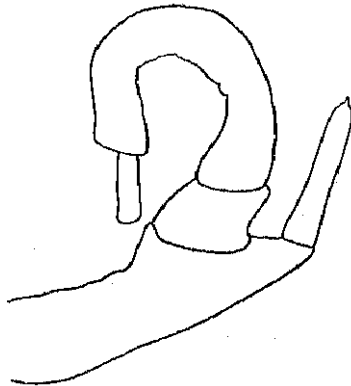
a. 1st leg. b. 2nd leg. c. 3rd leg.

to ivory yellow with the notum light buff. In ovigerous females the eggs impart a distinct ivory yellow colour to the abdomen. The head

is light cream buff, and is fuscous dotted with dirty white between the ocelli. The longitudinal brownish streaks on the mesonotum are very well seen. The abdominal tergites are clouded with gray as described for the pinned examples, and the disposition of colour patches is clearly seen in the accompanying drawing (plate IX, fig. 3). The venter and sides are dirty whitish and the legs are pale whitish.

The wing venation is like that of the male.

The legs are greatly reduced in the female, and, as seen from the accompanying text-figure 8, are proportionately much smaller than those



TEXT-FIG. 9.—*Anagenesia minor*  
(Eaton).  
Foretarsus of female, enlarged :  $\times 75$ .

of the male. The part undergoing the greatest amount of reduction is the tarsus, and this is reduced both in size and in the number of segments composing it. In the first pair of legs the tarsus is extremely reduced, being hardly half as long as the tibia, and the segments forming it cannot be made out distinctly. A basal segment seems to be marked off more or less distinctly and at the apex a finger-like process is also demarcated. Besides these two there is no other trace of segmentation. Just below the tarsus at the outer side of the tibia there is a large forwardly-directed finger-like structure, rounded at the extremity and bearing a very minute

process at the tip. I am not aware of the existence of such a structure on the leg of any mayfly, and I am unable to suggest anything regarding its nature or function. The remaining legs are also atrophied, but there is no secondary development in them. In the hind-leg the tarsus is about a third as long as the tibia, and, except for a small portion marked off at the tip, there is no segmental differentiation. The second leg is also proportionately reduced. As in the male the margins of the tibia are in places finely serrated.

The setae are small ; the median seta can also be seen distinctly.

*A. minor* is a fairly large insect, the male sometimes attaining to a length of 22 mm. with the wing 18 and the lateral setae up to 56 mm. The female is generally somewhat larger, often being up to 24 mm. long with the setae about 10. In a large number of male specimens the body is strongly telescoped so that the length appears to be 14—16 mm. only.

Nymphs of this species have not been described so far.

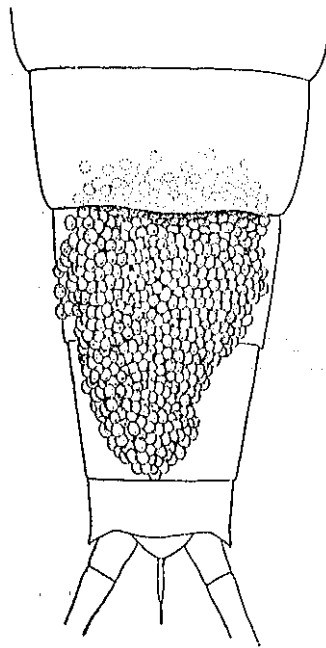
*Type-specimens.*—9689-90/5, Zoological Survey of India (*Ind. Mus.*).

*Locality.*—*Anagenesia minor* seems to be a widely distributed species having been recorded from the following localities :—

|                        |                         |   |
|------------------------|-------------------------|---|
| ?                      | "Karachi Mus."          | Types. 2 pinned males in the Indian Museum. |
| Nattor, Eastern Bengal | ?                       | †   |
| Sara Ghat, Bengal      | J. Dovan,<br>May, 1911. | 1 pinned male in the Indian Museum.         |

|                              |                 |  |
|------------------------------|-----------------|--|
| Pakokhu, Upper Burma         | E. Colenso.     | 1 pinned male in the Indian Museum.  |
|                              | October, 1911.  |  |
| Digha Ghat, nr. Patna, Bihar | T. B. Fletcher. | Several examples of both sexes in spirit in the Pusa collection and the Indian Museum. |
|                              | May, 1915.      |  |
| Mokamah, Bihar               | T. B. Fletcher. | Ditto.   |
|                              | May, 1918.      |  |
| Saran, Bihar                 | M. Mackenzie    | A pinned male and female in the Pusa collection.                                       |

Leaving out of consideration the type-specimens from the "Karachi Museum," the exact provenance of which is not known, the species seems to be widely distributed in Bihar and Bengal, extending even into Burma. I have carefully examined the Upper Burma specimen referred by Gravely to this species, and cannot find any important difference between it and other specimens from Bihar and Bengal. It is, however, smaller in size than the other specimens, and like all old specimens is badly faded in colour. If the "Karachi Museum" specimens were collected anywhere near Karachi, the species, as mentioned by Gravely, would thus appear to be "very widely distributed over the Indian Empire."



TEXT-FIG. 10.—*Anagenesia minor*  
(Eaton).  
Ventral view of the posterior abdominal sternites of the female, showing masses of eggs adhering to it:  $\times 19$ .

In Bengal and Bihar the species is met with in different places along the Ganges and its branches and appears to emerge in May, chiefly in the latter half of the month. The Upper Burma specimen is said to have been collected in October.

The pinned male and female specimens from Saran are much lighter in colour than any other pinned examples. In some specimens from other localities also, notably in those from Digha Ghat, the colouration of the body is greatly affected by the strong telescoping of the abdominal segments. Thus specimens which are fully extended appear to be considerably lighter in colour than those in which the segments are telescoped. Besides affecting the colour the proportions of the body are also considerably changed by this telescoping, and insects in which telescoping occurs give an appearance of being considerably shorter and stouter than those which are normally extended.

*A. minor* is easily recognized from other species of *Anagenesia* by its

somewhat smaller size, paler colour and by the characteristic clouding of the posterior abdominal tergites with gray. This last character is much better seen in the female than in the male.

A very large number of eggs are produced by the female, and in most of the specimens of this sex the posterior region of the abdomen is full of egg-ma. ses. The eggs on being expelled out of the distended oviducts appear to stick to the ventral surface of the last three tergites, where, as seen in the accompanying text-figure 10, they form a thick covering over the body-wall. The eggs seem to be held together by some sticky substance which is not dissolved in alcohol.

The eggs, as seen in spirit specimens, are pale yellowish in colour, and have the shape of thin circular, or oval discs. They have a very thin, almost transparent shell, through which the inner structures can be faintly made out. In eggs made transparent granules of albumen are seen in great abundance scattered about more or less evenly, but the larger ones aggregated especially towards the centre. Just inside the shell there is a very small clear space all round, and the vitelline membrane is not very clearly seen. The peripheral region in which the large albumen grains are more or less absent takes anneline stains very feebly.

#### *Anagenesia picta* (Gravely).

(Plate IX, figs. 5, 6).

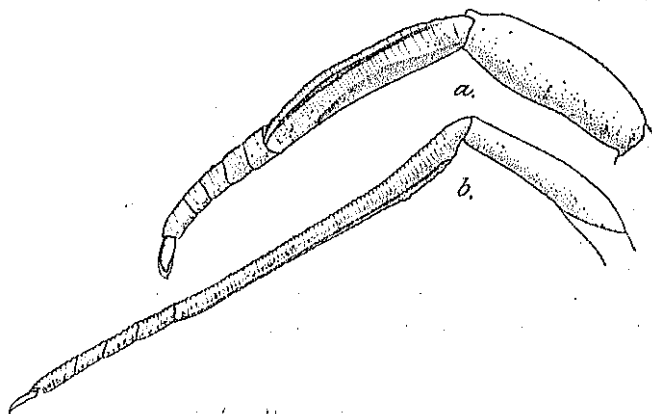
1920. *Palingenia* (*Anagenesia*) *picta*, Gravely, *Rec. Ind. Mus.* XVIII, p. 140, pl. xx, figs. 24, 25.  
 1923. *Anagenesia picta*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 109.  
 1924. *Anagenesia picta*, Ulmer, *Trenbia* VI, p. 32.

Besides the two pinned male specimens from Sarawak described by Gravely, there are in the Indian Museum collection two males in spirit also from the same locality.

As pointed out by Gravely, *Anagenesia picta* is only slightly larger than *A. lata* (Walker), but can be easily distinguished from it by its different colouration. The general colouration of *A. picta* is reddish brown approaching chestnut. In one of the spirit specimens the colour is more yellowish than reddish brown resembling greatly buckthorn brown; the other spirit specimen, though somewhat faded, has a colour more or less like that of the pinned insects. The head between the eyes is fuscous black, with a median brown line on the vertex. The eyes are black. The mesonotum is concolorous with the head, and the pronotum is much paler than either of these. On the dorsum of the abdomen narrow pale streaks on the posterior borders of the tergites alternate with the broad chestnut ones covering the major portions of the segments. The last three tergites are darker than the rest and are more or less uniformly coloured. The venter and the sides are hazel and the femora of the legs are of about the same colour. The tibiae and the tarsi are considerably lighter in colour than the femora. The genital forceps are concolorous with the venter and the setae are buckthorn brown. The wings are dirty whitish to light buff, with ochraceous buff opaque venation, and, as described by Gravely, those of the anterior pair have an infuscate costal margin.

