

Odonata from the BEFTA Project area, Riau Province, Sumatra, Indonesia

Rory A. Dow^{1,2}, Andreas Dwi Advento³, Edgar C. Turner⁴, Jean-Pierre Caliman³,
William A. Foster⁴, Sarah H. Luke⁴, Mohammad Naim³, Jake L. Snaddon⁶,
Sudharto Ps³

¹Naturalis Biodiversity Center, P.O. Box 9517, 2300 RA Leiden, The Netherlands

²Sarawak Museum Campus Project, Jabatan Muzium Sarawak, Jalan Barrack, 9300 Kuching, Sarawak, Malaysia. (rory.dow230@yahoo.co.uk)

³SMART Research Institute, PT SMART Tbk, Jalan Teuku Umar 19, 28112 Pekanbaru, Indonesia

⁴Department of Zoology, University of Cambridge, Downing Street, Cambridge, CB2 3EJ

⁵School of Geography and Environmental Science, Centre for Environmental Science, University of Southampton, Highfield Campus, Southampton, SO17 1BJ

Abstract

The Odonata found during work on the Biodiversity and Ecosystem Function in Tropical Agriculture (BEFTA) Project in Riau Province, Sumatra, Indonesia are reported. Prior to the BEFTA project we are only aware of published records of 37 species of Odonata from Riau Province (these are listed in an appendix). Seventy five species have been recorded during the BEFTA project, including five that had not been recorded in Sumatra before (*Archibasis incisura*, *Archibasis rebecca*, *Argiocnemis* species, *Mortonagrion* species cf *aborensis* and *Pseudagrion williamsoni*). *Macromia dione* is recorded for the first time since its description. The number of species now known from Riau Province is 88; 51 of these are reported from the province for the first time here.

Introduction

Although a relatively large number of records of Odonata are available from the Indonesian island of Sumatra, excluding its satellite islands, they are the result of piece-meal sampling and mostly date to before Indonesian independence; the majority are of widespread and common species. There is an urgent need for fresh data from Sumatra, where considerable changes to habitats, especially lowland habitats, have occurred over the last sixty years. Here we present records of Odonata from a part of Riau Province, Siak Regency, in the east of Sumatra. Records were generated as part of the Biodiversity and Ecosystem Function in Tropical Agriculture (BEFTA) Project (Foster *et al.* 2014; see www.oilpalmbiodiversity.com for full project details), a large-scale plantation management project based within Oil Palm estates owned and managed by PT Ivo Mas Tunggal, a subsidiary company of Golden Agri Resources (GAR), with technical advice from Sinar Mas Agro Resources and Technology Research Institute (SMARTRI, the Research and Development Centre of upstream activities in GAR).

Odonata were surveyed using transects within established research plots, as part of the general BEFTA work, over the period February 2013 to February 2015. Plots consisted of eighteen 150 metre by 150 metre study plots located in Ujung Tanjung and Kandista Estates. All plots were located in flat areas of between 10-30 m above sea level in areas of

Oil Palm planted between 1987 and 1993, so were mature at the time of these surveys, with an established canopy. Additional sampling was carried out in estate areas adjacent and away from these plots to provide a broader understanding of the Odonata present in the area. The area surrounding these estates consists predominately of mature Oil Palm plantations either owned by companies or by local smallholders, with only small amounts of other crops. In addition, a small number of additional surveys were carried out at Rama Rama Estate, managed by PT Ramajaya Pramukti, another subsidiary company of GAR, in Kampar Regency. More details on locations sampled can be found below.

Prior to the commencement of the BEFTA Project, we are aware of records of only 37 species of Odonata definitely from Riau Province, compared with over 280 species and subspecies (including satellite islands) or over 225 species and subspecies (without satellite islands) for Sumatra as a whole (Dow unpublished; these figures exclude records of *Heliocypha perforata* (Percheron, 1835), *Euphaea ochracea* Selys, 1859 and *Indocnemis orang* (Förster in Laidlaw, 1907) based on specimens collected by B. Jachan, see footnotes on pages 13, 17 and 50 of Lieftinck (1954) and do not include any of the islands that are administratively part of Riau Islands Province). Records from Riau Province can be found in Dow *et al.* (2010), Hämäläinen, Dow & Stokvis (2015), Lieftinck (1935, 1940a, 1940b, 1951, 1953, 1965), Ris (1913, 1919, 1927), Seehausen & Dow (2016) and Tsuda & Kitagawa (1988). The holotype of *Podolestes buwaldi* Lieftinck, 1940 is from Riau Province. The species recorded from Riau Province prior to the BEFTA Project are listed in an appendix. Here we present a full list of Odonata recorded from the BEFTA Project area and Rama Rama Estate.

