

The distribution, phenology and altitudinal range of dragonflies and damselflies in Bhutan

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Abstract

Dragonflies and damselflies are attractive and relatively well studied insects that can serve to monitor the conservation status of freshwater habitats. Their effective use as conservation tools necessitates some basic requirements. It should be possible to identify adults and preferably also larvae with relative ease, and basic data on distribution and habitat preferences needs to be available. Freshwater habitats in Bhutan are relatively well preserved but are nonetheless threatened by both climate change and the construction of hydroelectric installations. Biological monitoring of freshwater biodiversity in Bhutan is therefore urgently needed and should include data on dragonflies and damselflies. In order to establish a framework for effective monitoring we constructed a database of all published records and use these to present information on the distribution, the altitudinal range and phenology of all species thus far recorded from Bhutan.

Key words: freshwater; conservation; Himalayan region; biogeography.

Introduction

Compared with the Himalayan regions of India and Nepal the freshwater habitats of Bhutan are relatively well preserved. This is the result of the relatively low population density of Bhutan combined with the attention for environment in Bhutan's constitution which for instance stipulates that at any time at least 60 percent of the country should be under forest cover. But this does not mean that freshwater habitats are completely unthreatened. The construction of roads and hydro-electric installations is impacting the larger rivers and on a more local scale the smaller tributaries of these rivers (Allen et al. 2010). The worst threat in the long run is likely to be climate change which already resulted in glaciers retracting and snow cover declining at higher altitudes and more intensive monsoon rains at lower altitudes. At present it is still difficult to predict how this will impact freshwater ecosystems and biodiversity (Wangmo & Rai 2017). In order to understand the changes in freshwater biodiversity a monitoring scheme is highly desirable. However,

monitoring all freshwater invertebrates is time consuming and expensive. Also, many freshwater invertebrates occurring in the Himalayan region are still undescribed meaning that they cannot be identified to species level. A relative cheap and time efficient alternative would be using standardised counts of adult dragonflies. This could be done by combining the efforts of professionals and volunteers and could be carried out equally in cities, agricultural areas and nature reserves. In order for dragonflies and damselflies to be used to measure change in freshwater biodiversity two criteria have to be met: (1) there must be field guides allowing the identification of species, (2) a basic scheme for the interpretation of the results needs to be available. For Bhutan a field guide to the common species of dragonflies and damselflies was recently published (Gyeltshen et al. 2017c). This guide is however still insufficient to identify all species but work is underway for a more detailed field guide to be published in the next few years.

The second criteria can be addressed by making use of existing monitoring methodologies such as the Dragonfly Biotic Index (DBI) (Samways & Simaika, 2016) or the Dragonfly Association Index (Chovanec et al. 2014). The former puts more emphasis on the distribution of species and their global threat status while the latter uses the composition of the Odonata fauna to measure habitat intactness. While the latter is probably better for a management point of view the former is easier to apply in areas where the exact indicator value of species is partly or even largely unknown. In order to work towards a better overview of the indicating value of odonates occurring in Bhutan this paper provides basic information on the distribution, the elevational preference and the phenology of all Bhutanese species. It is hoped that this data will contribute to development of a freshwater monitoring scheme on the basis of dragonflies and damselflies for the eastern Himalayan region.

Material and methods

The data on distribution, altitudinal range and phenology presented in this paper is compiled from all published records of dragonflies and damselflies from Bhutan. This includes a total of 22 papers: Brockhaus & Hartmann 2009; Conniff & Sasamoto 2019; Dorji, 2014 2015; Dorji & Nidup 2020; Fraser 1936; Gurung et al. 2021; Gyeltshen 2017, 2020; Gyeltshen & Kalkman 2017; Gyeltshen et al. 2017a, b; Kalkman & Gyeltshen 2016; Lieftinck 1977; Mitra 2002, 2006, 2008, 2013; Mitra & Thinley 2006; Mitra et al. 2012, 2014 and Nidup et al. 2020. All records from these publications were compiled into a database. When not stated in the publication the coordinates were determined using Google Earth. For some of the older records the level of detail given on the locality is poor and in these cases the coordinate was determined as best as possible. In the database constructed by us we have noted the species name as given in the original reference and included a separate field with our own interpretation partly based on re-identifications or nomenclatural changes. The taxonomy used is that of Kalkman et al. (2020). The database has two fields for the date, with the second one only used to indicate a period of observation, for example when the original paper only indicates 'site visited from 15 June to 2 August'.

We used the database to summarise information creating maps showing the distribution and making a checklist indicating the altitudinal range and phenology. For the maps all records were used for which coordinates were available and for which we were certain of the identification. The maps of species were made using the outline of country Bhutan in

QGIS Desktop 3.16.2. For the altitudinal range we simply used the lowest observation and the highest observation of either an adult or a larva. The phenology is based on the records of adults only with only records which could be attributed to a single month being used.

A record of *Orthetrum internum* by Mitra et al. (2012) is from 247 m elevation, far lower than any of the other records of this species from Bhutan and the elevation is therefore indicated with a question mark in Table 1.

Results

The database is based on slightly over 1200 records (presence of a species on a given day at a locality) of a total 123 species (on average about eight records per species). Almost 98% percent of these records have a coordinate, over 90% percent have a date referring to a single month and 92% percent have information on the elevation.

Figure 1 shows all the localities where records were collected and figure 2 (see appendix) shows the distribution map for each species. Table 1 contains a checklist of the species known from Bhutan with information on the months in which adults were observed and the altitudinal range in which species were observed (the later based on adults & larva). For the altitudinal range the lowest and highest record was used and it was assumed that the species was also present in the areas in between.

Figure 3 shows the number of species observed for each altitudinal section of 500 m. Figure 4 shows the number of species observed as adult for each of the twelve months of the year.

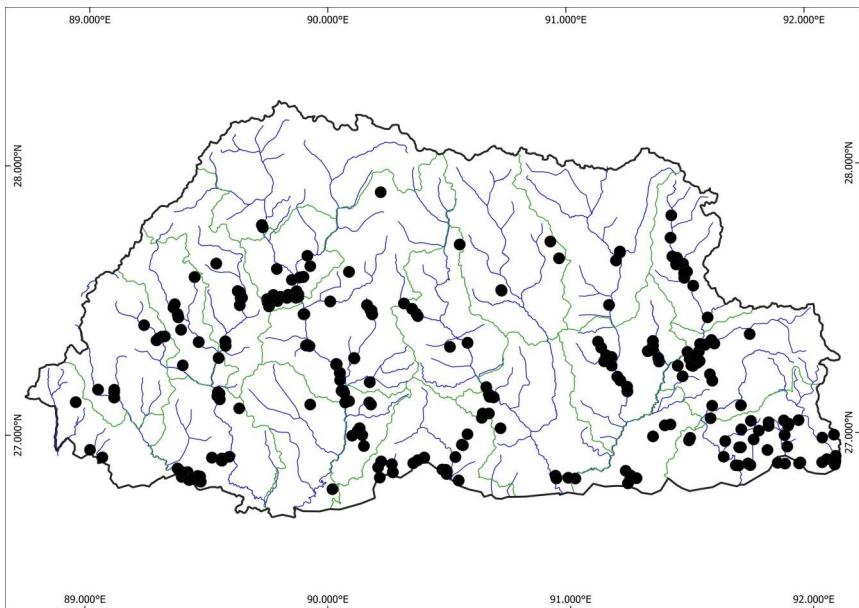


Figure 1. Distribution of records of dragonflies and damselflies in Bhutan.

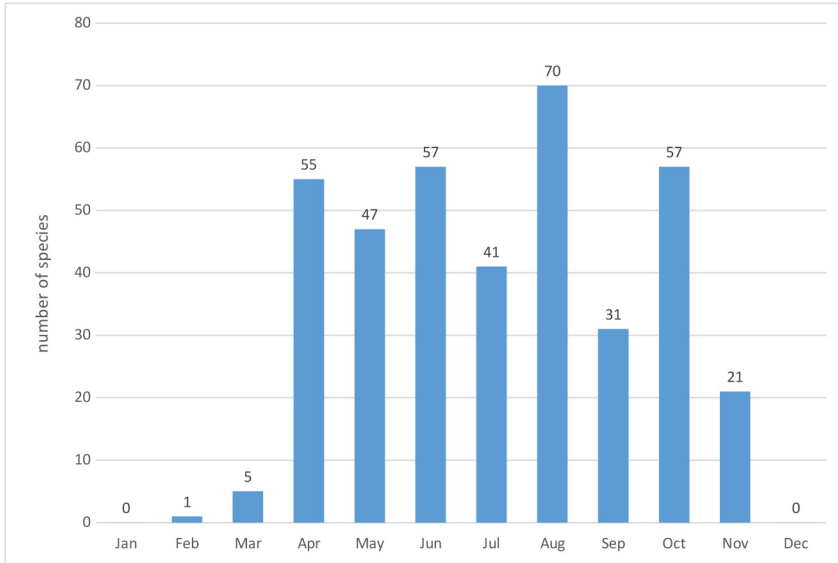


Figure 3. The number of species observed as adults during each of the twelve months of the year.

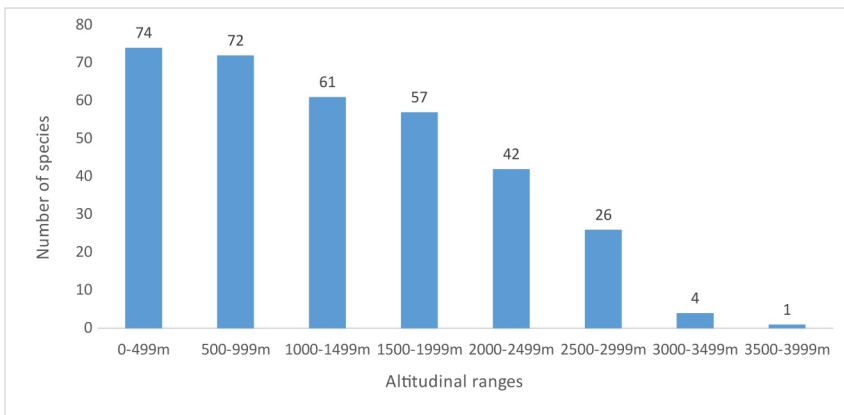


Figure 4. The number of species observed either as adult or larva for different altitudinal ranges.

Table 1. Checklist of the dragonflies and damselflies in Bhutan. For each species the altitudinal range and the presence of adults in each month is given. (1) The upper limit of occurrence of *C. servilla* is unclear as it is likely that many of the reports of this species from higher altitudes in fact pertain to *C. erythraea*.