The venation of the fore-wing is clearly brought out in Gravely's figure, and greatly resembles that of *A. minor* Eaton. The number of intercalaries, however, especially in the posterior half of the terminal margin, is considerably larger than that in Eaton's species.

The hind-wing, of which I give a figure (plate IX, fig. 5), is also somewhat like that of the preceding species, but there appear to be fewer veins.

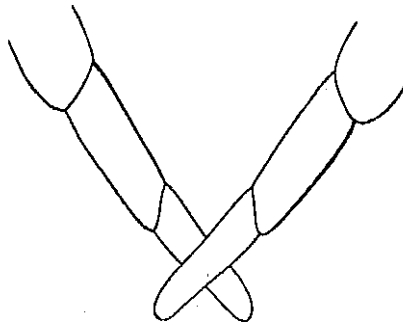


TEXT-FIG. 11.—*Anagenesia picta* (Gravely).  
a. 1st leg of male :  $\times 10$ . b. 3rd leg of male :  $\times 10$ .

The legs of the male are well developed, those of the first pair being considerably shorter than the third. In the fore-leg the tibia is lighter in colour than the femur but has longitudinal streaks of a brownish colour. It has a deep groove running obliquely in a longitudinal direction, starting near the base on the inner surface of the tibia and running along the outer side to the commencement of the tarsus. This groove is clearly seen in the accompanying text-figure 11. The tarsus is lighter in colour than even the tibia and has faint grayish black rings. The tibia is considerably longer than the tarsus and is somewhat longer than the femur. The outer margin of the tibia and the tarsus is transversely rugose. The fore-tarsus is composed of five distinct segments of which the fifth is the longest, while the other four are more or less subequal. The claw is double. In the hind-leg the tarsus is only a little more than half as long as the tibia and is somewhat longer than the femur. Here also the tibia is longitudinally grooved, and the same is seen in the second leg also. The outer margin of the tibia and the tarsus is transversely rugose, while the former is rugose along the inner margin also. The tarsus has only four segments of which the last is the longest, the first a little shorter than the fourth and a little longer than the second. The third is only very slightly shorter than the second. The claw is single and is acutely pointed.

The genitalia of the male have the usual structure. The long basal segment of the genital forceps is about two and a half times as long as the two terminal ones put together. It is deeply grooved ventrally and has hairy margins. The large bluntly rounded projection on the

inner side of this segment near the base is very prominent. Of the two terminal segments the last one is distinctly smaller than the one preceding it. The penis lobes have the usual shape and are lodged in a cup-like depression of the 10th sternite. The penis lobes show only a slight constriction near the apex.



TEXT-FIG. 12.—*Anagenesia picta* (Gravely).

Terminal joints of the genital forceps of male, showing the ultimate segment only a little shorter than the penultimate one :  $\times 26$ .

One of the spirit specimens differs from all the others in having the two terminal joints of the genital forceps more or less equal in length. As seen in the accompanying text-figure 12 the last segment in this example is only very slightly shorter than the one preceding it. In typical specimens, however, this segment is markedly shorter than the penultimate one.

The two lateral setae are long and ribbon-like and are densely pubescent throughout. The rudimentary median seta is very small.

*Anagenesia picta* is a large species, the males being a little more than 22 mm. with the wings 20 and the setae as long as 60 mm.

*Type-specimens.*—9221/H<sub>2</sub>, Zoological Survey of India (*Ind. Mus.*).

*Locality.*—The species is so far known from Kapit, Sarawak, in Borneo only and is represented in the Indian Museum collection by the two pinned types and two other specimens in spirit. All the four specimens are males and were collected by Mr. C. W. Beebe in July, 1910.

The species does not appear to be widely distributed even in the Malay Archipelago, as it was not represented in the extensive collection from the Sunda Islands and the Philippines recently reported upon by Dr. Ulmer.

In size and general colouration of the body the present species is more or less like *Anagenesia lata* (Walker), but is easily distinguished from it on account of its dirty whitish wings. In *A. lata* the wings and body are both darkly coloured. From other Indian species of *Anagenesia*, *A. picta* is separated by the warm reddish brown colour of its body, both *A. robusta* and *A. minor* being of a very pale colour.

Genus *Mortogenesis* Lestage.

1921. *Palingenia* (s. l.), Morton, *Entomol.* LIV, pp. 177-180, pl. ii.  
 1923. *Mortogenesis*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 110.

The genus *Mortogenesis* is based on a single species from Mesopotamia that Morton had doubtfully included in the composite genus *Palingenia*. The combination of characters that this insect, however, presents—as pointed out by Morton himself—is not met with in any other genus of the family Palingeniidae, and Lestage was fully justified in setting up a new genus for its reception. In the forking of the media (of the fore-wing) before the middle, in the presence of a single intercallary vein in the first anal fork, and a double claw on the hind-tarsus, and in the possession of a seven-segmented genital forcep by the male—to mention only a few of the more important features—these insects possess a set of characters which easily distinguish them from any other member of the family to which they belong.

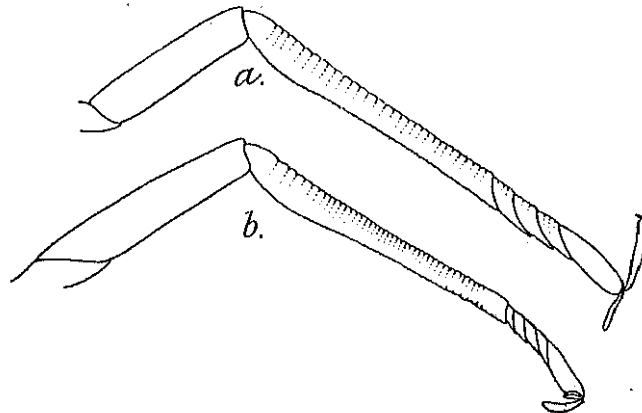
*Mortogenesis mesopotamica* (Morton).

1921. *Palingenia mesopotamica*, Morton, *Entomol.* LIV, pp. 177-180, pl. ii.  
 1923. *Mortogenesis mesopotamica*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 110.

This Mesopotamian species is very easily recognized by, among other characters, the dark mesonotum which stands out prominently in a light brownish dorsum. The species is represented in the collection of the Madras Government Entomologist at Coimbatore by a single male pinned specimen collected at Karradah, Bagdad, on the river Tigris by Mr. Duraisami on the 10th of April, 1920.

The Coimbatore specimen is much larger than those seen by Morton. It is a little less than 30 mm. long (ex. forceps) and the wings, which are very much crumpled, also appear to be longer. The caudal setae are fragmentary.

Morton's description of the species is quite adequate for the proper determination of this remarkable insect, and his illustrations show the



TEXT-FIG. 13.—*Mortogenesis mesopotamica* (Morton).  
 a. 2nd leg of male:  $\times 15$ . b. 3rd leg of male:  $\times 15$ .

necessary parts quite clearly. I, however, give here figures of the second and third legs. In the latter the claw is clearly seen to be double,



## Family POLYMITARCIDAE.

In his *Revisional Monograph* Eaton included four genera in the Polymitarcidae, but of these only three are now considered to be members of this family, while *Jolia* Eaton has been abolished on the ground that the imago described by Eaton belongs to the genus *Polymitarcys*, while the nymph is a *Chirotonetes*. To the remaining three genera, viz., *Euthyplocia* Eaton, *Campsurus* Eaton and *Polymitarcys* Eaton, Ulmer (1920) has added another three: *Povilla* Navás, *Exeuthyplocia* Lestage and *Asthenopus* Eaton. Of these the last named was created by Eaton in 1871, but was dropped by him in 1883 (*Revisional Monograph*) without giving any reasons; it has, however, been rightly revived by Ulmer. *Povilla* is another genus about which there has been some discussion, Lestage (1922) considering it synonymous with *Asthenopus*, but as explained by Ulmer (1924b) there can be little doubt that the insect described by Navás cannot be included in Eaton's *Asthenopus*.

The six genera that now go to form the family Polymitarcidae can easily be distinguished from one another with the help of the excellent key given by Ulmer (1920). Lestage (1923b) in his "Notes critiques sur les *Campsurus*" has also given very good keys for recognizing the genera. There are separate keys for the male and the female insects.

The neuration of the fore-wing, especially in the anal area, presents great variation in the different members of this family. In *Polymitarcys* there are numerous subsidiary veins enclosed in the fork formed by the first anal vein, their number usually varying from 2—9; on the other hand in *Euthyplocia* and *Exeuthyplocia* there may be no such veins at all, and if present their number never exceeds three. In the remaining three genera the condition is more constant, there being always two veins in the first anal area. In *Asthenopus*, however, both of these arise from the first anal vein (1A), while in *Povilla* one arises from the first anal, the other from the second anal.

Of the genera included in this family only two are so far known from India, *Polymitarcys* and *Povilla*, the first from three species<sup>1</sup>, one of which is new to science, and the other from a single species hitherto known from Java.

Genus *Polymitarcys* Eaton.

Ulmer in 1920 included definitely six species in this genus, of which one, *P. australis* Hagen, may possibly be synonymous with Pictet's *P. indicus*. Out of the remaining five only two are known from India: one, *P. indicus*, hitherto recorded from the Malay Archipelago and Ceylon only, and the other, *P. annandalei*, described in this paper for the first time. The Malayan form that has now been extensively met with in India, at least in the north-eastern parts, can be easily distinguished from my new species. In *P. indicus* the body colouration of the male is quite different from that of the female; in the former the general colour is dirty whitish, overshadowed with light gray and with the thorax somewhat brown; in the female the body is distinctly brownish yellow.