Sampling locations

The numbering system for locations introduced here is used throughout the rest of the report. Fig. 1 shows the positions of the estates. The BEFTA plots are listed first, they are in sets of three adjacent plots, coordinates are given for the first plot in each set. The other locations are listed afterwards.

BEFTA Plots (all Siak Regency, Fig. 2)

Ujung Tanjung Estate:

1C-10 (0.97758N, 101.27487E); 1C-11; 1C-12.

2C-17 (0.98253N, 101.29518E); 2C-18; 2C-19.

4D-28 (0.96203N, 101.32299E); 4D-29; 4D-30.

Kandista Estate:

1F-04 (0.94952N, 101.34029E); 1F-05; 1F-06.

1G-07 (0.94036N, 101.34929E); 1G-08; 3G-09.

3G-14 (0.93958N, 01.3658E); 3G-15; 3G-16.

Other locations:

Ujung Tanjung Estate (Fig. 3):

1 Damp ditches in Oil Palm opposite one of the BEFTA plots (1C-10).

2 Large stream in Oil Palm on way to 1, tributaries, in plantation and ditches.

Near Libo Estate and SMART Research Institute (SMARTRI):

3 Small conservation area near SMARTRI, at a stream in degraded forest.

4 Remnant, highly degraded, swamp forest near 3.

Kandista Estate (Fig. 3):

- 5 Deep channels and marsh in Oil Palm opposite one of the BEFTA plots (1F-04).
- 6 In BEFTA plot opposite 5 (1F-04).
- 7 Shallow sandy stream in Oil Palm near 5 and 3G-14, in tributary.
- 8 Small sandy stream in Oil Palm, plus a ditch with muddy water nearby.
- 9 In BEFTA plot 4D-30.
- 10 Deeper stream in Oil Palm near 8.

Kampar Regency (Fig 4)

Rama Rama:

- 11 Small stream flowing beside disturbed original forest and running into Oil Palm.
- 12 Large stream beside disturbed but good original forest, Oil Palm on opposite bank, and tributaries and swamp patches inside the original forest.
- 13 Large stream in Oil Palm with strong flow, deep in places.

Figs 5-8 show some typical habitats in the BEFTA project area. Figs 5 and 6 shows streams in Oil Palm, Figs 7 and 8 show the conditions under the Oil Palm in the BEFTA plots.

Species recorded during the BEFTA Project

First records for Riau Province are indicated with a *; first records for Sumatra with **. References to Sumatra and satellite islands below should be understood not to include islands in Riau Islands Province that are remote from the Sumatran mainland (e.g. the Lingga Islands). For each taxa the locations were recorded during the background surveys and the BEFTA plots where it was found on transect are listed. In some cases the same taxa was also (or only) found during the BEFTA surveys but off plot/transect; these cases are mentioned in the text.

ZYGOPTERA (DAMSELFLIES)

Lestidae

Three genera and four species are known from Sumatra and its satellite islands.

- 1. *Orolestes wallacei* (Kirby, 1889)*
1F-05, 3G-16, 6.

Argiolestidae

In Sumatra this family is represented by the genus *Podolestes*, with only three species recorded to date.

- 2. *Podolestes orientalis* Selys, 1862*
12.

Calopterygidae

Three genera occur and seven species are known to occur in Sumatra.

- 3. *Neurobasis chinensis* (Linnaeus, 1758)*
12.
- 4. *Vestalis amoena* Hagen in Selys, 1853
11, 12, 13.

Chlorocyphidae

Five genera are known from mainland Sumatra, when the satellite islands are included 20 species and subspecies have been recorded, but only 15 from the mainland.

- 5. *Libellago aurantiaca* Selys, 1859*

12, 13.

6. *Libellago hyalina* Selys, 1859*

This species was common at streams in Oil Palm during the background surveys and BEFTA surveys. Fig. 9 shows an immature male.

1F-04, 1F-05, 1F-06, 3G-09, 3G-14, 3G-15, 3G-16, 2, 3, 5, 7, 8, 10, 12.

Devadattidae

Only one species from this family has been recorded from Sumatra.