Bhutan Odonata distribution, phenology altitudes

| | | Alt (low) | Alt (high) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|--------------------------------------|-------------------------------------|--------------|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Order Odonata | Fabricius, 1793 | | | | | | | | | | | | | | |
| Suborder Zygoptera | Selys, 1854 | | | | | | | | | | | | | | |
| Superfamily Lestoidea | Calvert, 1901 | | | | | | | | | | | | | | |
| Family: Synlestidae | Tillyard, 1917 | | | | | | | | | | | | | | |
| <i>Megalestes gyalsey</i> | Gyellshen, Kalkman & Orr 2017 | 2450 | 2450 | | | | | | | | | | x | | |
| <i>Megalestes major</i> | Selys, 1862 | 741 | 2562 | | | | | | x | | x | x | x | x | |
| <i>Megalestes micans</i> | Needham, 1930 | 1165 | 1827 | | | | | x | | | | | x | | |
| Family: Lestidae | Calvert, 1907 | | | | | | | | | | | | | | |
| <i>Indolestes cyaneus</i> | (Selys, 1862) | 950 | 3274 | | | | x | x | x | x | x | | x | x | |
| <i>Lestes dorothea</i> | Fraser, 1924 | 1927 | 1927 | | | | | | x | | | | x | | |
| <i>Lestes concinnus</i> | Hagen in Selys, 1862 | 253 | 253 | | | | | x | | | | | | | |
| <i>Lestes praemorsus decipiens</i> | Kirby, 1893 | 270 | 2195 | | | | x | x | x | | x | | | | |
| Superfamily: Platystictioidea | Kennedy, 1920 | | | | | | | | | | | | | | |
| Family: Platystictidae | Kennedy, 1920 | | | | | | | | | | | | | | |
| <i>Drepanosticta carmichaeli</i> | (Laidlaw, 1915) | 337 | 508 | | | | | x | x | | | | | | |
| <i>Protosticta himalaica</i> | Laidlaw, 1917 | 255 | 1844 | | | | | | | | | | | | |
| Superfamily Calopterygoidea | Selys, 1850 | | | | | | | | | | | | | | |
| Family: Calopterygidae | Selys, 1850 | | | | | | | | | | | | | | |
| <i>Caliphaea confusa</i> | Hagen in Selys, 1859 | 1150 | 1965 | | | | x | x | x | | x | x | | | |
| <i>Neurobasis chinensis</i> | (Linnaeus, 1758) | 149 | 1233 | | | | x | x | x | x | x | x | x | | |
| <i>Vestalisa gracilis</i> | (Rambur, 1842) | 265 | 360 | | | | x | x | | | x | | | | |
| Family: Chlorocyphidae | Cowley, 1937 | | | | | | | | | | | | | | |
| <i>Aristocypha cuneata</i> | (Selys, 1853) | 125 | 1493 | | | | x | x | x | | x | | x | | |
| <i>Aristocypha quadrimaculata</i> | Selys, 1853 | 125 | 1071 | | | | x | x | | | x | | x | | |
| <i>Libellago lineata</i> | (Burmeister, 1839) | 405 | 405 | | | | | | | | | | | x | |
| <i>Parocypha unimaculata</i> | (Selys, 1853) | 125 | 1870 | | | | x | x | x | x | | | | | |
| Family: Euphaeidae | Yakobson & Bainchi, 1905 | | | | | | | | | | | | | | |
| <i>Anisopleura comes</i> | Hagen, 1880 | 508 | 2380 | | | | x | x | x | | x | x | x | | |
| <i>Anisopleura lestoides</i> | Selys, 1853 | 536 | 1290 | | | | x | | x | | | | x | | |
| <i>Anisopleura subplatystyla</i> | Fraser, 1927 | 980 | 2846 | | | | | | x | x | x | | x | | |
| <i>Bayadera indica</i> | (Selys, 1853) | 325 | 1774 | | | | x | x | x | x | x | | | | |
| <i>Bayadera longicauda</i> | Fraser, 1928 | 2187 | 2187 | | | | | | x | | | | | | |
| <i>Dysphaea gloriosa</i> | Fraser, 1938 | 535 | 535 | | | | x | | | | | | | | |
| <i>Euphaea ochracea</i> | Selys, 1859 | 326 | 399 | | | | x | x | | | x | | | | |
| Family: Philogangidae | Kennedy, 1920 | | | | | | | | | | | | | | |
| <i>Philoganga montana</i> | (Hagen in Selys, 1859) | 399 | 720 | | | | x | x | | | | | | | |
| Superfamily Coenagrionidea | Kirby, 1890 | | | | | | | | | | | | | | |
| Family: Platycnemididae | Yakobson & Bainchi, 1905 | | | | | | | | | | | | | | |
| <i>Calicnemia eximia</i> | (Selys, 1863) | 247 | 2900 | | | | x | x | x | x | x | x | x | x | |

| | | Alt (low) | Alt (high) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|--|-------------------------|-----------|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <i>Calicnemia miniata</i> | (Selys, 1886) | 399 | 1614 | | | | x | x | x | | x | | | | |
| <i>Calicnemia mortoni</i> | (Laidlaw, 1917) | 240 | 2068 | | | | | x | x | x | x | | | | |
| <i>Coelliccia svihleri</i> | Asahina, 1970 | 247 | 923 | | | | x | x | | | x | | | | |
| <i>Copera vittata</i> | Selys, 1863 | 255 | 750 | | | | x | x | | | | | | | |
| Family: Coenagrionidae | Kirby, 1890 | | | | | | | | | | | | | | |
| <i>Aciagrion olympicum</i> | Laidlaw, 1919 | 980 | 2425 | | | | | x | x | x | x | | x | | |
| <i>Aciagrion pallidum</i> | Selys, 1891 | 498 | 604 | | | | | | x | | | | x | | |
| <i>Agriocnemis clauseni</i> | Fraser, 1922 | 265 | 821 | | | | | | | | x | | x | | |
| <i>Agriocnemis femina</i> | (Brauer, 1868) | 253 | 821 | | | | x | | | | x | | | | |
| <i>Agriocnemis lacteola</i> | Selys, 1877 | 345 | 345 | | | | x | | | | | | | | |
| <i>Agriocnemis pygmaea</i> | (Rambur, 1842) | 240 | 317 | | | | | | x | x | | | x | | |
| <i>Amphialagma parvum</i> | (Selys, 1877) | 253 | 2860 | | | | x | x | | | x | | | | |
| <i>Agriocnemis rubescens rubeola</i> | Selys, 1877 | 253 | 349 | | | | x | x | | | x | | x | | |
| <i>Ceriagrion azureum</i> | (Selys, 1891) | 581 | 581 | | | | | x | | | | | | | |
| <i>Ceriagrion coromandelianum</i> | (Fabricius, 1798) | 253 | 574 | | | | x | x | | | x | | x | | |
| <i>Ceriagrion fallax</i> | Ris, 1914 | 476 | 2696 | | | | x | x | x | x | x | x | x | x | |
| <i>Ceriagrion rubiae</i> | Laidlaw, 1916 | 253 | 253 | | | | | x | | | | | | | |
| <i>Coenagrion exclamationis</i> | (Fraser, 1919) | 1973 | 1973 | | | | | | | | x | | | | |
| <i>Hucosoma tinctipenne</i> | (McLachlan, 1894) | 2620 | 2633 | | | | | | | | x | x | | | |
| <i>Ischnura forcipata</i> | Morton, 1907 | 1750 | 2000 | | | | | | | x | | | x | x | |
| <i>Ischnura rubilio</i> | Selys, 1876 | 125 | 2705 | | | x | x | | x | x | x | x | x | x | |
| <i>Pseudagrion rubriceps</i> | Selys, 1876 | 125 | 1973 | | | | x | | | x | x | | x | | |
| Suborder Anisozygoptera | Hanlirsch, 1906 | | | | | | | | | | | | | | |
| Superfamily Epiophlebioidae | Muttkowshi, 1910 | | | | | | | | | | | | | | |
| Family: Epiophlebiidae | Muttkowshi, 1910 | | | | | | | | | | | | | | |
| <i>Epiophlebia laidlawi</i> | Tillyard, 1921 | 1568 | 2922 | | | | | | | | | | | | |
| Suborder Anisoptera | Selys, 1854 | | | | | | | | | | | | | | |
| Superfamily Platystictoidea | Leach, 1815 | | | | | | | | | | | | | | |
| Family: Aeshnidae | Leach, 1815 | | | | | | | | | | | | | | |
| <i>Aeshna shennong</i> | Zhang & Cai, 2014 | 2850 | 2850 | | | | | | | | x | | | | |
| <i>Aeshna petalura</i> | Martin, 1906 | 2042 | 2695 | | | | | | x | | x | | x | | |
| <i>Anaciaeschna martini</i> | (Selys, 1897) | 1775 | 1775 | | | | | | x | | | | | | |
| <i>Anaciaeschna jaspidea</i> | (Burmeister, 1839) | 296 | 296 | | | | x | | | | | | | | |
| <i>Anax ephippiger</i> | (Burmeister, 1839) | 240 | 500 | | | | | | | | x | | | | |
| <i>Anax guttatus</i> | (Burmeister, 1839) | 1435 | 1435 | | | | | | | | x | | | | |
| <i>Anax indicus</i> | Lieftinck, 1942 | 270 | 2696 | | | | x | x | x | | x | x | | x | |
| <i>Anax nigrofasciatus nigrolineatus</i> | Fraser, 1935 | 508 | 2695 | | | | x | x | x | | x | | x | | |
| <i>Cephalaeschna triadica</i> | Lieftinck, 1977 | 2195 | 2300 | | | | | | x | | | | x | | |
| <i>Gynacantha khasiaca</i> | McLachlan, 1896 | 320 | 320 | | | | | | | | | | x | | |
| <i>Gynacantha incisura</i> | Fraser, 1935 | 1290 | 1290 | | | | | | | | | | x | | |

Bhutan Odonata distribution, phenology altitudes

| | | Alt (low) | Alt (high) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|--------------------------------------|------------------------|--------------|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <i>Gynacantha subinterrupta</i> | Rambur, 1842 | 250 | 250 | | | | | | | | x | | | | |
| <i>Gynacanthaeschna sikkima</i> | (Karsch, 1891) | 1165 | 1992 | | | | | | | | | | x | | |
| <i>Periaeschna magdalena</i> | Martin, 1909 | 720 | 1507 | | | | x | | | | x | | | | |
| <i>Polycanthygyna erythromelas</i> | (McLachlan, 1896) | 632 | 1794 | | | | | x | | | x | x | | | |
| Superfamily Gomphoidea | Rambur, 1842 | | | | | | | | | | | | | | |
| Family: Gomphidae | Rambur, 1842 | | | | | | | | | | | | | | |
| <i>Anisogomphus bivittatus</i> | Selys, 1854 | 868 | 1233 | | | | | | | | | x | | | |
| <i>Anisogomphus occipitalis</i> | (Selys, 1854) | 460 | 1708 | | | | x | x | x | x | | | | | |
| <i>Asiagomphus odoneli</i> | (Fraser, 1922) | 320 | 320 | | | | | | | | x | | | | |
| <i>Davidius baronii</i> | Lieftinck, 1977 | 931 | 1900 | | | | x | x | x | | | | | | |
| <i>Davidius delineatus</i> | Fraser, 1926 | 848 | 2187 | | | | | x | x | | | | | | |
| <i>Lamelligomphus biforceps</i> | (Selys, 1878) | 900 | 950 | | | | | | | | | | x | x | |
| <i>Lamelligomphus risi</i> | (Fraser, 1922) | 320 | 545 | | | | | | | | x | | x | | |
| <i>Nychogomphus duaricus</i> | (Fraser, 1924) | 399 | 399 | | | | | x | | | | | | | |
| <i>Scalimogomphus bistrigatus</i> | (Hagen in Selys, 1854) | 460 | 1870 | | | | | | x | x | | | | | |
| <i>Paragomphus lineatus</i> | (Selys, 1850) | 317 | 360 | | | | | | x | x | | x | | | |
| <i>Perissogomphus stevensi</i> | Laidlaw, 1922 | 345 | 1917 | | | | x | x | x | x | | | | | |
| <i>Stylogomphus inglisi</i> | Fraser, 1922 | 720 | 720 | | | | x | | | | | | | | |
| Superfamily Cordulegastroidea | Hagen, 1875 | | | | | | | | | | | | | | |
| Family: Chlorogomphidae | Needham, 1903 | | | | | | | | | | | | | | |
| <i>Chlorogomphus mortoni</i> | Fraser, 1936 | 390 | 923 | | | | x | | | | | | | | |
| <i>Chlorogomphus preciosus</i> | (Fraser, 1924) | 923 | 923 | | | | x | | | | | | | | |
| Family: Cordulegasteridae | Hagen, 1875 | | | | | | | | | | | | | | |
| <i>Anotogaster nipalensis</i> | Selys, 1854 | 1234 | 2325 | | | | | x | x | x | x | x | | | |
| <i>Neallogaster hermionae</i> | (Fraser, 1927) | 2685 | 2685 | | | | | | | x | | | | | |
| <i>Neallogaster latifrons</i> | (Selys, 1878) | 2134 | 2134 | | | | | | | | | | | | |
| Family: Macromiidae | Needham, 1903 | | | | | | | | | | | | | | |
| <i>Macromia moorei</i> | Selys, 1874 | 545 | 2380 | | | | x | x | x | x | x | x | | | |
| Somatochlora | Selys, 1871 | | | | | | | | | | | | | | |
| <i>Somatochlora daviesi</i> | Lieftinck, 1977 | 2425 | 3480 | | | | | | | x | | | x | | |
| Family: Libellulidae | Leach, 1815 | | | | | | | | | | | | | | |
| <i>Acisoma panorpoides</i> | Rambur, 1842 | 349 | 2002 | | | | | x | | x | x | x | x | | |
| <i>Brachydiplax sobrina</i> | (Rambur, 1842) | 240 | 1228 | | | | | | | | x | | | | |
| <i>Brachythemis contaminata</i> | (Fabricius, 1793) | 255 | 2699 | | | | | x | x | x | | | x | | |
| <i>Bradinopyga geminata</i> | (Rambur, 1842) | 240 | 400 | | | | | | x | x | | | | | |
| <i>Camacinia gigantea</i> | (Brauer, 1867) | 581 | 581 | | | | | x | | | | | | | |
| <i>Cratilla lineata calverti</i> | Förster, 1903 | 832 | 832 | | | | x | | | | | | | | |