<sup>1</sup> Including *Polymitarcys* sp. of Eaton.

with grayish violet bands running transversely on the abdominal tergites. The wings are whitish, with the costal region light violet. In *P. annandalei* only the female is known, and it has a dirty whitish colour, with the thorax somewhat warmer than the rest of the body. The wings are also dirty whitish and the costal region is not coloured violet. The membrane has a distinctly mottled appearance, owing to the presence of very faint spots on almost the entire surface. Besides these two species there is another Indian form, described by Eaton (1892) as *Polymitarcys* sp. This, as explained in its appropriate place (*vide infra*, p. 133), is distinct from the other two species and can be recognized by the yellowish brown costal margin of the fore-wing. The membrane is not spotted.

The genus *Polymitarcys* has a very wide range of distribution, and occurs almost all over the world. In India it has so far been met with in Bengal, Bihar and Assam.<sup>1</sup> *P. indicus* is known from Bihar and Assam only, but it is likely that this species has a much wider range. *P. annandalei* is from Chota Nagpur, and Eaton's *P. sp.* from East Bengal.

#### *Polymitarcys indicus* (Pictet).

(Plate IX, figs. 7—11 and plate X, fig. 1).

- 1843-45. *Palingenia indica*, Pictet, *Hist. Nat. Ins. Neuropt. Ephem.* pp. 151, 152, pl. xiii, fig. 4.  
 1853. *Palingenia indica*, Walker, *Brit. Mus. Cat. Neuropt.*, part iii, p. 549.  
 1871. *Polymitarcys indicus*, Eaton, *Trans. Ent. Soc. London*, p. 61.  
 1883. *Polymitarcys indicus*, Eaton, *Trans. Linn. Soc. London* (2) III, p. 47.  
 1913. *Polymitarcys indicus*, Ulmer, *Notes Leyden Mus.* XXXV, p. 102.  
 1914. *Anagenesia greeni*, Banks, *Proc. Acad. Nat. Sci. Philadelphia*, pp. 612, 613.  
 1920. *Polymitarcys indicus*,<sup>2</sup> Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 197.  
 1921. *Polymitarcys indicus*, Lestage, *Ann. Soc. Ent. Belgique* LXI, p. 212.  
 1924. *Polymitarcys indicus*, Ulmer, *Traubia* VI, pp. 32-34.

This somewhat common species, hitherto known from Ceylon, Java, Philippines, etc., is represented in my collection by a large number of specimens from Bihar, and a single damaged example from Assam. Of the Bihar specimens only two are males and are pinned, while all the females are in spirit. The mutilated Assam specimen, which is in spirit, is a male.

Most of the descriptions of *Polymitarcys indicus* so far published are based on dried insects, and depend chiefly on points of colouration. In specimens that have been preserved in spirit for any length of time the colour is invariably faded and does not, therefore, correspond exactly with that of the pinned insects. It is for this reason, therefore, that of the Indian examples of this species only the pinned males conform exactly with the published descriptions, while the females, that are in spirit, show some small differences from such accounts. Through the courtesy of the authorities of the Vienna Museum I have, however, been able to examine the unique female type-specimen of this species and am convinced that the Indian examples belong to Pictet's species. I have, however, considered it advisable to give a fairly detailed description of the Indian examples.

<sup>1</sup> Also from Burma; see foot-note on page 130.

<sup>2</sup> I am unable to say if Hagen's *P. australis* is synonymous with *P. indicus* or not. *P. sp.* Eaton, however, is a distinct form.

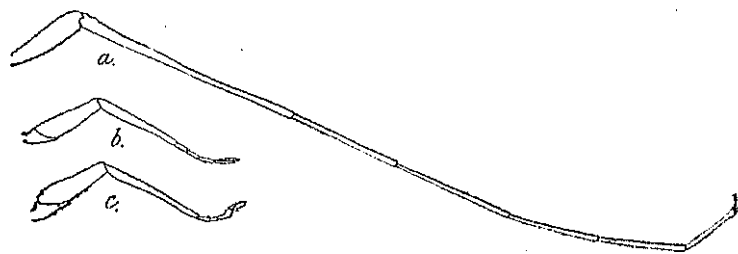
Both the dried males that I have seen agree in all material respects with Ulmer's description published in *Treubia* quoted above. The head is ochraceous brown and is somewhat darker behind the ocelli. The eyes are black, and the ocelli are dirty whitish encircled with brownish black. The eyes are widely separated from one another, somewhat oval in shape and are small in size. The ocelli are proportionately large, the median one being considerably smaller than the others. The head is more or less like that of *Polymitarceys virgo*, as figured by Eaton (1883, pl. vi, fig. 10a). The pronotum is light grayish yellow and has a waxy appearance. The mesonotum and the metanotum are much warmer than the pronotum and are distinctly brownish in shade. The dorsum of the abdomen is dirty whitish, with all the tergites overshadowed with gray, the posterior three being much warmer than the rest and slightly tinged with light violet. The posterior borders of the tergites are white. The venter and the sides are dirty whitish, except the sternum which is light ochraceous brown.

The legs are more or less concolorous with the venter, except those of the first pair, in which the coxa has a blackish streak along the outside; the femur is more or less uniformly sooty black, except at its articulations; the tibia is blackish and the tarsus is dirty whitish spotted with black.

The setae are dirty whitish with the joints white.

The wings are white, with the veins of the same colour. The costa, subcosta and the radius, with the transverse veins between them, are light violet. The venation is typical, but in the first anal area there are definitely six veins, instead of five as described and figured by Ulmer. I have carefully examined the wings of all the three specimens in my collection, but I find that the fork of the first anal vein invariably contains six subsidiary veins.

The hind-wing has a strongly developed costal projection, and the anal area is considerably reduced.



TEXT-FIG. 14.—*Polymitarceys indicus* (Pictet).

Legs of male, second and third slightly diagrammatic; all drawn to same magnification:  $\times 11$ .

a. 1st leg. b. 2nd leg. c. 3rd leg.

The legs, especially those of the first pair, are fairly well developed. In both the pinned specimens some of the legs are missing and the fore-tarsi are broken in both, but almost all the legs are intact in the Assam example. The first leg is almost as long as the body, but is very thin. The femur is very short, and the tibia is also hardly half as long as the

tarsus. The latter is formed of five segments of which the fifth appears to be the shortest. The claw is biunguiculate. The second and the third legs are greatly reduced, and are hardly a third as long as those of the first pair. The comparative sizes of the legs is clearly brought out in the accompanying text-figure 14. The tarsi are so reduced that it is difficult to make out their exact structure.

The genital apparatus is as described by Ulmer. The forceps are concolorous with the venter, and the penis lobes are warmer in colour, being slightly more yellow. The disposition of the genital forceps with reference to the penis lobes is interesting in the examples I have examined. As a rule the forceps lie more ventrally than the penis lobes. In the three male insects of this species that I have examined, however, the forcep of one side lies in its usual position, namely ventrally to the penis lobe of its side, while that of the other side lies dorsally to its penis lobe. In the two pinned males it is the right forcep that lies over the penis lobe of its side, while in the Assam specimen the left forcep is more dorsally placed than the left penis lobe. This character has not, however, been remarked upon by Ulmer, and it is possible it was not present in his specimens. The forceps have the usual structure. Each is formed of four segments, but their arrangement is quite different from what Ulmer has described and figured. In Ulmer's drawing there are shown only three distinct segments, of which the basal and the terminal are subequal, while the middle one is considerably longer than either of these. Besides these there is between the basal segment and the second a short articulation which is not clearly differentiated and is not fully chitinized. In my specimens the forcep is very clearly formed of four



TEXT-FIG. 15. — *Polymitaecys in licus* (Pictet).  
Genital forcep of male,  
enlarged:  $\times 50$ .

seems, however, likely that this apparent difference is only due to the specimen being in spirit.

The caudal setae are in the form of narrow ribbons. The median seta, though reduced, is quite distinct.

All the female imagos that I have examined are preserved in spirit. The general colour of the body is much warmer than that of the male, and is distinctly browner. The prevailing colour tint in the female is brownish yellow, approaching yellow ochre, while that of the male is dirty white. The head is drab coloured and is conspicuously bordered with black. The eyes are black and the ocelli are white encircled with black. The pronotum has a waxy appearance and is light ochraceous buff, tinged with brown in the median parts, but without any trace of violet. The mesonotum and the metanotum are ochraceous tawny, but are lighter in some specimens. The five regular stripes on the mesonotum mentioned by Ulmer are not visible in my specimens. There are, however, two parallel closely running thin longitudinal streaks of dark brown in the middle of the mesonotum, and some near the margins, but they are not as described by Ulmer. The posterior median projection of the metanotum is bordered with black. The dorsum of the abdomen is light brownish yellow, but all the tergites have grayish violet bands of a fairly dark colour running transversely along their posterior margins. These bands extend considerably forwards and in specimens in which the abdominal segments are telescoped a continuous broad longitudinal dark band is formed in the median line. The last two or three segments are somewhat more extensively coloured than the preceding ones. The venter and sides are pale yellowish, with the head and thorax warmer than the rest of the body.