7. *Devadatta argyroides* (Selys, 1859)*

A species of small forest streams, usually in hilly terrain, known from Sumatra, Singapore, Peninsular Malaysia and southern Thailand.

12.

Euphaeidae

Two genera and six species have been recorded in Sumatra.

8. *Dysphaea dimidiata* (Selys, 1853)

A species of larger forest streams.

12, 13.

Platycnemididae

Seven genera are known from Sumatra, with 20 species and subspecies known when the satellite islands are included.

9. *Coeliccia octogesima* (Selys, 1863)*

This species was only found in original forest during the surveys.

11, 12.

10. *Copera marginipes* (Rambur, 1842)*

This species was common in a variety of shady habitats during the survey.

1C-10, 1C-11, 1F-05, 1F-06, 1G-07, 3G-09, 3G-15, 3G-16, 1, 2, 5, 7, 8, 10, 12,

13.

11. *Copera vittata* (Selys, 1863)

Copera vittata exists in a confusing variety of colour forms. The form found during BEFTA surveys is identical to that found in Singapore.

1C-10, 1F-04, 1F-05, 1F-06, 1G-07, 1G-08, 3G-09, 3G-15, 3G-16, 5, 7, 10, 12.

12. *Copera vittata acutimargo* (Krüger, 1898)*

This taxon, endemic to Sumatra and which has generally been treated as a subspecies of *C. vittata* for most of the last one hundred years, is distinct morphologically, and appears to exhibit variation in its markings outside of that seen in the rest of the *vittata*-complex.

10.

13. “*Elattoneura*” *aurantiaca* (Selys, 1886)*

This species is most often found at streams in low pH swamp forest. Surprisingly one male was found at a stream, that was not obviously low pH, in Oil Palm, during the surveys.

7.

14. *Prodasineura collaris* (Selys, 1860)*

A locally occurring but fairly common species.

1F-04, 1F-05, 1F-06, 1G-07, 3G-09, 3G-14, 3G-15, 3G-16, 4D-30, 7, 12.

15. *Prodasineura interrupta* (Selys, 1860)*

In Peninsular Malaysia and Singapore this is a very local species, associated with streams in lowland forest, including swamp forest. However on the island of Belitung it is a common species. There are very few records from mainland Sumatra; Förster in Laidlaw & Förster (1907) merely lists the species as from “Sumatra, Singapore” with no justification for the Sumatran record, and Lieftinck (1954) lists it from south Sumatra. The

record in Lieftinck (1954) may be based on a single male in the collections of the Naturalis Biodiversity Center, collected in southern Sumatra in 1936. Although not found during the main BEFTA surveys, it was found in the background surveys, when it was abundant at a stream in highly disturbed forest near the Libo estate, and also found at two locations in Oil Palm, suggesting that it may be a common species in Riau Province.

3, 7, 13.

16. *Prodasineura notostigma* (Selys, 1860)*

This species was only found in original forest.

12.

17. *Prodasineura verticalis* (Selys, 1860)*

A common species on larger streams in Borneo and, it appears, in Sumatra as well. However it was not found in the BEFTA plots. Fig. 10 shows a male.

3, 12, 13.

18. *Pseudocopera ciliata* (Selys, 1863)

Fig. 11 shows a pair in tandem.

1F-04, 1F-05, 1F-06, 3G-15, 3G-16, 1, 2, 5, 7, 8, 12.

Coenagrionidae

Thirteen genera are currently known from Sumatra and its satellite islands, with 48 species.

19. *Aciagrion hisopa* (Selys, 1876)*

A widespread species, but local in occurrence.

1F-04, 1F-06, 3G-16, 5.

20. *Agriocnemis femina* (Brauer, 1868)

4D-28, 1, 2, 10.

21. *Agriocnemis minima* (Selys, 1877)*

A widespread species, but seldom reported. In Borneo this species appears to be associated with low pH habitats, but that was not the case with the habitats where it was found in Riau Province.

3, 5, 8.

22. *Amphicnemis gracilis* Krüger, 1898

One female was found at each of two locations; these females appear identical to *A. gracilis*, which is known from Sumatra, Singapore and Peninsular Malaysia. However *Amphicnemis* is an extremely difficult genus and at present certain identification is not always possible even with male specimens.

4, 12.

23. *Archibasis incisura* Lieftinck, 1949**

This is the first record of this stream species from Sumatra. It is otherwise known from Borneo and Peninsular Malaysia.

3, 13.

23. *Archibasis oscillans* (Selys, 1877)*

Only a single male was found.