| | | Alt (low) | Alt (high) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|--|-----------------------------|-----------|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <i>Crocotthemis erythraea</i> | (Brullé, 1832) | 1435 | 2326 | | | | | | | | x | | x | | |
| <i>Crocotthemis servilia</i> | (Drury, 1770) | 125 | 2900 (1) | | x | x | x | x | x | x | x | x | x | x | |
| <i>Diplacodes lefebvreii</i> | (Rambur, 1842) | 226 | 226 | | | | | | | x | | | | | |
| <i>Diplacodes nebulosa</i> | (Fabricius, 1793) | 125 | 446 | | | | x | | | x | | | | | |
| <i>Diplacodes trivialis</i> | (Rambur, 1842) | 149 | 3274 | | | | x | x | x | x | x | x | x | x | |
| <i>Indothemis limbata</i> | (Selys, 1891) | 240 | 400 | | | | | | | x | | | | | |
| <i>Lyriothemis bivittata</i> | (Rambur, 1842) | 187 | 1085 | | | | x | | x | | | | | | |
| <i>Neurothemis fulvia</i> | (Drury, 1773) | 250 | 1080 | | | | x | x | | x | x | x | x | | |
| <i>Neurothemis intermedia</i> | (Rambur, 1842) | 240 | 400 | | | | | | x | x | x | | | | |
| <i>Orthetrum chrysis</i> | (Selys, 1891) | 240 | 400 | | | | | | x | x | | x | | | |
| <i>Orthetrum glaucum</i> | (Brauer, 1865) | 250 | 2699 | | | | x | | x | | x | | x | x | |
| <i>Orthetrum internum</i> | McLachlan, 1894 | 247 (?) | 3570 | | | x | x | x | x | x | | | | | |
| <i>Orthetrum luzonicum</i> | (Brauer, 1868) | 265 | 1756 | | | | x | | x | x | x | | | x | |
| <i>Orthetrum pruinosum neglectum</i> | (Rambur, 1842) | 265 | 1992 | | | | x | | x | x | x | x | x | x | |
| <i>Orthetrum sabina sabina</i> | (Drury, 1770) | 250 | 2326 | | | x | x | | | x | x | x | x | x | |
| <i>Orthetrum taeniolatum</i> | (Schneider, 1845) | 149 | 2195 | | | | | | x | x | x | | x | | |
| <i>Orthetrum triangulare triangulare</i> | (Selys, 1878) | 149 | 2326 | | | | x | x | x | x | x | x | x | x | |
| <i>Palpopleura sexmaculata</i> | (Fabricius, 1787) | 125 | 2300 | | | x | x | | x | x | x | x | x | x | |
| <i>Pantala flavescens</i> | (Fabricius, 1798) | 149 | 2845 | | | | x | x | x | x | | | x | | |
| <i>Potamarcha congener</i> | (Rambur, 1842) | 270 | 270 | | | | x | | | | | | | | |
| <i>Rhyothemis variegata</i> | (Linnaeus, 1763) | 240 | 400 | | | | | | x | | | x | | | |
| <i>Rhyothemis phyllis</i> | (Sulzer, 1776) | 320 | 320 | | | | | | | | x | | | | |
| <i>Sympetrum commixtum</i> | Selys, 1884 | 800 | 2900 | | | | | | | x | x | x | x | x | |
| <i>Sympetrum fonscolombii</i> | (Selys, 1840) | 509 | 2705 | | | | x | | | | x | | x | | |
| <i>Sympetrum hypomelas</i> | (Selys, 1884) | 1182 | 2920 | | | | | | | x | x | x | x | x | |
| <i>Sympetrum speciosum</i> | Oguma, 1915 | 1999 | 1999 | | | | | | x | | | x | | | |
| <i>Tholymis tillarga</i> | (Fabricius, 1798) | 149 | 149 | | | | | | | | | | | x | |
| <i>Tramea basilaris</i> | (Palisot de Beauvois, 1805) | 240 | 1352 | | | | | | x | | x | | x | x | |
| <i>Tramea limbata</i> | (Desjardins, 1832) | 1999 | 1999 | | | | | | x | | | x | | | |
| <i>Tramea virginia</i> | (Rambur, 1842) | 240 | 1435 | | | | | | | x | x | | | x | |
| <i>Trithemis aurora</i> | (Burmeister, 1839) | 149 | 2699 | | | | | x | x | x | x | x | x | x | |
| <i>Trithemis festiva</i> | (Rambur, 1842) | 149 | 1922 | | | | x | | x | x | x | x | x | | |
| <i>Trithemis pallidineris</i> | (Kirby, 1889) | 125 | 446 | | | | x | | | x | x | | | | |
| <i>Urothemis signata</i> | (Rambur, 1842) | 2326 | 2326 | | | | | | | x | x | | | | |
| <i>Zygonyx iris</i> | Selys, 1869 | 915 | 915 | | | | | x | | | | | | | |
| Genera incertae sedis | | | | | | | | | | | | | | | |
| <i>Idionyx stevensi</i> | Fraser, 1924 | 460 | 460 | | | | | | x | | | | | | |

Discussion

The available records of dragonflies and damselflies from Bhutan are not evenly distributed (Figure 1). The virtual absence of records from the north corresponds with the high altitude of this region and is due to a combination of inaccessibility and genuine absence of species above 4000 m elevation. The absence of records from parts of the southern two-thirds of the country indicates a lack of exploration and, as can be seen from Figure 1, many areas have not been explored at all. Some of these are difficult to access mountain areas where roads and villages are scarce making exploration difficult. Despite of the limited number of records available, the distribution maps are already a great help in understanding diversity patterns in this part of the Himalayan region. Examples for this are the maps of *Megalestes gyalsey*, *M. micans* and *M. major* which clearly show that the latter is by far the most common and widespread species of this genus. Good examples of the visualisation of the altitudinal range are the maps of *Aristocypha quadrimaculata* (low elevation; 125-1071 m), *Caliphaea confusa* (mid elevation; 1150-1965 m) and *Somatochlora daviesi* (upper elevation; 2425-3480 m). The clearest general distributional pattern is the difference between the southern lowland which is dominated by Oriental species with Palearctic species becoming more dominant in the north, above 1000 m. Figure 3 clearly shows that the diversity is highest below 1000 m, that there is a gradually decline in number of species between 1000 and 2000 m and that the number of species start to drop rapidly above 2000 m. Only four species have been recorded above 3000 m: *Indolestes cyaneus* which was found reproducing at 3274 m at Rukubji along the Wangdue Phodrang to Trongsa road, *Somatochlora daviesi*, *Diplacodes trivialis* and *Orthetrum internum*. Of these *Orthetrum internum* and especially *Somatochlora daviesi* seem to be restricted to high altitude. *Diplacodes trivialis* is a very wide-ranging species which is highly abundant in the lowland of the Indian Peninsula but also reproduces at higher altitudes in the main valleys of Bhutan. There are several records above 2500 m including one of at least 10 individuals at 2695 m which seems to indicate that the species can reproduce at higher elevations although it might not be able to survive the winter. Further field work will undoubtedly show more species to be present above 3000 m and probably also some will be found above 4000 m. However, the number of new species to be found at lower altitudes is expected to be far greater and their discovery would result in an even stronger difference in diversity between low and high altitudes.

In addition to the clear south-north patterns related to elevation the maps also show some east-west patterns with some species such as *Coelliccia svihleri* seemingly being restricted to the east. More data is needed to determine if these patterns are real or merely a sampling artefact. If real, then it needs to be determined if these patterns can be explained by climatic conditions or if some of the deeper river valleys form barriers to the distribution of species.

Data on the phenology of dragonflies and damselflies in the Indian Peninsula is scattered and no overviews are currently available. Despite the relatively small number of records available the data from Bhutan gives a good indication of the flight period of most species. Figure 4 gives an indication of the number of species on the wing during each month. This graph is influenced by the period of year in which field work was conducted and probably underestimates the number of species on the wing during the winter. A small number of species is found throughout the year. All of these are species breeding at standing waters

and mainly occur at lower altitude. There are however some species such as *Indolestes cyaneus*, *Ischnura rubilio*, *Diplacodes trivialis* and *Orthetrum sabina* which probably also occur throughout the winter at slightly higher altitudes from 1500-2000 m in the valleys where the main towns (Paro and Thimphu) of Bhutan are located. Species from running water have not been found as adults during the winter (December-February) period. Nonetheless a surprising number of them have a long flight period stretching from early spring (March-April) to late autumn (October-November); these include *Neurobasis chinensis*, *Aristocypha cuneata*, *A. quadrimaculata*, *Anisopleura comes*, *Calicnemia eximia* and *Macromia moorei*. The most interesting are those which have a restricted flight period as these species can easily be missed when a site is visited at the wrong time of the year. The following species seem to have a flight period that is largely restricted to spring and early summer (pre monsoon): *Paracypha unimaculata*, *Bayadera indica*, *Calicnemia miniata*, *C. mortoni*, *Anisogomphus occipitalis*, *Davidius* sp., *Perissogomphus stevensi* and *Orthetrum internum*. Species for which the available records suggest a flight period largely restricted to late summer and autumn (post monsoon) include: *Megalestes major*, *Cephalaeschna* sp., *Gynacanthaeschna sikkima*, *Gynacantha* sp., *Lamelligomphus* sp., *Sympetrum comixtum*, *S. hypomelas*. Projects estimating the abundance of dragonflies and damselflies of certain habitats throughout the year will enable the flight periods of species to be determined in greater detail.