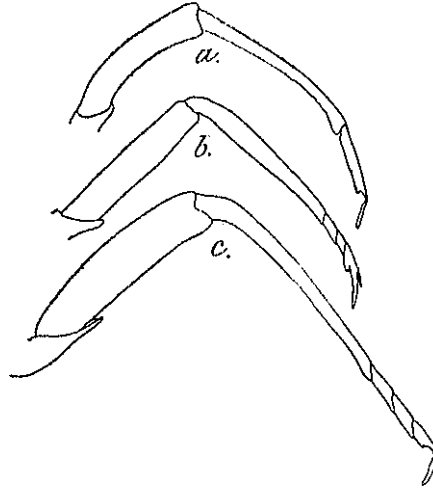
The legs are concolorous with the venter, except those of the first pair, which are somewhat warmer in colour and have thin streaks of a dark brownish colour on their outer sides. The tarsi are almost completely encircled with brown, while the tibiae are also extensively coloured. The tail setae are whitish in colour, while the wings are dirty whitish, with the veins white. The costal margin of the fore-wings and the first three longitudinal veins, together with the great cross vein, are light grayish violet.

The venation is like that of the male. The subcosta is well displayed and the radius is strong and prominent. The radial sector is forked well in advance of the media, and the latter is forked a little before the middle of the wing. The cubitus is not distinctly forked, and the intercalary vein enclosed in the "cubital fork" arises in this case from the base. The third cubital branch ( $Cu_2$ ) is grafted to the first anal near its base. In the first anal area there are six subsidiary veins, from the last of which there are several curved somewhat S-shaped veins going to the wing margin. The second and the third anal veins are fairly well developed. As usual in the genus there is a very large number of cross veins, which give the wing a mat-like appearance.

In the hind-wing the radial sector vein branches quite close to the wing base, and the media, as in the fore-wing, forks before the middle. The cubitus is considerably reduced, and its three branches cannot be made out. The anal area is reduced. The costal projection is very prominent.

The legs show a great deal of reduction. The fore-legs are considerably shorter than the hind-legs, and of the three pairs these are the least developed. In the fore-tarsus no distinct segments are discernible;

there is apparently only one long joint, followed by a poorly-developed claw. In the tarsi of the second and third pairs of legs two well-defined segments besides the claw can be seen.



TEXT-FIG. 16.—*Polymitarceys indicus* (Pictet).  
Legs of female, second and third tarsi slightly diagrammatic; all drawn to same magnification:  $\times 20$ .  
a. 1st leg. b. 2nd leg. c. 3rd leg.

Masses of eggs of a light buff-yellow colour are seen sticking to the posterior sternites of some of the specimens. The eggs are not clustered together in bodies of any regular shape, as in the case of the following species (*vide infra*, p. 132, also pl. X, figs. 5, 6), but they form irregular masses. Each egg is an ovalish structure slightly less than half as broad as long with the polar knob or the "micropylar apparatus," as Miss Morgan calls it, well developed. There is no prominent sculpturing of the chorion. In eggs that have been rendered transparent large granules are seen aggregated near the centre.

The Indian specimens of *Polymitarceys indicus* are somewhat smaller in size than those described by Ulmer. The males are about 9 mm. long, while the females are 1—2 mm. longer. The wings in the male are 9—10 and those of the female 12—14 mm. long. The setae in the male are 22; in the female the lateral ones are 11—13, while the median seta is 7—8 mm. long.

The nymphs of this species are not known.

*Locality.*—A large number of female imagos were collected by the late Dr. N. Annandale at the East Bank Railway Station on the Sone River in Bihar on 14th November, 1914. The insects were attracted to the light of a railway carriage. The two pinned males that I have seen belong to the Pusa collection and were collected by Mr. T. B. Fletcher, also at light in a railway carriage on the Sone River between Arrah and Patna Stations on 9th October, 1922. The third male specimen was recently (March, 1925) found by Dr. S. L. Hora of the Zoological Survey of India, floating down the Dhaleswari River at Katlicherra in

South Cachar, Assam. This specimen is very much crumpled and is preserved in alcohol.

Though the males and females of this form were collected at different places and at different times I have no doubt that they are referable to the same species. The two localities in Bihar from which Dr. Annandale and Mr. Fletcher collected these insects are quite close to one another. The colouration of the male and female differs considerably, but that is the case in several other mayflies also, and has already been noticed by Ulmer with regard to this species. The wings in the two sexes are identical.

Owing to the kindness of Drs. Maidl and Zerny of the Vienna Museum it has been possible for me to examine Pictet's type-specimen of this species. This specimen, which is still in a fairly good state of preservation, resembles exactly in almost every detail the Indian examples of this species. The colour is somewhat faded in the type, and neither the violet lines on the pronotum, nor the five streaks on the mesonotum, mentioned by Ulmer, can now be made out. The grayish violet bands on the abdomen, which is strongly telescoped, the violet colour of the costal region of the fore-wing, the blackish streaks on the fore-legs and in fact most other characters are exactly as I have described them above. There is, however, one difference between the Indian examples and the Vienna specimen. In the latter the first anal area of the fore-wing has four subsidiary veins on the right side and five on the left, in my examples there are six on both sides. Ulmer has described "4 bis 5, selten 6 Längsadern" in his specimens. This character, therefore, appears to be variable, and consequently not of any great importance.

Ulmer's figure and description of the genitalia of the male do not agree with my specimens. The last segment of the genital forceps, shown in Ulmer's figure, seems to be divided in two in the Indian forms, and the indistinct, partly chitinized articulation between the basal and the penultimate joint is present in my specimens in a different position. The forcep of the European *P. virgo* (Oliver), as figured by Eaton (1883, pl. vi, fig. 10 a.), and of other species is, however, formed of four distinct segments and is very much like that of the Indian specimens of the present species. It seems to me likely that the figure given by Ulmer is not quite correct in this respect, as the number of segments forming the genital forceps is generally very constant for all species of a genus. The position of the indistinct and partly chitinized articulation does not appear to be of any great importance, for the tendency to the formation of such articulations seems to be present in both cases. Further, the penis lobes in my examples are not quite as sharp apically as those shown in Ulmer's illustration, but, as mentioned above, this is probably due to the fact that Ulmer's figure is based on dried material, while mine is drawn from an example preserved in spirit. In the two pinned specimens that I have seen the penis lobes are pointed, though not to quite so great an extent as is shown in Ulmer's figure.

As already remarked by Ulmer (1924b), *Polymitarcys indicus* appears to be a very variable species with regard to the number and arrangement of the subsidiary veins enclosed in the first anal area. The first anal vein forks near its base and there are usually 4—6 subsidiary veins

enclosed in this fork. In the type-specimen there are five such veins on the left side and only four well-developed ones on the right; Banks has described only four veins in his *Anagenesia greeni* from Ceylon, while Ulmer has mentioned the number as four to five, sometimes six. From Lestage's account it appears there were only three subsidiary veins enclosed in the first anal fork of his specimens. Three intercalary veins is an unusually small number, but Lestage's brief description is not quite clear on this point. In all the specimens that I have examined there are six veins enclosed in the anal fork.

*Polymitarcys indicus* was hitherto known to occur in the "East Indies" (Pictet), Ceylon (Walker and Banks), Java (Ulmer, 1913), Indo-China (Lestage) and Sunda Islands and the Philippines (Ulmer, 1924b). The record of occurrence of this species in India, though not very remarkable, extends its range considerably. In India the species is so far known chiefly from the Sone River, Bihar, though one specimen was collected in Assam also. It seems probable, however, that this insect has a wider distribution in India<sup>1</sup> than these records would show, and in time is likely to be collected in other parts of the country also.

***Polymitarcys annandalei*, sp. nov.**

(Plate X, figs. 2—6).

The present species is represented in the Indian Museum collection by about half a dozen imagos preserved in spirit. All the specimens are females and are in a good state of preservation.

Female imago (in spirit).—The general colouration of the body is dirty whitish, with the head and thorax somewhat warmer in colour. The head on its dorsal surface is light cream, with a short transverso fuscous streak in its anterior region between the ocelli. The eyes are blackish and the ocelli are broadly encircled with dark blackish-brown. There is also a thin, and in some specimens very faint, dark streak running longitudinally in the middle line and the area behind the median ocellus is somewhat fuscous. The pronotum is lighter than the head, and is ivory yellow. It has also a narrow fuscous streak running transversely just behind the anterior margin. The mesonotum is much warmer in colour than the head or the pronotum and is cream coloured. There are the usual dark lines on the mesonotum, and a streak darker than the rest runs longitudinally in the median line, and is continued on the metanotum. The dorsum of the abdomen is dirty whitish to ivory yellow, but the masses of eggs inside give it a buff yellow colour. Each tergite along its posterior margin has a faint brownish to dark grayish-brown broad streak, which is produced anteriorly in the median line so as to form a broad band running longitudinally almost from end to end of the

<sup>1</sup> Quite recently (9th October, 1926) I collected this species in very large numbers in Burma. I was travelling in a railway train near Pogu at about 8 in the evening and a swarm of these insects, no doubt attracted by bright light, flew right into the carriage. They were in such large numbers that they seemed to fill the whole carriage. On switching off the lights they fell down on the floor and the seats and were later picked up almost half dead. As usual with such swarms the females outnumbered the males. The species is now, therefore, known to occur in Burma, Assam and Bihar. There seems little doubt that it will be met with in Bengal also.