2.

25. *Archibasis rebecca* Kemp, 1989**

This is the first record of this species from Sumatra. It is otherwise known from a few locations in Peninsular Malaysia and Singapore and is usually associated with low gradient streams in original or old second growth forest.

11.

26. *Archibasis viola* Lieftinck, 1948*

The most common *Archibasis* species in Sundaland.

1F-04, 1F-05, 1F-06, 1G-07, 1G-08, 3G-09, 3G-14, 3G-15, 3G-16, 4D-30, 1, 3, 5, 7, 8, 10.

27. *Argiocnemis rubescens rubeola* Selys, 1877

1F-04, 1F-05, 1F-06, 1G-07, 1G-08, 3G-09, 3G-16, 4D-29,

28. *Argiocnemis* species**

A common species in peninsular Malaysia, Sarawak and Sumatra, possibly with a name buried in the synonymy of *Argiocnemis rubescens* Selys, 1877.

1F-04, 1F-05, 1F-06, 1G-07, 3G-15, 3G-16, 4D-30, 1, 2, 5, 8, 10, 12.

29. *Ceriagrion auranticum* Fraser, 1922

A wide-ranging species, occurring from southern China to Sumatra.

1F-04, 1F-06, 3G-16, 4D-30, 1, 2, 10.

30. *Ceriagrion cerinorubellum* (Brauer, 1865)

A very common and widespread species.

1F-04, 1F-05, 1F-06, 1G-07, 1G-08, 1G-09, 3G-14, 3G-15, 3G-16, 4D-28, 4D-29, 4D-30, 1, 3, 5, 7, 9, 10, 12.

31. *Ischnura senegalensis* (Rambur, 1842)

Even more widespread than the last species.

2.

32. *Mortonagrion aborense* (Laidlaw, 1914)*

The discovery that specimens treated as *M. aborense* have two distinct forms of genital ligula and are therefore likely to be separate species was already reported and discussed in Dow (2016). Both taxa are present at the sites in the BEFTA area, but that typically regarded as *M. aborense* appears to be more common; it was found at four sites, versus one site for the other taxa. The two taxa are listed separately here.

2, 3, 10, 12.

33. *Mortonagrion* species cf *aborense* (Laidlaw, 1914)**

5.

34. *Pseudagrion australasiae* (Selys, 1876)

A widespread species.

1F-06, 2, 5.

35. *Pseudagrion microcephalum* (Rambur, 1842)*

A very common and widespread species.

2, 3, 8, 10, 12, 13.

36. *Pseudagrion pruinatum* (Burmeister, 1839)*

Also recorded off plot near 3G-15 during the BEFTA surveys. Fig. 12 shows a pair in tandem.

2, 3, 7, 8, 10, 12.

37. *Pseudagrion rubriceps* (Selys, 1876)*

1F-06, 2, 10, 13, 12.

38. *Pseudagrion williamsoni* Fraser, 1922**

This is the first record of this species from mainland Sumatra. *Pseudagrion coomansi* Lieftinck, 1937, which is sometimes considered to be a junior synonym of *P. williamsoni*, has been recorded from Belitung.

2, 3, 5.

ANISOPTERA (DRAGONFLIES)

Aeshnidae

Currently there are records of eight genera and 27 species from the Aeshnidae from Sumatra and its satellite islands.

39. *Gynacantha basiguttata* Selys, 1882*

A widespread species.

1, 7.

40. *Gynacantha dohrni* Krüger, 1899*

The most frequently recorded *Gynacantha* species in Peninsular Malaysia, Singapore, Sumatra and Borneo. It was frequently found amongst Oil Palm during the BEFTA surveys.

All BEFTA plots, 1, 2, 3, 5, 7, 9, 10.

41. *Gynacantha subinterrupta* Rambur, 1842*

A widespread but local species.

3G-16, 1.

Gomphidae

At least 12 genera (more depending on the view taken on some genera in the Onychogomphinae) and at least 31 species and subspecies have been recorded from Sumatra and its satellite islands.

42. *Ictinogomphus decoratus melaenops* (Selys, 1854)

A very common species of disturbed habitats. Seen at locations **12, 13** in addition to the locations listed below.

1F-06, 2C-17, 3G-15, 4D-30, 2, 5, 10.

43. *Macrogomphus decemlineatus* (Selys, 1878)*

A widespread but seldom recorded species. One male was found at a stream in Oil Palm.

10.