Acknowledgements

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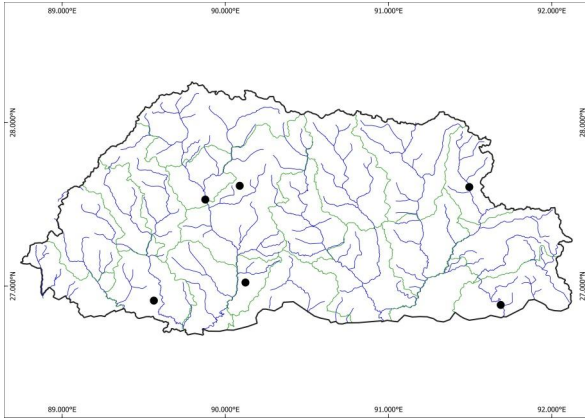
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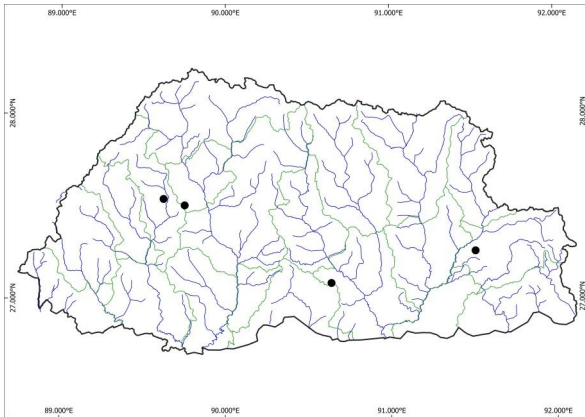
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Appendix: Distribution maps 1-123