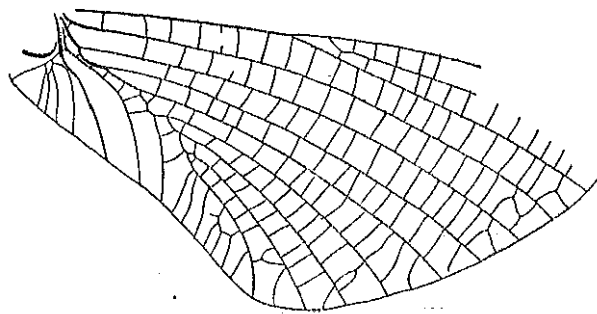
dorsum. The last two or three tergites are warmer than the rest. The venter and sides are dirty whitish, except in the thoracic region where the sternites are ivory yellow.

The legs are more or less concolorous with the venter. In the fore-leg the femur has on its dorsal surface a number of inconspicuous fuscous streaks running longitudinally, and the tibia and tarsus are also more or less similarly marked.

The setae are whitish.

The wings are dirty whitish, with most of the veins in opaque view whitish. The costal region, especially the pterostigmatal area, is considerably warmer than the rest of the wing, except a small region along the terminal margin behind the third anal vein, which is of the same colour. The costal, subcostal and the radial veins are cream coloured. The wing membrane has a mottled appearance on account of the presence of faint spots in the cells formed by the crossing of veins. Except in the anterior region of the wing almost every cell has a small spot in its middle. The spots are only very slightly warmer in colour than the wing membrane and are consequently inconspicuous. In some of the specimens this mottling is very faint.

The shape of the fore-wing is somewhat different from that of the preceding species. The inner margin is proportionately longer, while the terminal is correspondingly shorter. The anal angle is also less defined, and is broadly rounded. The venation is, however, typical of the genus. The subcosta is well displayed, the radial sector forks well in advance of the media, which branches a little before the middle of the wing and the cubitus does not form a definite fork at all, its anterior branch arising separately near the base of the media, while the two posterior ones, which are more or less equally developed, join the first anal a little below the base. The fork formed by the latter contains in some examples four intercalary veins and in others five. When there are four veins enclosed in the anal fork instead of five the curved transverse veins going from the last of these to the wing margin are more prominent and better



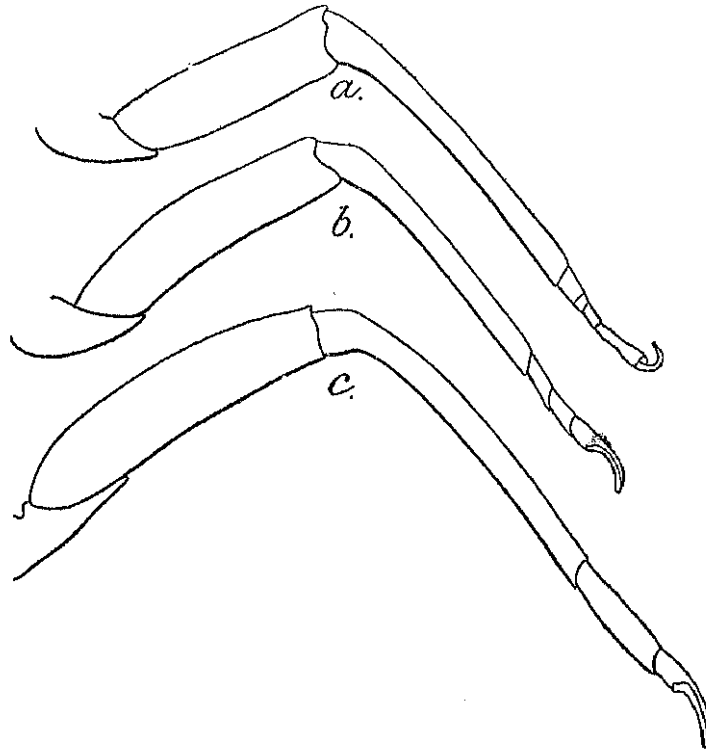
TEXT-FIG. 17.—*Polymitarcys annandalei*, sp. nov.

Posterior region of a fore-wing, showing four subsidiary veins enclosed in the first anal fork:  $\times 8$ .

developed. The wing has a closely reticulated appearance on account of the large number of transverse veins.

The hind-wing is similar to that of the preceding species, and the membrane does not present a spotted appearance. The costal projection is highly developed.

The legs are extremely reduced. The fore-legs are of about the same size as the middle ones and are distinctly smaller than the hind-legs. The femur and the radius are well developed in all the legs, but the tarsus shows great reduction, especially in the last pair of legs. In the fore-tarsus four segments can be more or less clearly made out, of which the second is the shortest and the fourth the longest. The first is a little shorter than the second and the third put together. In the mid-tarsus only three segments can be distinguished, while in the tarsus of the last leg only two segments are discernible. The claws are well developed and appear to be double.



TEXT-FIG. 18.—*Polymitarceys annandalei*, sp. nov.

Legs of female, tarsi somewhat diagrammatic; all drawn to same magnification:  $\times 34$ .

a. 1st leg. b. 2nd leg. c. 3rd leg.

The setae have the usual structure.

Masses of eggs are seen through the transparent walls of the abdomen and are of a buff-yellowish colour. The eggs are grouped together in elongate oval masses, two of which are seen protruding out of the genital openings in some of the specimens. In most cases the abdomen is sharply bent upwards at the seventh segment so as to enlarge the paired

openings of the oviducts and thus provide an easy exit for the large egg-masses. This condition is exactly like that shown by Needham<sup>1</sup> for *Polymitarcys albus* Say. Each egg is oval in shape, with the apex somewhat truncate, and the "micropylar apparatus" well developed. The eggs are proportionately longer than those of *P. indicus*. The chorion is sculptured and presents a strikingly scaly appearance. Inside the granules are arranged more or less like those in the eggs of the preceding species.

The male is not known.

The nymphs are not known.

*Polymitarcys annandalei* is somewhat larger than the preceding species, the female reaching up to a length of 14 mm., with the fore-wing of the same length. The outer setae are 12 mm. long and the median 10.

*Type-specimens.*—9222/H<sub>2</sub>, Zoological Survey of India (*Ind. Mus.*).

*Locality.*—All the specimens of this species in the collection of the Indian Museum were collected by the late Dr. N. Annandale and Dr. F. Gravely at Chakradharpur on the Sanjai River in Chota Nagpur in February, 1918. The insects were captured at light at the edge of the river.

*P. annandalei* can be easily distinguished from *P. indicus* by its paler body and larger size. In this species the body is dirty whitish, while in the female of *P. indicus* the prevailing colour is brownish yellow. Further the wing in *P. annandalei* is faintly spotted, while that of Pictet's species has no spots, but has the costal region coloured violet. Also there are six intercalary veins in the first anal fork in the wing of *P. indicus*, while in the Chota Nagpur form the number of such veins does not exceed five. The eggs in the two forms are also somewhat different.

#### *Polymitarcys* sp. Eaton.

(Plate X, fig. 7).

1892. *Polymitarcys* sp., Eaton, *Journ. As. Soc. Bengal* I.X, p.408.  
1924. *Polymitarcys indicus*, Ulmer, *Traubia* VI, pp. 32-34 (*partim*).

A single pinned female example, labelled in Eaton's handwriting as *Polymitarcys* sp., is preserved in the collection of the Indian Museum. The specimen is now in a very poor condition, but from an examination of the one complete fore-wing that still exists it is clearly seen to be different from Pictet's *P. indicus*. From the drawing of the fore-wing that I am giving here the difference in the arrangement of the various veins between the present species and Pictet's *P. indicus* will be readily seen. There are only four subsidiary veins in the first anal fork. The shape of the wing is different from that of *P. indicus*, and the costal region is not violet, but a shade of yellowish brown approaching raw sienna. The dorsum also is somewhat differently coloured, there being more of a brownish tint in Eaton's example than in *P. indicus*.

The wing of *P.* sp. in its shape and the disposition of its veins somewhat resembles that of *P. annandalei*, but the costal region is differently

<sup>1</sup> Needham, *Bull. U. S. Bur. Fish, Washington* XXXVI, pl. lxxvii, fig. 20 (1917, 18).

tinted in the two and the membrane is not spotted in the former. The colouration of the body is also different in the two species.

As mentioned by Eaton this specimen probably belongs to an undescribed species, but, owing to the inadequacy of the material, it is best not to give it a specific name.

The specimen is from Raneeganj in West Bengal.

#### Genus *Povilla* Navás.

1912. *Povilla*, Navás, *Rev. Zool. Afric.* I, pp. 401-403.  
 1919. *Povilla*, Ulmer, *Arch. Naturgesch.* LXXXV, Heft II, pp. 5, 6.  
 1920. *Povilla*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 107.  
 1922. *Asthenopus*, Lestage, *Ann. Soc. Ent. Belgique* LXII, pp. 142---148 (*partim*).  
 1924. *Povilla*, Ulmer, *Treubia* VI, pp. 34-37.