Macromiidae

Nine species from two genera have been recorded from Sumatra.

44. *Epophthalmia vittigera* (Rambur, 1842)*

Found during BEFTA surveys, off plot near 3G-15.

45. *Macromia dione* Lieftinck, 1971*

A single, freshly emerged male was found at a stream in Oil Palm. Until now this species, endemic to Sumatra, had been known only from the holotype. It may be regarded as surprising that the second record of the species was made in Oil Palm and its teneral condition and the fact that the site was remote from original forest, make it likely that it had emerged from the stream where it was found.

7.

Libellulidae

Thirty eight genera and 85 species and subspecies have been recorded from Sumatra and its satellite islands.

46. *Acisoma panorpoides* Rambur, 1842

A locally common species usually associated with ponds and marshes. Also recorded along streams in Libo Estate during the BEFTA surveys.

2, 5, 10.

47. *Agrionoptera insignis* (Rambur, 1842)*

A widely distributed species, typically occurring in swampy forest habitats.

All BEFTA plots, 1, 5, 7, 9.

48. *Agrionoptera sexlineata* Selys, 1879*

More local than the last species.

1G-07, 2C-18, 9.

49. *Brachydiplax chalybea* Brauer, 1868

A common and widespread species. Fig. 13 shows a male.

- 1C-10, 1F-04, 1F-06, 2C-17, 2C-19, 3G-15, 3G-16, 4D-28, 5, 8, 10.**
50. *Brachygonia oculata* (Brauer, 1878)
1F-04, 1F-05, 1F-06, 3G-09, 3G-14, 3G-16, 4D-28, 4D-29, 4D-30, 5, 12.
51. *Cratilla lineata* (Brauer, 1878)*
1F-04, 1F-05, 1F-06, 3G-09, 3G-14, 3G-15, 3G-16,
52. *Cratilla metallica* (Brauer, 1878)*
 A widespread forest species, it normally breeds in forest pools.
1C-11, 7.
53. *Diplacodes trivialis* (Rambur, 1842)*
 Seen at Rama Rama.
54. *Hydrobasileus croceus* (Brauer, 1867)*
 A species that typically flies over deep water, rarely perching.
5.
55. *Lathrecista asiatica* (Fabricius, 1798)*
 This species is often common in Oil Palm; this was the case during the BEFTA surveys.
 Fig. 14 shows a male.
All BEFTA plots, 1, 2, 7, 9, 10, 12.
56. *Nannophya pygmaea* Rambur, 1842
1F-04, 1F-06, 1G-07, 3G-09, 3G-15, 3G-16, 3, 5, 10, 12.
57. *Nesoxenia lineata* (Selys, 1879)*
3G-16.
58. *Neurothemis fluctuans* (Fabricius, 1793)
Every BEFTA plot, 1, 2, 3, 4, 10.
59. *Onychothemis culminicola* Förster, 1904*
 A stream specialist species, normally requiring at least some forest to be present on the banks. Also recorded near BEFTA plot **2C-18** during the BEFTA surveys.
12.
60. *Orchithemis pulcherrima* Brauer, 1878*
 Most often found in swamp forest or swampy areas within other forest formations.
1F-05, 1G-08, 4D-28, 4D-29, 3, 12.
61. *Orthetrum chrysis* (Selys, 1891)*
1C-10, 1C-11, 1C-12, 1F-04, 1F-05, 1F-06, 1G-07, 1G-08, 2C-17, 2C-18, 2C-19, 3G-09, 3G-15, 3G-16, 4D-28, 4D-29, 4D-30, 1, 2, 3, 5, 8, 10.
62. *Orthetrum glaucum* (Brauer, 1865)*
 Fig. 15 shows a male.
1C-10, 1C-12, 1G-07, 1G-08, 2C-17, 2C-18, 2C-19, 3G-09, 4D-30, 10, 12.
63. *Orthetrum sabina* (Drury, 1773)
All BEFTA plots, 2.
64. *Orthetrum testaceum* (Burmeister, 1839)
2.
65. *Potamarcha congener* (Rambur, 1842)*
 A wide ranging species, common in parts of its range.
1C-10, 1F-06, 3G-09, 4D-30, 8.
66. *Rhodothemis rufa* (Rambur, 1842)*
1F-06, 2C-19, 4D-30, 5.
67. *Rhyothemis obsolescens* Kirby, 1889
1C-12, 1F-04, 1F-06, 1G-07, 3G-09, 3G-16, 5, 8.
68. *Rhyothemis phyllis* (Sulzer, 1776)

Fig. 16 shows individuals in flight in Oil Palm.