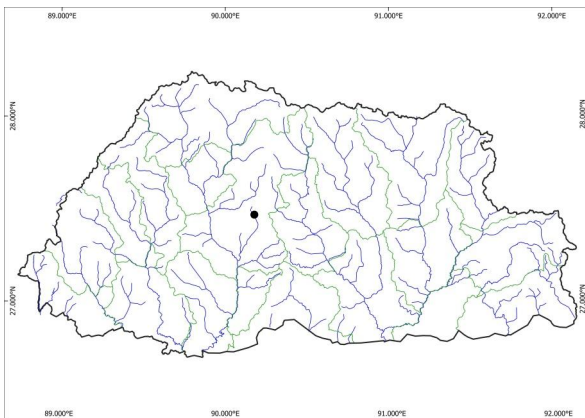
Anisoptera: 1-75



1. *Acisoma panorpoides*

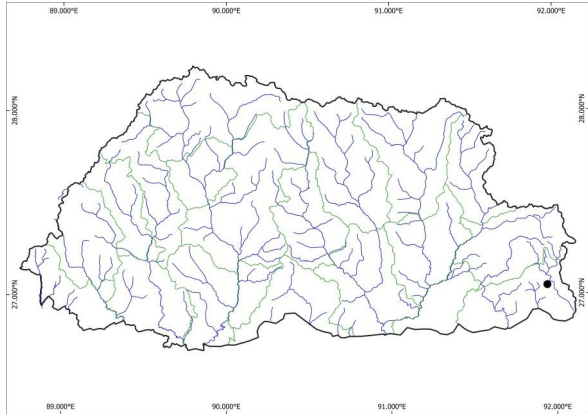


2. *Aeshna petalura*

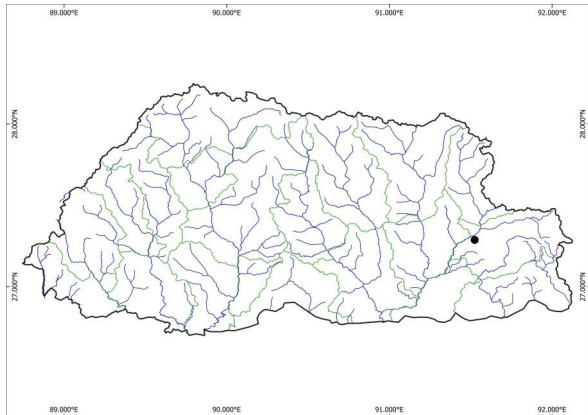


3. *Aeshna shennong*

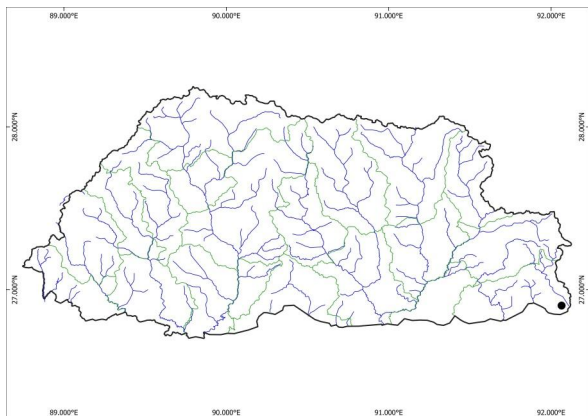
4. *Anaciaeschna jas-pidea*

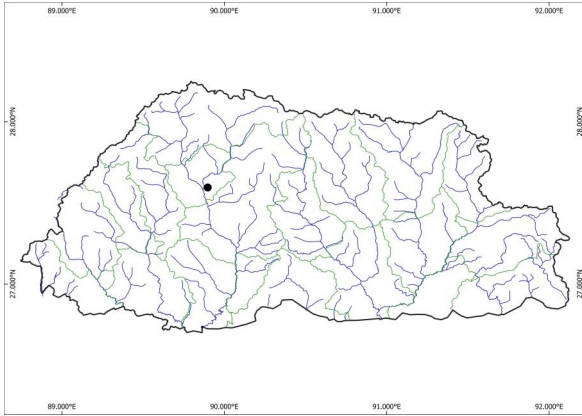


5. *Anaciaeschna martini*

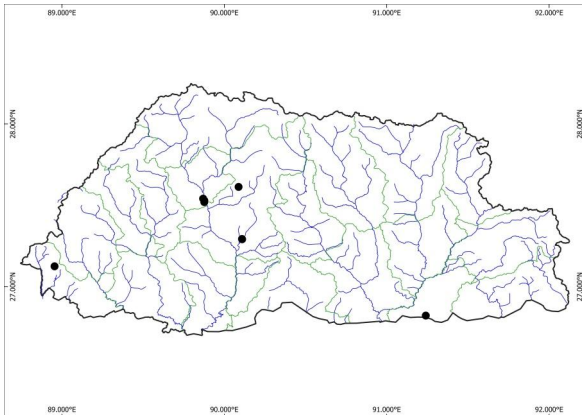


6. *Anax ephippiger*

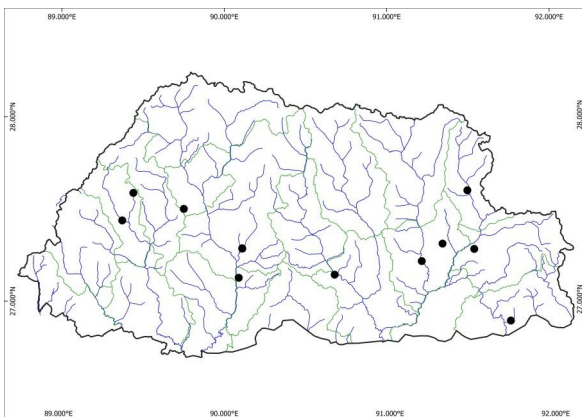




7. *Anax guttatus*

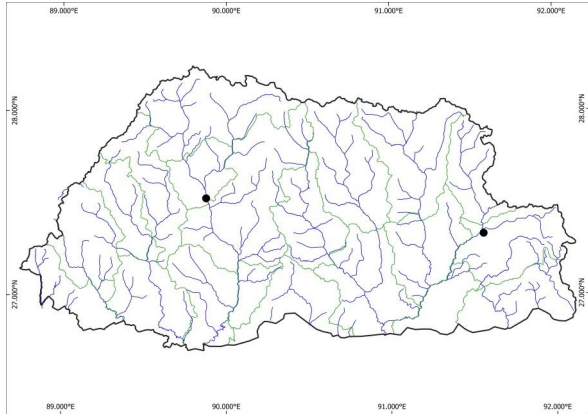


8. *Anax indicus*

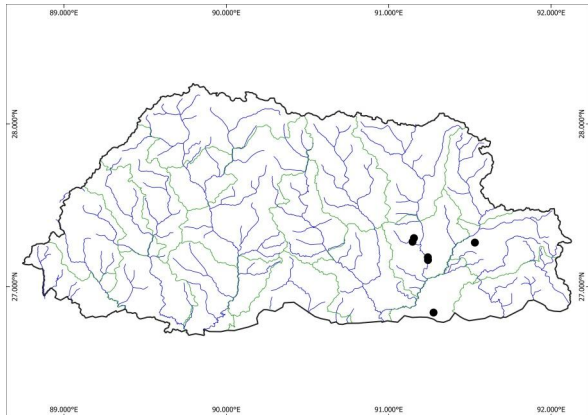


9. *Anax nigrofasciatus*

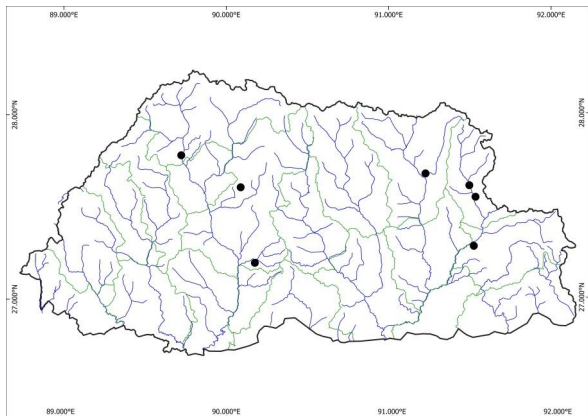
10. *Anisogomphus bivittatus*

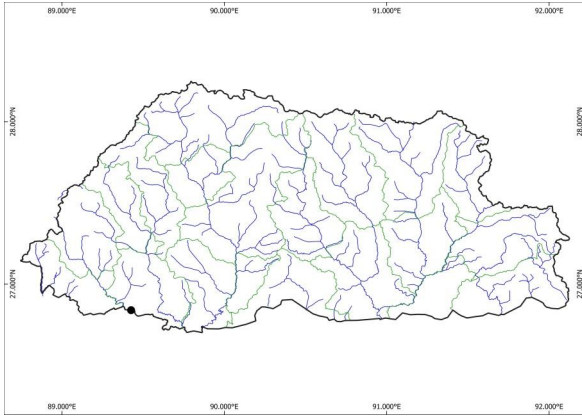


11. *Anisogomphus occipitalis*

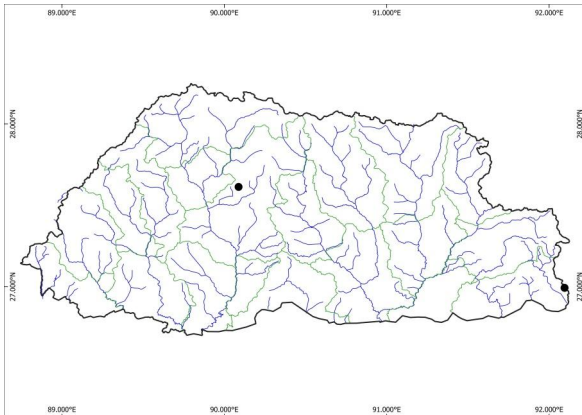


12. *Anotogaster nipalensis*

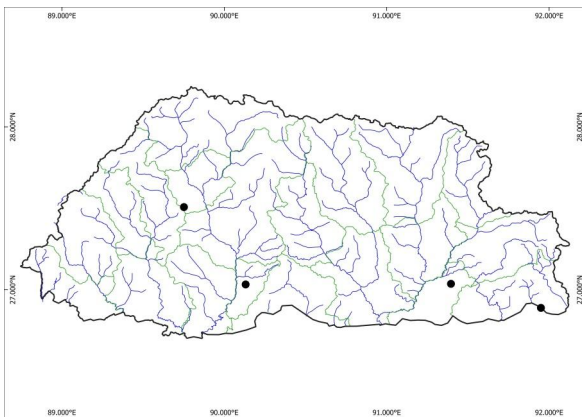




13. *Asiagomphus odoneli*

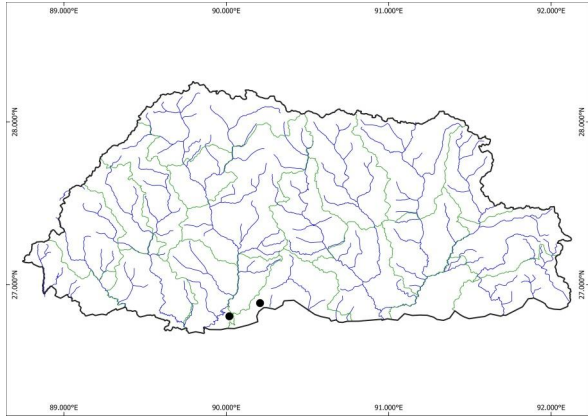


14. *Brachydiplax sobrina*

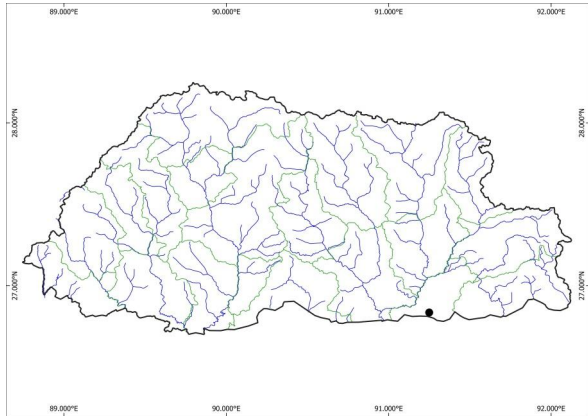


15. *Brachythemis contaminata*

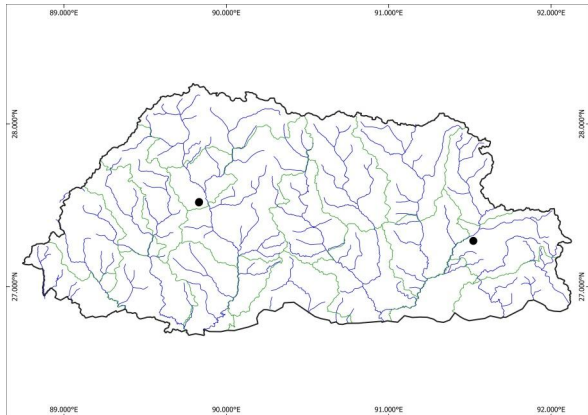
16. *Bradinopyga geminata*

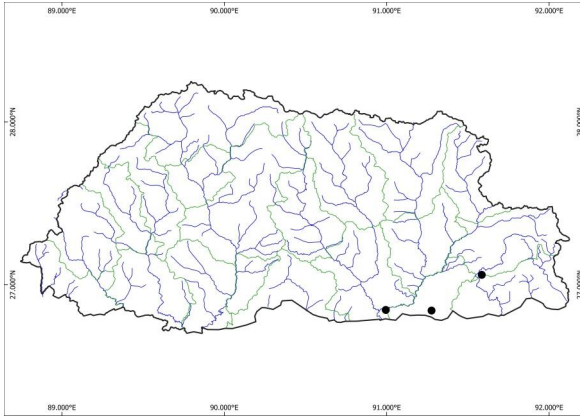


17. *Camacinia gigantea*

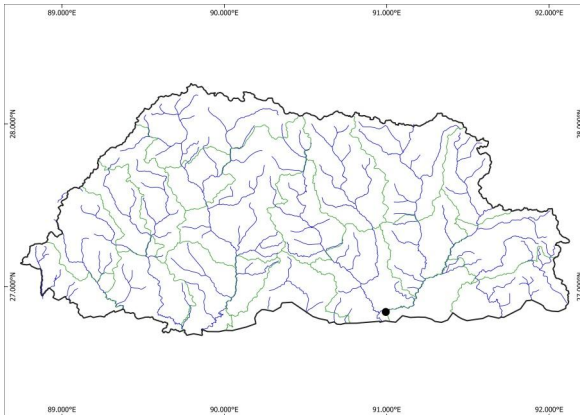


18. *Cephaloeschna triadica*