The history of the genus *Povilla* has been described by Lestage in the work cited above. Navás created this genus for an insect from the Congo, considering it to be closely similar to *Campsurus*, but differing from it in having greatly reduced legs and a peculiar neuration in the anal region of the fore-wing. Ulmer in 1919 added one more species to the genus from Siam and Cambodge and Lestage (1922) described another under the name of *Asthenopus corporali* from Java, which, however, appears to be a true *Povilla*. Thus the genus now includes three species, *P. adusta* Navás, the genotype, originally described from the Congo, but now known to occur more extensively in Africa (Ulmer, 1915), *P. camboljensis* Ulmer, from Siam, etc., and *P. corporali* (Lestage) originally from Java, but now recorded by me from India also.

The remarkable diversity in the venation of the fore-wing, and especially in its anal area, that exists in the different members of the family Polymitaecidae has been already referred to, and this diversity has given rise to doubts regarding the validity of the genus *Povilla*. Lestage (1922) in his well-reasoned "Notes sur les genres *Asthenopus-Povilla*" combined the two genera under the older name *Asthenopus*, considering that the definition of *Asthenopus* Eaton (revived by Ulmer) was broad enough to include the species described as *Povilla*. He also noticed the strong peculiarity of the two intercalary veins enclosed in the anal fork, but he does not seem to have given this character its due importance. In all the species described as *Povilla* the two intercalary veins arise at about the same level, the anterior one from the first anal, and the posterior from the second anal vein. This character is found in no other genus of Polymitaecidae; in *Asthenopus* the two veins in question arise in quite a simple manner from the first anal vein. Besides this the penis lobes are said to be different in the two genera. For these reasons, among others, Ulmer (1924b) was, in my opinion, quite justified in changing the genus of Lestage's species from *Asthenopus* to *Povilla*.

From India the genus is so far known from a single species, represented by a single female specimen, collected in Assam. The genus has, however, a wide range, having been met with in Africa and the Oriental Region.

***Povilla corporaali* (Lestage) ?**

(Plate X, figs. 8—11).

1922. *Asithenopus corporaali*, Lestage, *Ann. Soc. Ent. Belgique* LXII, p. 146.1924. *Povilla corporaali*, Ulmer, *Traubia* VI, pp. 34-37.

I have examined a single female pinned specimen of this remarkable insect, preserved in the collection of the Forest Research Institute, Dehra Dun. The specimen is not in a perfect state of preservation as parts of the abdomen have been eaten away, probably by cabinet pests. The wings, legs and all the essential parts are, however, present in an undamaged condition.

My specimen agrees in most particulars with the descriptions published by Lestage and Ulmer, and a few important differences that do exist may possibly be due to the bad condition of my specimen. The most important difference seems to me to be in the colouration of the body and wings and in the different shape of the pronotum.

In the specimen that I have examined the dorsum is dark brownish-black, with the notum considerably lighter than the rest of the body, it being brownish. The head is almost pitch black, with the exception of a small portion between the eyes, which is brown. The eyes are black, oval in outline, and, as shown in the figure (plate X, fig. 8), are very remotely placed. The ocelli are whitish encircled with black, and the median ocellus is smaller than the lateral ones. The posterior margin of the head is black. The pronotum is very short and broad, being considerably shorter than the head. A fairly conspicuous median ridge (running longitudinally) divides the pronotum in two equal halves, and another transverse ridge just behind the anterior margin cuts off a small anterior segment and a larger posterior one. As shown in the illustration the pronotum, as seen from above, is pointed at the sides in a forwardly direction. It is fuscous to clove brown in colour, suffused with very fine spots of black in the median region. The lateral regions are more brown than black, and there is a black streak along the posterior margin. The mesonotum is considerably paler in colour than the pronotum and is amber brown. It has a few streaks of blackish brown, and the posterior spine is blackish. The metanotum has the same ground colour as the mesonotum, though it has more black suffused on it than the latter.

The abdomen is in a considerably damaged condition. The ground colour appears to have been a dark shade of brown, something like blackish brown, but in most places it is uniformly fuscous-black to sooty black. The posterior one or two tergites are slightly paler in colour than the rest of the abdomen. The last two tergites in my specimen are somewhat telescoped in those preceding them and thus appear to be very small. The last segment ends broadly, so that the abdomen has a distinctly truncate appearance (plate X, fig. 11).

The sides and the venter are dirty whitish to very pale yellowish in colour. The sternum is light brownish, and some of the abdominal sternites have a transverse dark streak, bluish in colour, a little behind the middle of each segment. There are no stripes on the last three sternites, and those on some of the anterior ones are faint.<sup>1</sup>

<sup>1</sup> The abdomen being damaged it is difficult to make out all these characters distinctly.

The legs are very greatly reduced and are like those described and figured by Ulmer.

The fore-wing as described by previous writers is bi-coloured and presents a very characteristic appearance. The basal half of the wing is of a very dark colour, while the other half is dirty whitish and transparent. It is very difficult to describe the colour of the basal portion accurately, for it does not resemble even approximately any of the numerous shades given in Ridgway's book. It, however, comes nearest to Hay's maroon, or some shade of chocolate, but in certain lights has a distinct purplish shade. The coloured area covers about half of the membrane, and extends more anteriorly on the inner margin. Its disposition and extent is clearly shown in the illustration (plate X, fig. 9). All the longitudinal veins are blackish. The venation is like that described by Lestage and Ulmer. The radial sector forks near the base, but well in advance of the media. The latter branches so close to the wing base that it has no stem and the intercalary vein  $M_2$  is only a little shorter than the posterior branch  $M_3$ . The cubitus does not appear to branch at all, and its posterior branch ( $Cu_2$ ) is grafted on to the first anal. The two intercalaries in the first anal area are as figured by Ulmer or as described by him and Lestage. The venation is fully brought out in the figure that I have given, and it is not necessary to describe it in detail.

The hind-wing (plate X, fig. 10) is dirty whitish and transparent, but near the costal projection the membrane is dark brownish (purplish?).

The setae are greatly reduced, and the median seta is considerably shorter than the lateral ones. They are dirty whitish in colour.

No males of this species are so far known.

The nymphs are not known.

*Locality.*—The single female pinned specimen of this species that I have seen is in the collection of the Forest Research Institute at Dehra Dun. It was collected in Assam. As already mentioned the specimen has been damaged by cabinet pests, parts of the mesonotum and the abdomen having been eaten away. The colour also appears to have undergone some change.

From the figure of a complete wing that I am giving for the first time, it will be seen that the species does not belong to the genus under which Lestage originally included it. Though my specimen differs considerably from Lestage's and Ulmer's accounts of this species, I have, however, thought it best not to describe it as a new species, firstly because there are many points of resemblance between the two and secondly because the material at my disposal is far from adequate. The chief difference lies in the fact that the colour of the coloured portion of the fore-wing is not "intensiv dunkelviolett" (Ulmer, p. 35) or "violacé très foncé" (Lestage, p. 146), but is a shade of dark brown. The extent of the coloured area, as seen from my illustration, is also somewhat different from what has been described by Lestage and Ulmer. The membrane of the hind-wing in my specimen is dirty whitish and transparent except for a small portion near the costal projection, while in examples examined by Lestage and Ulmer it is bicoloured like that of the mesothoracic wing. The colouration of the abdomen also differs

from the published accounts and the prothorax has also a somewhat different shape.

## BIBLIOGRAPHY.

Banks, N.—

1914*a*. Neuropteroid Insects (collected by the Abor Expedition)  
*Rec. Ind. Mus.* VIII, p. 354.

1914*b*. New Neuropteroid Insects, native and exotic. *Proc. Acad. Nat. Sci. Philadelphia* LXVI, pp. 612-616, pl. xxviii.

Comstock, J. H., and Needham, J. G.—

1899. *The Wings of Insects*, pp. 1-124.

Comstock, J. H.—

1918. *The Wings of Insects*, pp. 1-430 (New York).

Eaton, A. E.—

1871. A Monograph on the Ephemeridae. *Trans. Ent. Soc. London* for 1871, pp. 1-164, pls. i-vi.

1883-1888. A Revisional Monograph of Recent Ephemeridae or Mayflies. *Trans. Linn. Soc. London* (2) III, pp. 1-352, pls. i-ixv.

1892*a*. Notes on some native Ephemeridae in the Indian Museum, Calcutta. *Journ. As. Soc. Bengal* LX, pp. 406-413.

1892*b*. New species of Ephemeridae from the Tenasserim valley. *Trans. Ent. Soc. London* for 1892, pp. 185-190.

1899. An annotated List of the Ephemeridae of New Zealand. *Trans. Ent. Soc. London* for 1899, pp. 285-293, pl. x.

Gravely, F. H.—

1920. Notes on some Asiatic species of *Palingenia* (Order Ephemeroptera). *Rec. Ind. Mus.* XVIII, pp. 137-143, pls. xviii-xx.

Hagen, H.—

1858. Synopsis der Neuroptera Ceylons. *Verh. Zool.-bot. ges. Wien* VIII, pp. 476, 477.

1859. Synopsis der Neuroptera Ceylons (Part II). *Verh. Zool.-bot. ges. Wien* IX, p. 206.

Lestage, J. A.—

1921*a*. Les Ephemerides Indo-Chinoises. *Ann. Soc. Ent. Belgique* LXI, pp. 211-221.

1921*b*. Ephemeroptera in Rousseau's *Les Larves et Nymphes Aquatiques de Insectes d'Europe* I, pp. 162-273.