1C-10, 1C-12, 1F-04, 1F-05, 1G-07, 1G-08, 2C-17, 2C-18, 2C-19, 3G-14, 3G-15, 4D-28, 4D-29, 4D-30, 3, 8.

69. *Rhyothemis triangularis* Kirby, 1889*

Also recorded near **3G-15** during the BEFTA surveys.

5.

70. *Tholymis tillarga* (Fabricius, 1798)

Also recorded off transect in the understory of mature Oil Palm during the BEFTA surveys.

2, 3.

71. *Trithemis aurora* (Burmeister, 1839)*

1C-11, 1C-12, 1F-04, 1F-05, 1F-06, 1G-07, 1G-08, 2C-18, 2C-19, 3G-09, 3G-15, 4D-30, 2, 10.

72. *Trithemis festiva* Rambur, 1842)

2, 8, 10, 12.

73. *Tyriobapta torrida* Kirby, 1889*

7, 12.

74. *Urothemis signata insignata* (Selys, 1872)*

1F-06, 3G-15, 5, 13.

75. *Zyxomma petiolatum* Rambur, 1842

1F-06, 2C-18, 2, 7, 12, 13.

Discussion and Conclusions

Seventy five species and subspecies of Odonata have been recorded during the BEFTA Project. We are not aware of published records of five of these (*Archibasis incisura*, *Archibasis rebecca*, *Argiocnemis* species, *Mortonagrion* species cf *aborensis* and *Pseudagrion williamsoni*) from Sumatra until now. However it is possible that specimens of *Mortonagrion* species cf *aborensis* have been collected previously and identified as *M. aborensis*. In the case of the unnamed *Argiocnemis* species it is almost certain that examples of this species will be found misidentified as *A. rubescens* in other collections from Sumatra. Altogether 88 species and subspecies are now known from Riau Province; 51 of which were first recorded during the BEFTA Project.

The fact that only 37 species of Odonata (listed in the appendix) had been recorded from Riau Province prior to the start of the BEFTA Project, as far as we are aware, makes any comparison with the fauna of the area prior to the extensive areas of Oil Palm plantation that now dominate the landscape impossible. However 75 species is a fairly large total for surveys concentrated mainly in plantation areas, suggesting that a relatively high diversity of Odonata can still be found within these areas. Sixty nine species were found in habitats actually within Oil Palm and, although the majority of the species recorded are typical of either open habitats or highly disturbed forest habitats (and so would be expected to find suitable habitats within Oil Palm), a small number of species generally regarded as more specialised were found. It is highly probable that the presence of these species is due, at least in part, to the practice of allowing the undergrowth to grow in the plantations. Six species (*Devadatta argyroides*, *Podolestes orientalis*, *Neurobasis chinensis*, *Coelliccia octogesima*, *Prodasineura notostigma* and *Amphicnemis gracilis*) were only found in original forest during the survey. Of these five were only found at Rama Rama, where both

the quality and extent of the original forest visited were greater than at the sites in Siak Regency.

The discovery of a freshly emerged male of *Macromia dione*, a species previously only known from the holotype male from North Sumatra (Lieftinck 1971), at a stream in Oil Palm is probably the most surprising finding reported here. Such poorly known species are often confined to original forest habitats or some highly specialised habitat. However since the location where the teneral male was found is remote from original forest it appears likely that it emerged at or near to the spot where it was found, in Oil Palm. Further investigation is needed, but this may be a highly disturbance tolerant species, whose apparent rarity is more due to its habits and the fact that insufficient sampling of Odonata has taken place in Sumatra than to anything else.

Table 1, summarises the numbers of families and of species collected at each of the 13 locations listed here. Of the species recorded during the surveys, 36 are forest species.

Deleted: Tabl

Location	Number of species	Number of families
1	13	4
2	12	6
3	18	5
4	2	2
5	24	6
6	1	1
7	18	6
8	13	4
9	5	3
10	24	6
11	3	3
12	31	9
13	13	7

Table 1: Numbers of families and species found at each of the areas surveyed.