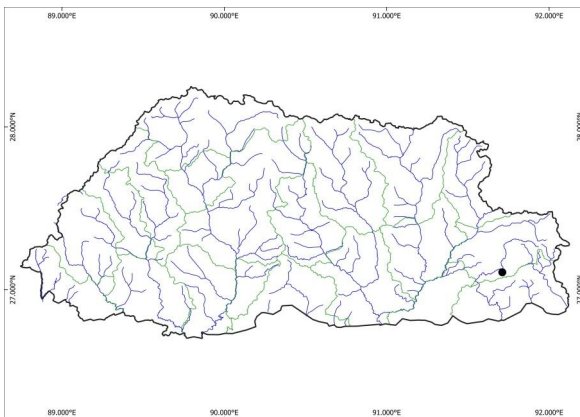




19. *Chlorogomphus mortoni*

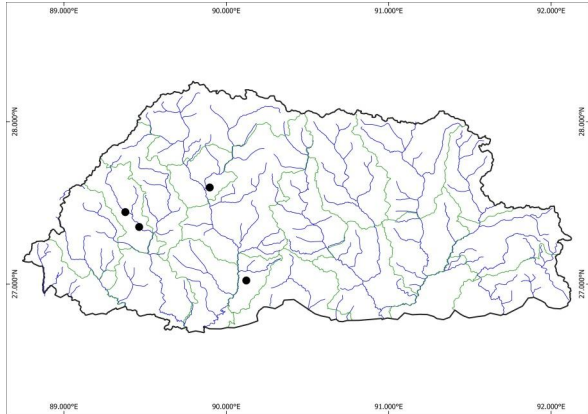


20. *Chlorogomphus preciosus*

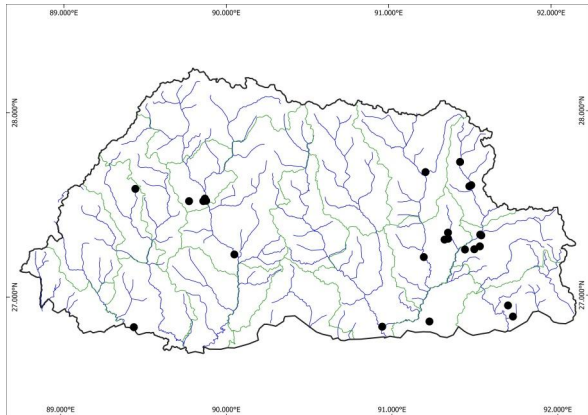


21. *Cratilla lineata*

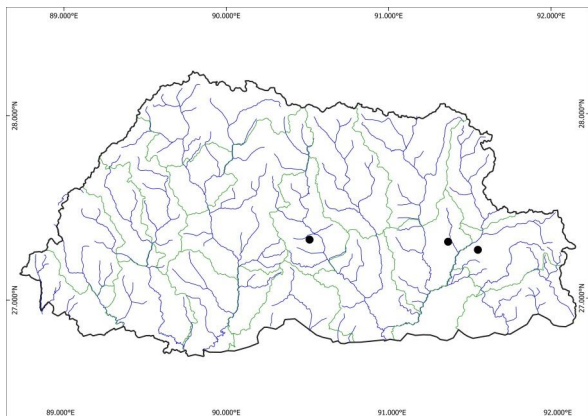
22. *Crocothemis erythraea*

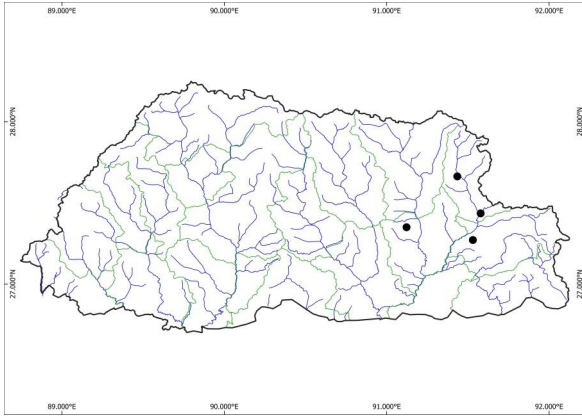


23. *Crocothemis servilia*

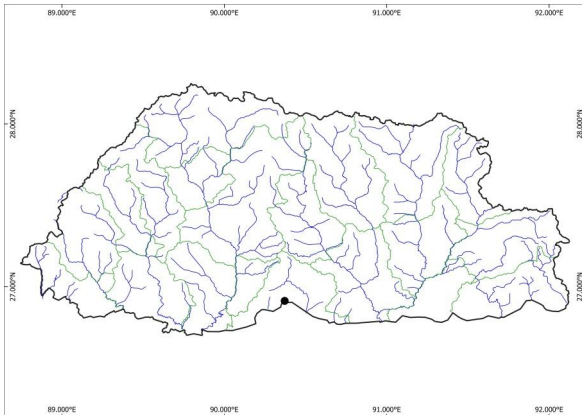


24. *Davidius baronii*

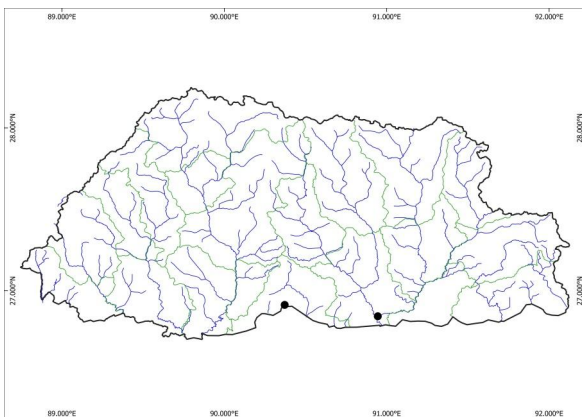




25. *Davidius delineatus*

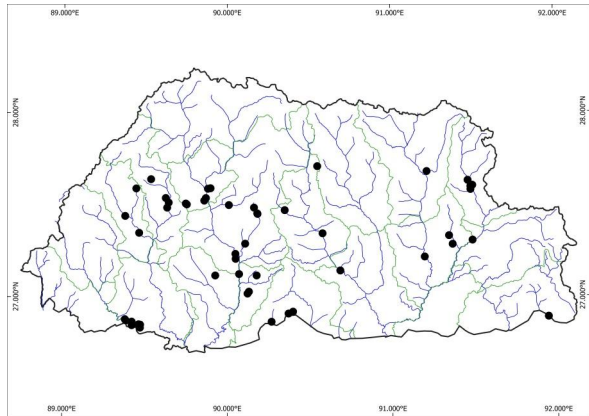


26. *Diplacodes lefebvrui*

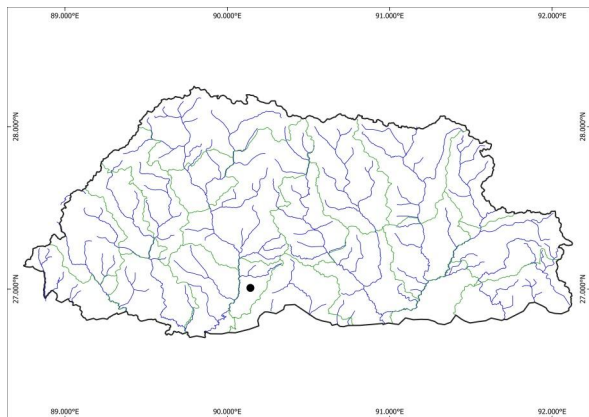


27. *Diplacodes nebulosa*

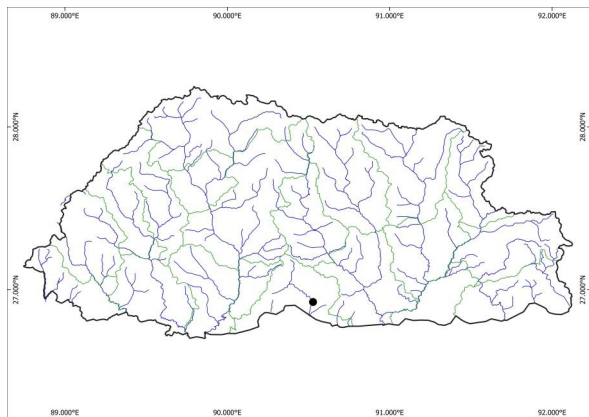
28. *Diplacodes trivialis*

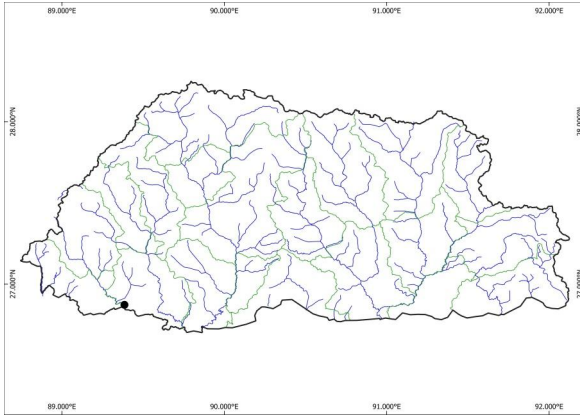


29. *Gynacantha incisura*

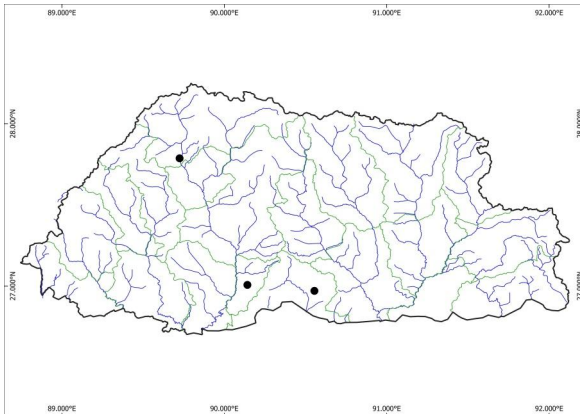


30. *Gynacantha khasiaca*

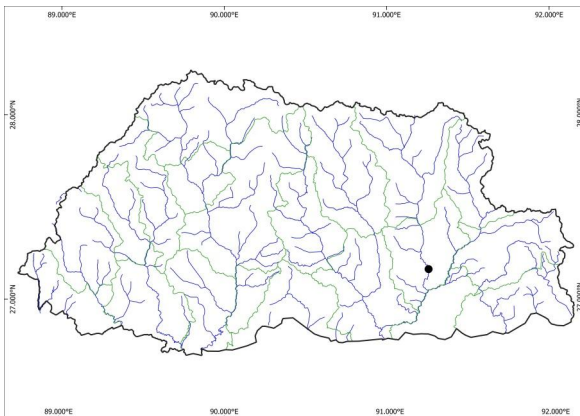




31. *Gynacantha subinterrupta*

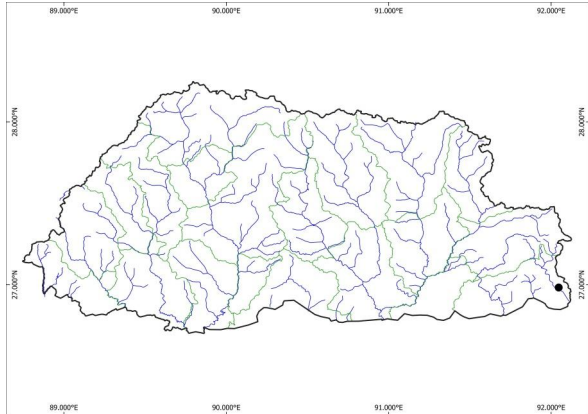


32. *Gynacanthaeschna sikkima*

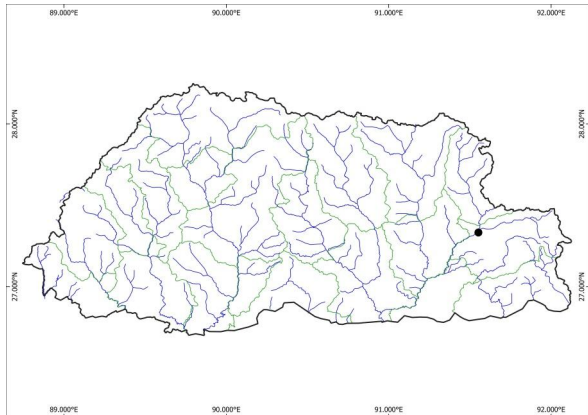


33. *Idionyx stevensi*

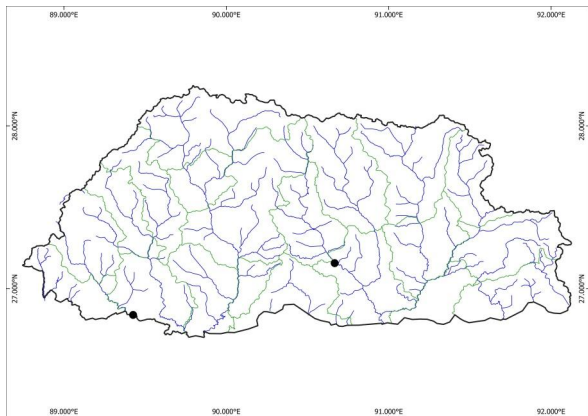
34. *Indothemis limbata*

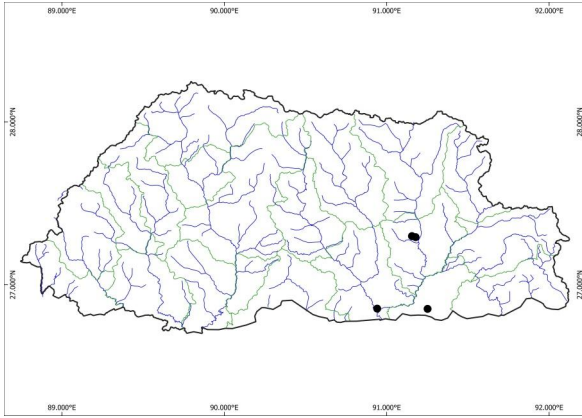


35. *Lamelligomphus biforceps*

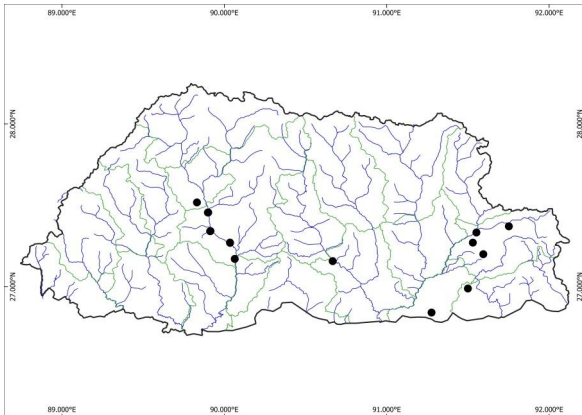