1922. Notes sur les genres *Asthenopus-Povilla* (Ephemeroptera) et Description d'une Espèce Javanaise nouvelle *Asthenopus corporaali* sp. nov. *Ann. Soc. Ent. Belgique* LXII, pp. 142-148.

1923*a*. Étude sur les Palingeniidae (Ephémères) et description de deux genres nouveaux et d'une espèce nouvelle de la Nouvelle Guinée. *Ann. Soc. Ent. Belgique* LXIII, pp. 95-112.

1923*b*. L'imbroglio Campsurien. Notes critiques sur les *Campsurus* (Ephemeroptera). *Ann. Soc. Ent. Belgique* LXIII, pp. 113-124.

1924*a*. Les Ephemerides de l'Afrique du Sud. *Rev. Zool. Afric.* XII, p. 317.

1924*b*. Notes sur les Ephemerides de la Monographical Revision de Eaton. *Ann. Soc. Ent. Belgique* LXIV, pp. 33-60.

- Morgan, A. H.—  
 1912. Homologies in the Wing-veins of May-Flies. *Ann. Ent. Soc. America* V, pp. 89-106, pls. v-ix.  
 1913. A contribution to the Biology of Mayflies. *Ann. Ent. Soc. America* VI, pp. 371-413, pls. xlii-liv.
- Morton, K. J.—  
 1921. A New Species of Mayfly, *Palingenia (sensu lato)*, from Mesopotamia. *Entomologist* LIV, pp. 177-180.
- Needham, J. G.—  
 1903. A Genealogical Study of Dragonfly Wing-Venation. *Proc. U. S. Nat. Mus.* XXVI, pp. 703-764, pls. xxxi-liv.  
 1905. Mayflies and Midges of New York (Ephemeroidea). *Bull. New York State Mus.* LXXXVI, pp. 17-62, pls. iv-xii.  
 1909. Notes on the Neuroptera in the collection of the Indian Museum. *Rec. Ind. Mus.* III, pp. 191, 192, pl. xx, figs. 6-10.  
 1917-18. Burrowing Mayflies of our larger lakes and streams. *Bull. Bur. Fish. Washington* XXXVI, pp. 269-292, pls. lxx-lxxxii.
- Navás, R. P. L.—  
 1912. Notes sur quelques Neuropteres d'Afrique. *Rev. Zool. Afric.* I, pp. 401-403.
- Pictet, F. J.—  
 1843. *Histoire Naturelle generale et particuliere des Insectes Neuropteres.* Famille des Ephemeroidea, pp. 1-300, pls. i-xlvi (Geneve et Paris: 1845).
- Tillyard, R. J.—  
 1923. The Wing-Venation of the Order Plecoptera or Mayflies. *Journ. Linn. Soc. (Zool.)* XXXV, pp. 143-162.
- Ulmer, G.—  
 1912-1913. Ephemeroidea aus Java, Gesammelt von Edw. Jacobson. *Notes Leyden Mus.* XXXV, pp. 102-120.  
 1915. Ephemeropteren von Aquatorial-Afrika. *Arch. Naturgesch.* LXXXI, part 7, pp. 1-19.  
 1919. Neue Ephemeropteren. *Arch. Naturgesch.* LXXXV, part 11, pp. 1-80.  
 1920. Übersicht über die Gattungen der Ephemeropteren, nebst Bemerkungen über einzelne Arten. *Stettin. Entomol. Zeitung* LXXXI, pp. 97-144.  
 1924a. Ephemeroptera in Schulze's *Biologischer Tiere Deutschlands.* Teil 34, pp. 1-40 (Berlin).  
 1924b. Ephemeropteren von den Sunda-Inseln und den Philippinen. *Treubia* VI, pp. 28-91.  
 1925. Beiträge zur Fauna sinica. Ephemeroptera. *Arch. Naturgesch.* LXXXI, part 5, pp. 86-110.
- Walker, F.—  
 1853. *List of the specimens of Neuropterous Insects in the collection of the British Museum.* Part III, p. 533 (London).



EXPLANATION OF PLATE VIII.

*Palingenia orientalis*, sp. nov.

- FIG. 1.—Head and prothorax of male, dorsal view :  $\times 8$ .  
FIG. 2.—Hind-wing of male :  $\times 3\frac{1}{2}$ .  
FIG. 3.—Genital forcep :  $\times 11$ .

*Anagenesia lata* (Walker).

- FIG. 4.—Head and prothorax of male, dorsal view :  $\times 8$ .  
FIG. 5.—Hind-wing of male :  $\times 5$ .  
FIG. 6.—Genitalia of male, ventral view :  $\times 16$ .

*Anagenesia robusta* Eaton.

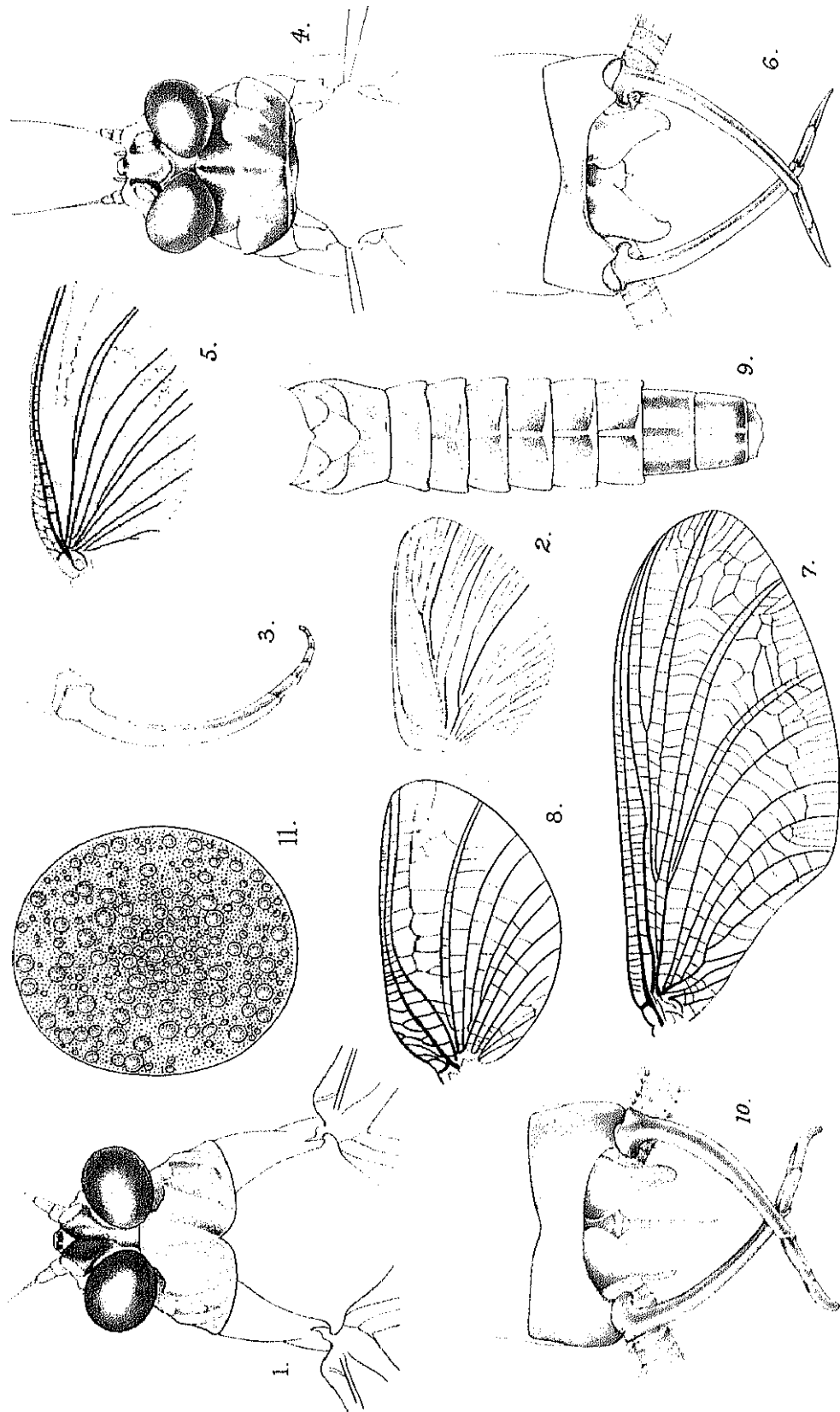
- FIG. 7.—Fore-wing<sup>1</sup> of female :  $\times 4$ .  
FIG. 8.—Hind-wing of male :  $\times 4$ .  
FIG. 9.—Abdomen of female, dorsal view :  $\times 4$ .  
FIG. 10.—Genitalia of male, ventral view :  $\times 12$ .

*Anagenesia minor* Eaton.

- FIG. 11.—Egg :  $\times 150$ .

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<sup>1</sup>The subcosta in this figure is not shown concealed in a fold of the membrane.



INDIAN EPHEMEROPTERA.

EXPLANATION OF PLATE IX.

*Anagenesia minor* Eaton.

- FIG. 1.—Fore-wing<sup>1</sup> of male : × 4.  
FIG. 2.—Hind-wing of male : × 4.  
FIG. 3.—Abdomen of female, dorsal view : × 4.  
FIG. 4.—Genitalia of male, ventral view : × 12.

*Anagenesia picta* Gravely.

- FIG. 5.—Hind-wing of male : × 4.  
FIG. 6.—Genitalia of male, ventral view : × 9.