Locations 3, 5, 7, 10 and 12 stand out as relatively rich in species, with more than 15 species recorded at each. Of the three sites with more than 20 species recorded, two (5 and 10) are in Oil Palm; of these location 5 is a mosaic of standing water habitats and location 10 is a stream. However the most diverse site was the original forest site 12 where 31 species were recorded in just a few hours in sub-optimal conditions (the weather was overcast during much of the time spent at this site; many odonates, even forest dwelling species, are only active in sunny conditions). Family level diversity was also higher at location 12 with nine families recorded, three more than any other site. Although more extensive sampling is needed to build up a more comprehensive inventory of the Odonata present in the area, the example of location 12 shows the value of even relatively small areas of original forest in preserving the biodiversity of plantation areas.

Given the results achieved within the area with a relatively small amount of sampling confined to relatively few locations, it would be extremely interesting to make longer

surveys covering a wider area of the GAR plantations in Riau Province. Further surveying is likely to reveal a number more species in the area, both within Oil Palm and within patches of original forest, and help to identify which of the species usually thought of as less adaptable can actually live in Oil Palm.

Acknowledgements

We would also like to thank all other staff of SMARTRI who assisted in the surveys. We thank PT Ivo Mas Tunggal, PT Ramajaya Pramukti and Golden Agri Resources for allowing us to conduct research on their Oil Palm plantations, as well as The Isaac Newton Trust, Cambridge, and Sinar Mas Agro Resources and Technology Research Institute (SMARTRI) for funding the BEFTA Project and providing the resources necessary to conduct all fieldwork. We thank RISTEK for research permission for ECT to conduct research in Indonesia (number 426/SIP/FRP/SM/XI/2012, 72/EXT/SIP/FRP/SM/IX/2013, 44/EXT/SIP/FRP/SM/IX/2014).

References

Dow, R.A., 2016. Odonata collected at the Samunsam Wildlife Sanctuary, Kuching Division, Sarawak, Malaysia in August 2015. *Faunistic Studies in South–East Asian and Pacific Island Odonata* 14: 1–12.

Dow, R.A., C.Y. Choong & Y.F. Ng, 2010. A review of the genus *Amphicnemis* in Peninsular Malaysia and Singapore, with descriptions of two new species (Odonata: Zygoptera: Coenagrionidae). *Zootaxa* 2605: 45–55.

Foster W.A, J.L. Snaddon, A. Dwi Advento, Anak Agung Ketut Aryawan, H. Barclay, J-P. Caliman, C. Kurniawan, D.J. Kurz, D. Mann, Mohd Naim, D. Purnomo, Pujiyanto, T. Dzulfikar S. Rambe, E.M. Slade, Soeprapto, Suhardi, Ps. Sudharto, Ribka Sionita Tarigan, Resti Wahyuningsih, Rudi Harto Widodo and E.C. Turner EC 2014. The Biodiversity and Ecosystem Function in Tropical Agriculture (BEFTA) Project. *The Planter, Kuala Lumpur* 90: 581–591.

Hämäläinen, M., R.A. Dow & F.R. Stokvis, 2015. Revision of the Sundaland species of the genus *Dysphaea* Selys, 1853 using molecular and morphological methods, with notes on allied species (Odonata: Euphaeidae). *Zootaxa* 3949(4): 451–490.
<http://dx.doi.org/10.11646/zootaxa.3949.4.1>

Laidlaw, F.F. and F. Förster, 1907. Report on the dragon flies. II. The Legions *Platycnemis* and *Protoneura*. *Fasciculi Malayenses (Zoology)* 4: 1–15.

Lieftinck, M.A., 1935. A Synopsis of the Odonata (Dragonflies) of Sumatra. *Miscellanea Zoologica Sumatrana* 92–93: 1–23.

Lieftinck, M.A., 1940a. Revisional notes on some species of *Copera* Kirby. With notes on habits and larvae (Odon., *Platycnemidae*). *Treubia* 17: 281–306.

Lieftinck, M.A., 1940b. Descriptions and records of South–east Asiatic Odonata (II). *Treubia* 17: 337–390.

Lieftinck, M.A., 1951. The Identity of some Malaysian Species of *Ceriagrion*, with Descriptions of Two New Species (Odon.). *Treubia* 21(1): 183–197.

Lieftinck, M.A., 1953. Additions to the odonate fauna of the Indo–Australian archipelago. *Treubia* 22(1): 233–269.

Lieftinck, M.A., 1965. The species–group of *Vestalis amoena* Selys, 1853, in Sundaland (Odonata, Calopteryiidae). *Tijdschrift voor Entomologie* 108(11): 325–364.

Lieftinck, M.A., 1971. Studies in Oriental Corduliidae (Odonata) I. *Tijdschrift voor Entomologie* 114 (1): 1–63.