36. *Lamelligomphus risi*

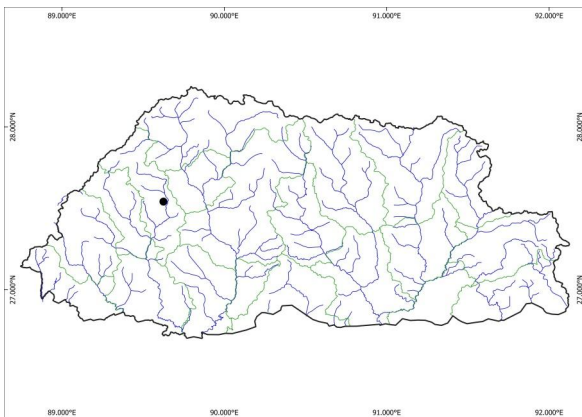




37. *Lyriothemis bivittata*

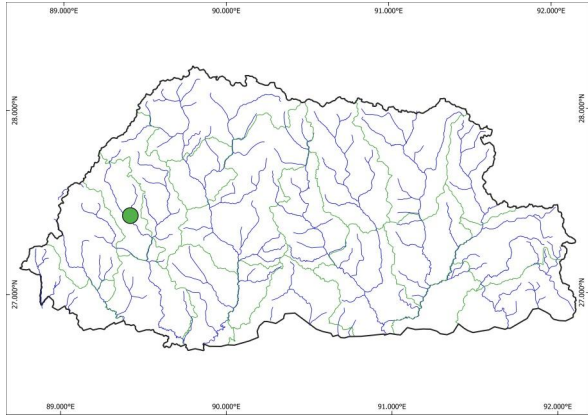


38. *Macromia moorei*

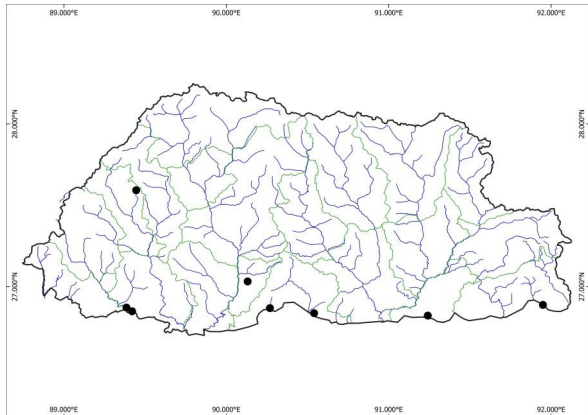


39. *Neallogaster hermionae*

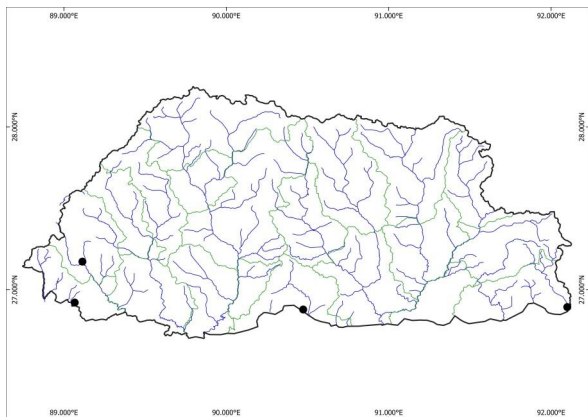
**40. *Neallogaster lati-*
*frons***

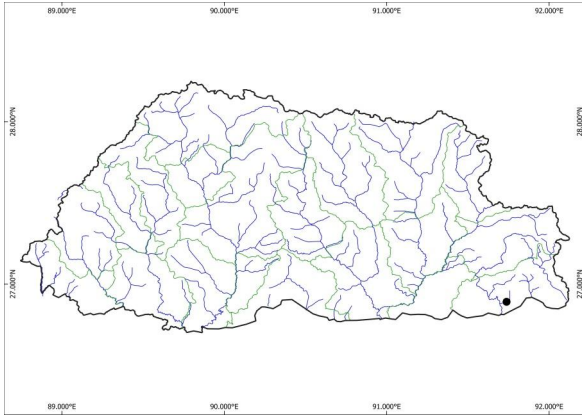


41. *Neurothemis fulvia*

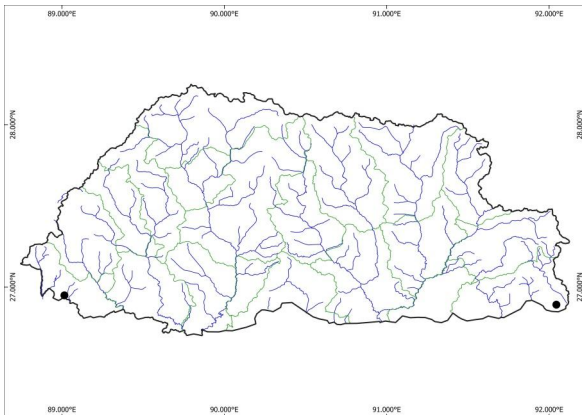


**42. *Neurothemis inter-*
*media***

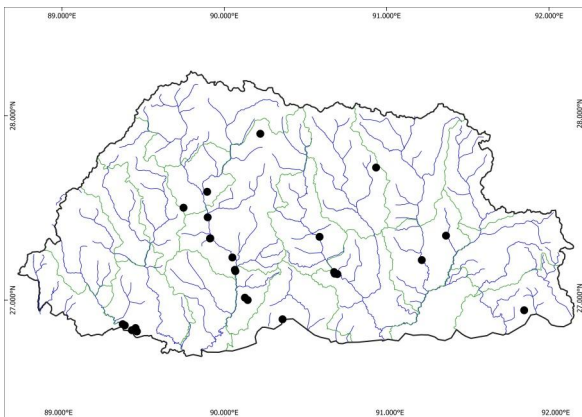




43. *Nychogomphus duaricus*

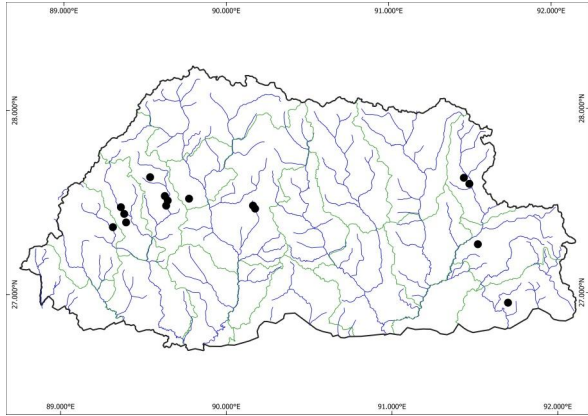


44. *Orthetrum chrysis*

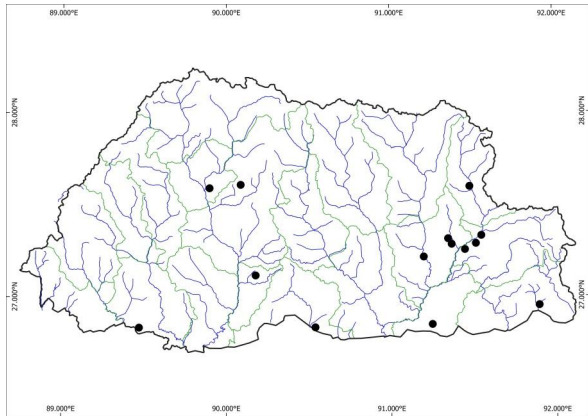


45. *Orthetrum glaucum*

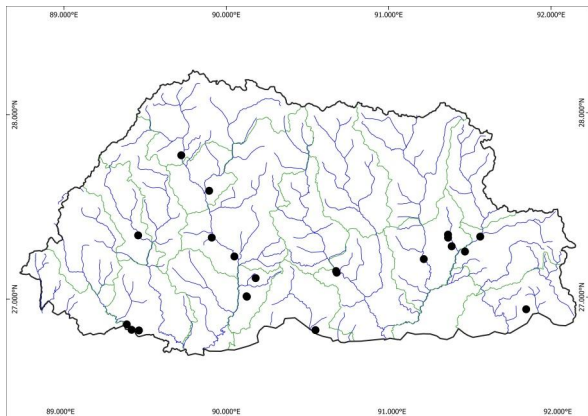
46. *Orthetrum internum*

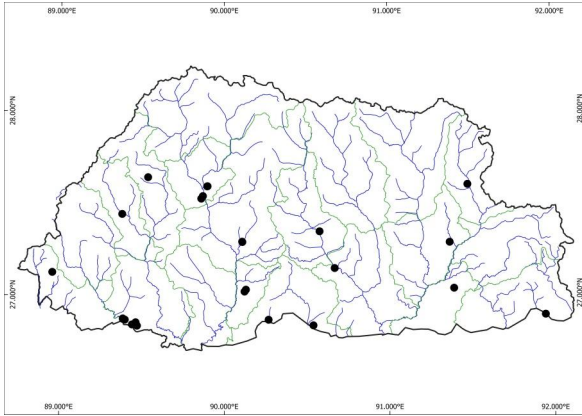


47. *Orthetrum luzonicum*

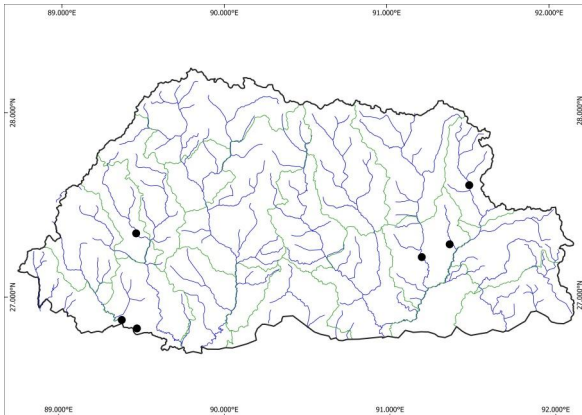


48. *Orthetrum pruinosum*

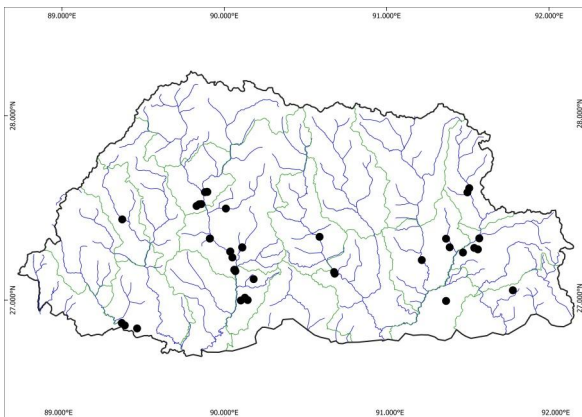




49. *Orthetrum sabina sabina*

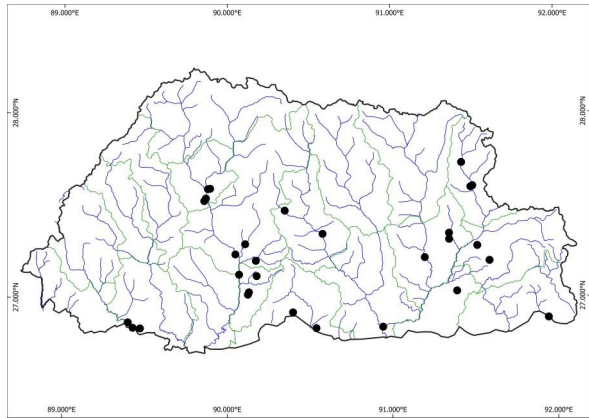


50. *Orthetrum taeniolatum*

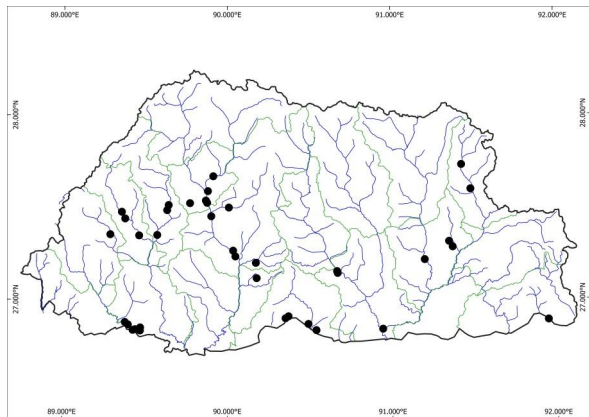


51. *Orthetrum triangulare*

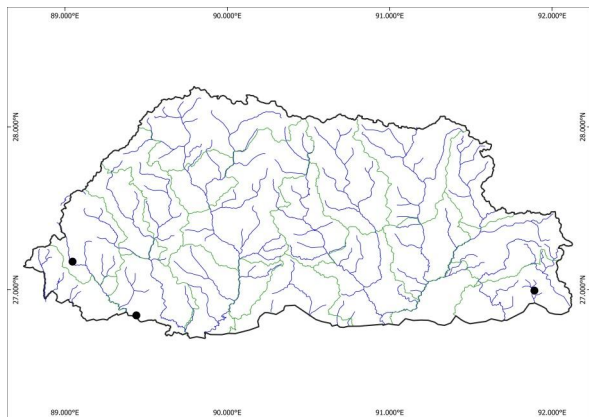
52. *Palpopleura sex-maculata*

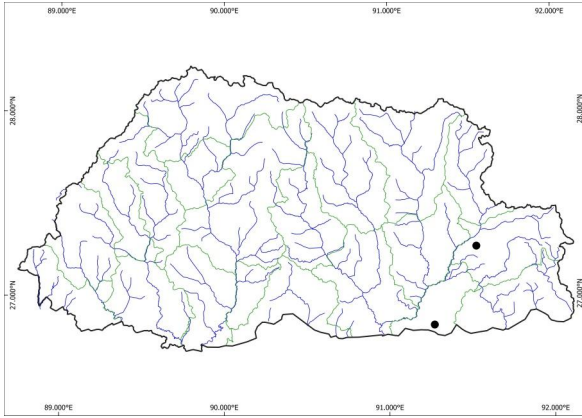


53. *Pantala flavescens*