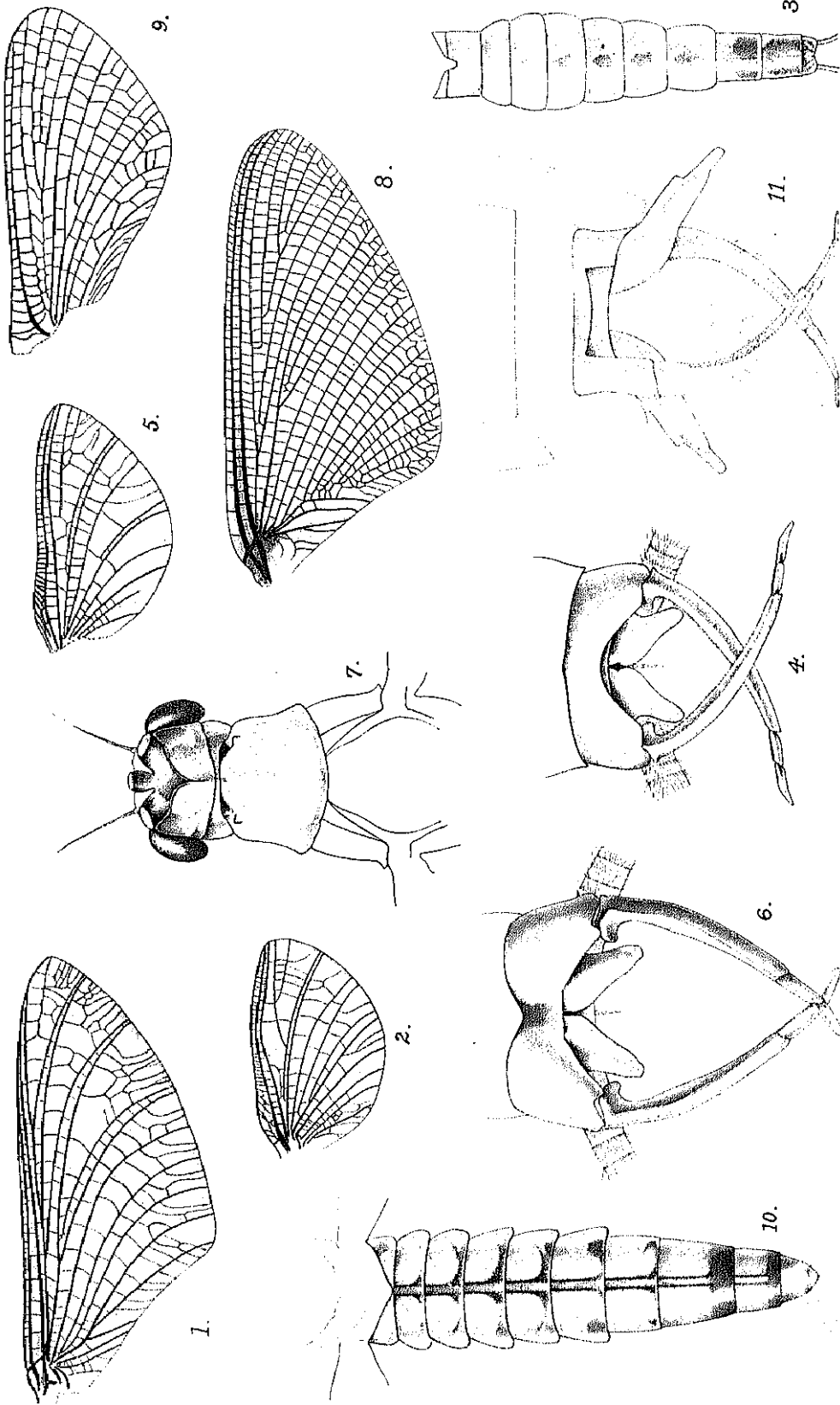
*Polymitarceys indicus* (Pictet).

- FIG. 7.—Head and prothorax of male,<sup>2</sup> dorsal view : × 18.  
FIG. 8.—Fore-wing of female : × 5.  
FIG. 9.—Hind-wing of female : × 10.  
FIG. 10.—Abdomen of female, dorsal view : × 12.  
FIG. 11.—Genitalia of male,<sup>3</sup> ventral view : × 36.

<sup>1</sup> The subcosta in this figure is not shown quite as much concealed as it is in the natural condition.

<sup>2</sup> This figure is drawn from one of the Bihar specimens.

<sup>3</sup> This figure is drawn from the Assam specimen.



INDIAN EPHEMEROPTERA.

EXPLANATION OF PLATE X.

*Polymitarcys indicus* (Pictet).

FIG. 1.—Egg :  $\times 200$ .

*Polymitarcys annandalei*, sp. nov.

FIG. 2.—Fore-wing of female :  $\times 5$ .

FIG. 3.—Hind-wing of female :  $\times 10$ .

FIG. 4.—Abdomen of female, dorsal view :  $\times 6$ .

FIG. 5.—An egg-mass :  $\times 16$ .

FIG. 6.—Egg :  $\times 200$ .

*Polymitarcys* sp. Eaton.

FIG. 7.—Fore-wing of female :  $\times 8$ .

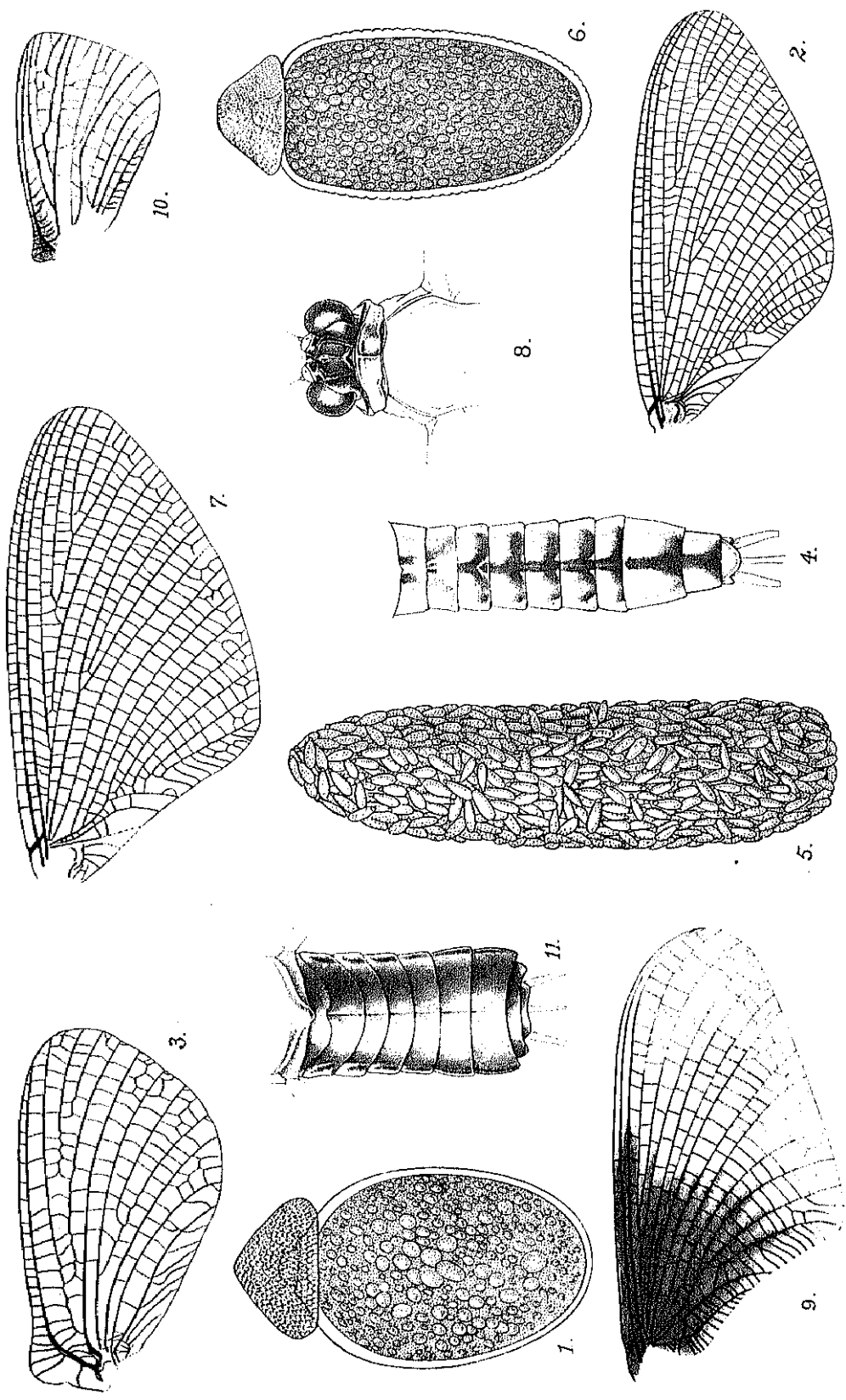
*Povilla corporali* (Lestage).

FIG. 8.—Head and prothorax of female, dorsal view :  $\times 5$ .

FIG. 9.—Fore-wing of female :  $\times 3\frac{1}{2}$ .

FIG. 10.—Hind-wing of female :  $\times 3\frac{1}{2}$ .

FIG. 11.—Abdomen of female, dorsal view :  $\times 6$ .



INDIAN EPHEMEROPTERA.