Ris, F., 1913. Libellulinen 7. Collections Zoologiques du Baron Edm. De Selys Longchamps. Catalogue Systématique et Descriptif 15: 837–964, plate VII.

Ris, F., 1919. Libellulinen 9. Collections Zoologiques du Baron Edm. De Selys Longchamps. Catalogue Systématique et Descriptif 16: 1043–1278.

Ris, F., 1927. Odonaten von Sumatra, gesammelt von Edward Jacobson. *Zool. Mededeelingen 's Rijks Museum van Nat Hist. Leiden*, 10: 1–49.

Seehausen, M. & R.A. Dow, 2016. Morphological studies and taxonomic considerations on the ‘reddish-brown-winged’ group of *Neurothemis* Brauer, 1867 with the description of *N. taiwanensis* sp. nov. (Odonata: Libellulidae). *International Dragonfly Fund Report* 93: 1–101.

Tsuda, S. and K. Kitagawa, 1988. Odonata of southeast Asia collected by the late Mr. M. Iwasaki. Part 2. Odonata of North Sumatra, Indonesia. *Gracile* 39: 1–5.

Appendix

This section lists the Odonata recorded from Riau Province prior to the BEFTA project, based on the sources listed in Section 1.

Zygoptera

Lestidae

Lestes praemorsus decipiens Kirby, 1894

Argiolestidae

Podolestes buwaldai Lieftinck, 1940

Calopterygidae

Vestalis amoena Hagen in Selys, 1853

Euphaeidae

Dysphaea dimidiata (Selys, 1853)

Platycnemididae

Copera vittata vittata (Selys, 1863)

Pseudocopera ciliata (Selys, 1863)

Coenagrionidae

Agriocnemis femina (Brauer, 1868)

Agriocnemis pygmaea (Rambur, 1842)

Amphicnemis gracilis Krüger, 1898

Agriocnemis rubescens rubeola Selys, 1877

Ceriagrion auranticum Fraser, 1922

Ceriagrion cerinorubellum (Brauer, 1865)

Ischnura senegalensis (Rambur, 1842)

Pseudagrion australiasiae (Selys, 1876)

Anisoptera

Aeshnidae

Anaciaeschna jaspidea (Burmeister, 1839)

Heliaeschna simplicia (Karsch, 1891)

Heliaeschna univervulata Martin, 1909

Gomphidae

Ictinogomphus decoratus melaenops (Selys, 1854)

Libellulidae

Acisoma panorpoides Rambur, 1842

Brachydiplax chalybea Brauer, 1868

Brachygonia oculata (Brauer, 1878)

Crocothemis servilia (Drury, 1773)

Diplacodes nebulosa (Fabricius, 1793)

Nannophya pygmaea Rambur, 1842

Neurothemis fluctuans (Fabricius, 1793)

Orthetrum sabina (Drury, 1773)

Orthetrum testaceum (Burmeister, 1839)

Pantala flavescens (Fabricius, 1798)

Rhyothemis aterrima Selys, 1891

Rhyothemis fulgens Kirby, 1889

Rhyothemis obsolescens Kirby, 1889

Rhyothemis phyllis (Sulzer, 1776)

Risiphlebia dohrni (Krüger, 1902)

Tholymis tillarga (Fabricius, 1798)

Trithemis festiva (Rambur, 1842)

Tyriobapta kuekenthali (Karsch, 1900)

Zyxomma petiolatum Rambur, 1842

Figure Captions

Figure 1: Positions of the estates where sampling of Odonata took place.

Figure 3: BEFTA plots.

Figure 3: Sites in Siak Regency.

Figure 4: Sites in Kampar Regency.

Figure 5: A stream in Oil Palm.

Figure 6: A stream in Oil Palm.

Figure 7: Conditions under Oil Palm in a BEFTA block with normal treatment.

Figure 8: Conditions under Oil Palm in a BEFTA block with enhanced treatment.

Figure 9: *Libellago hyalina*, immature male.

Figure 10: *Prodasineura verticalis* male.

Figure 11: *Pseudocopera ciliata* pair in tandem.

Figure 12: *Pseudagrion pruinosum* pair in tandem.

Figure 13: *Brachydiplax chalybea* male.

Figure 14: *Lathrecista asiatica* male.

Figure 15: *Orthetrum glaucum* male.

Figure 16: *Rhyothemis phyllis* in flight.