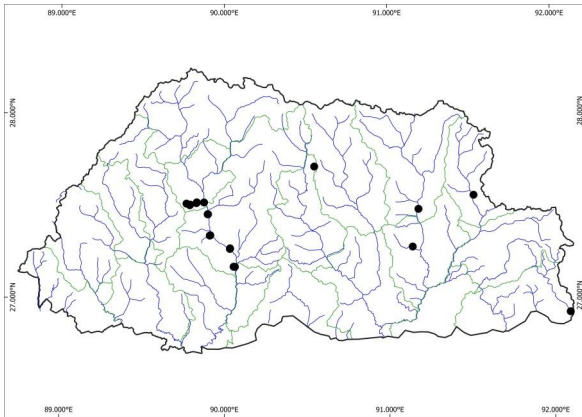


54. *Paragomphus lineatus*

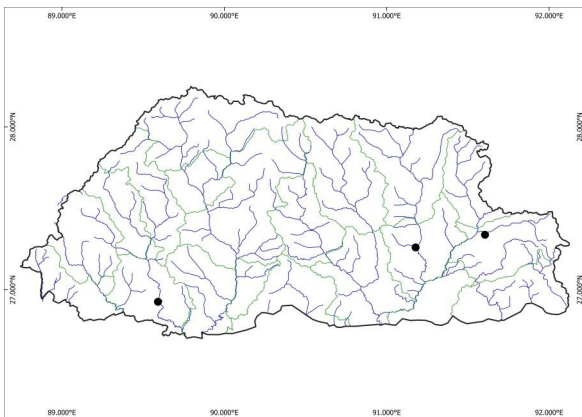




55. *Periaeschna magdalena*

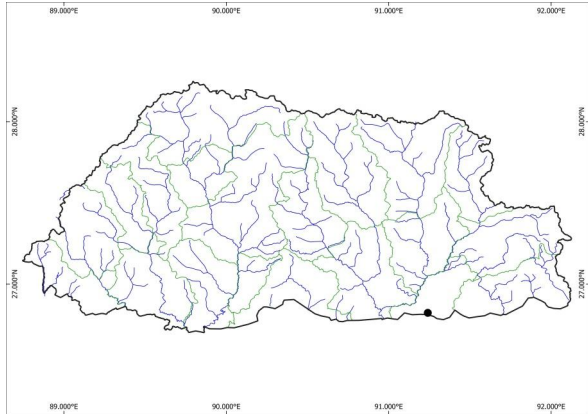


56. *Perissogomphus stevensi*

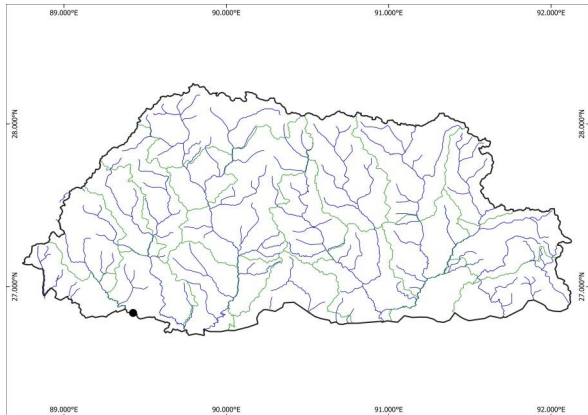


57. *Polycanthagyna erythromelas*

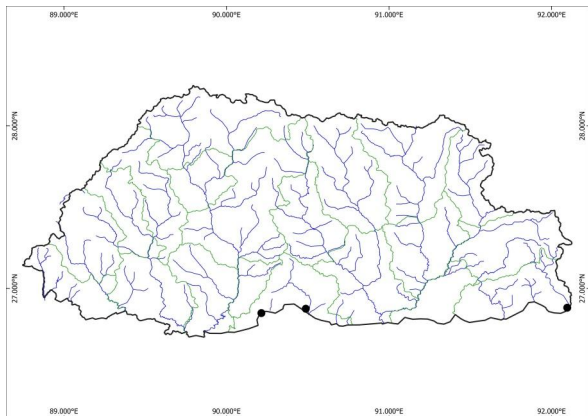
58. *Potamarcha congener*

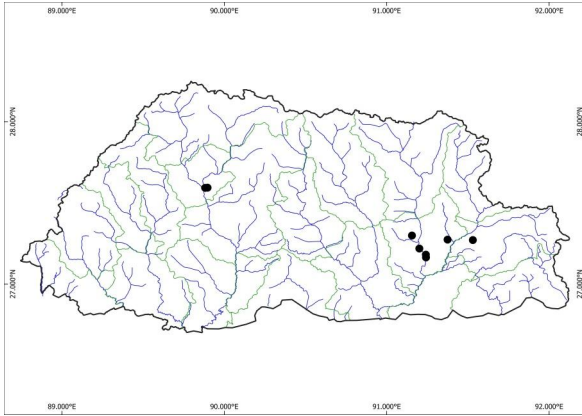


59. *Rhyothemis phyllis*

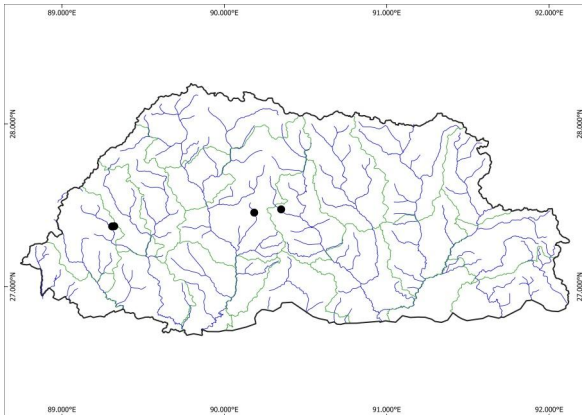


60. *Rhyothemis variegata*

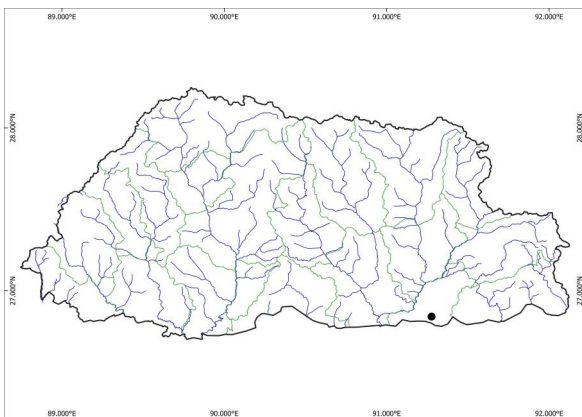




61. *Scalmogomphus bistrigatus*

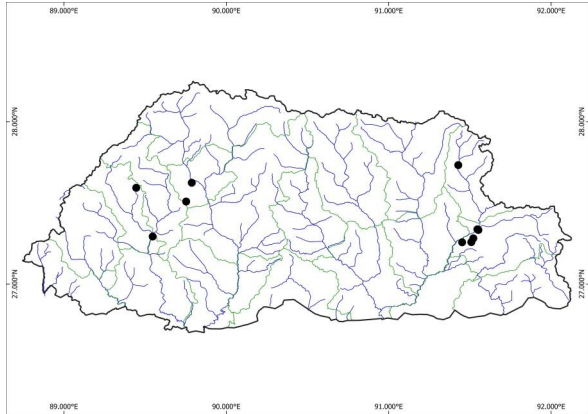


62. *Somatochlora daviesi*

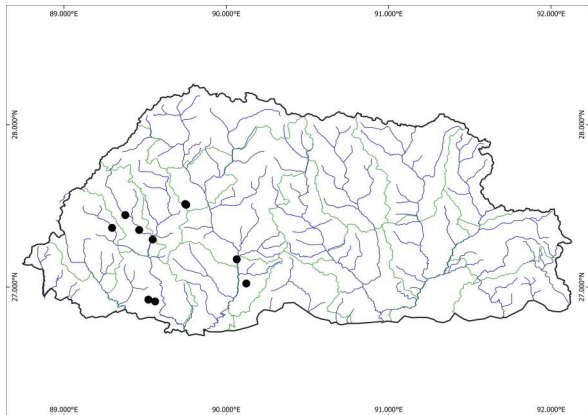


63. *Stylogomphus inglisi*

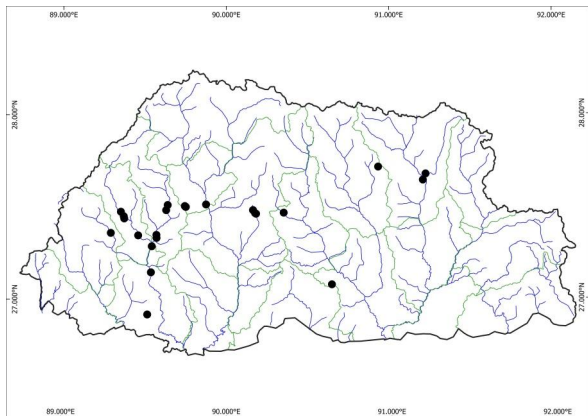
64. *Sympetrum com-mixtum*

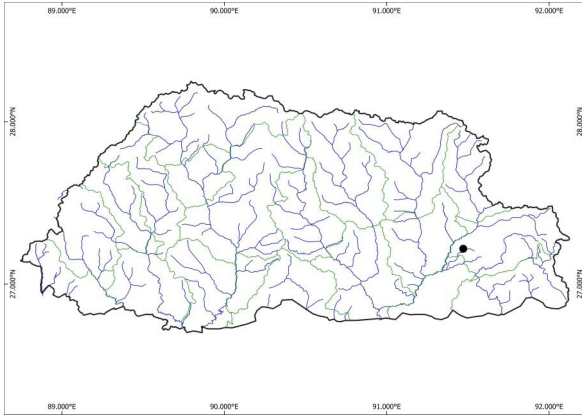


65. *Sympetrum fons-columbii*

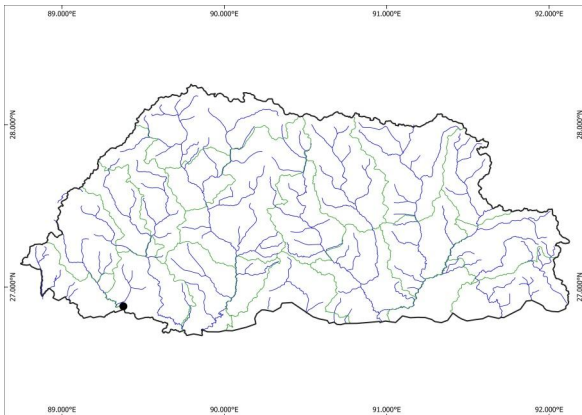


66. *Sympetrum hypo-melas*

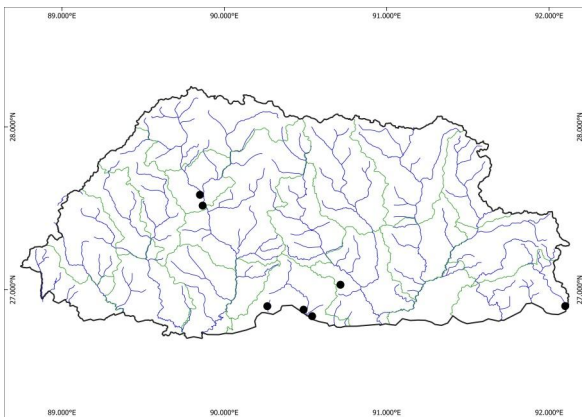




67. *Sympetrum speciosum*

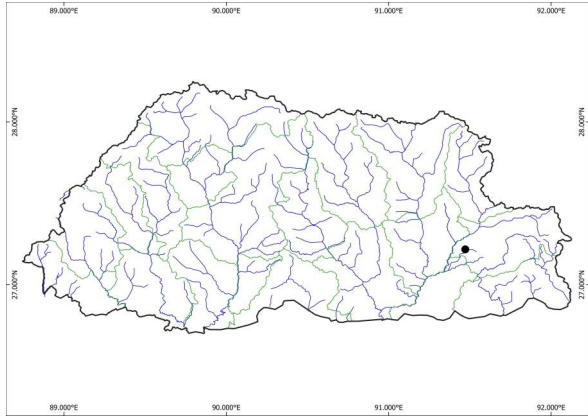


68. *Tholymis tillarga*

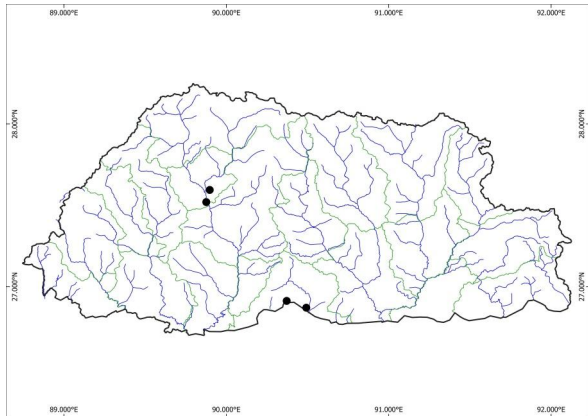


69. *Tramea basilaris*

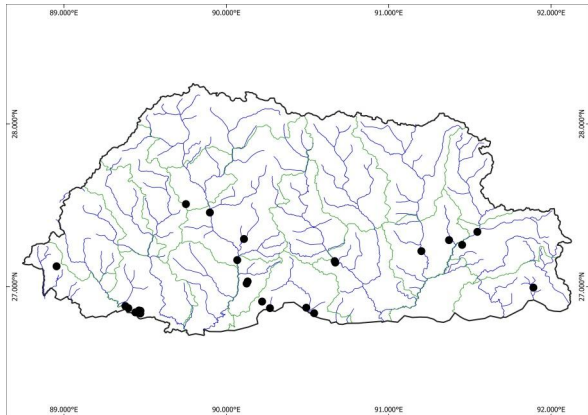
70. *Tramea limbata*

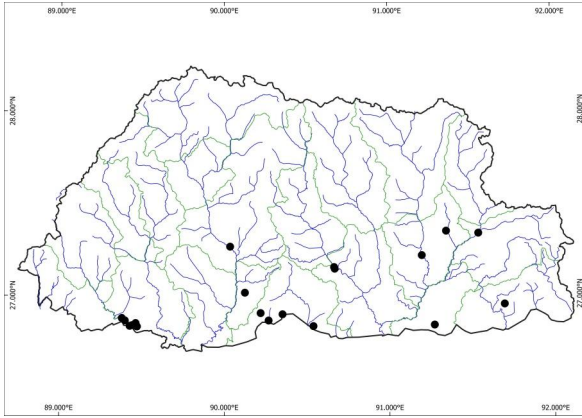


71. *Tramea virginia*

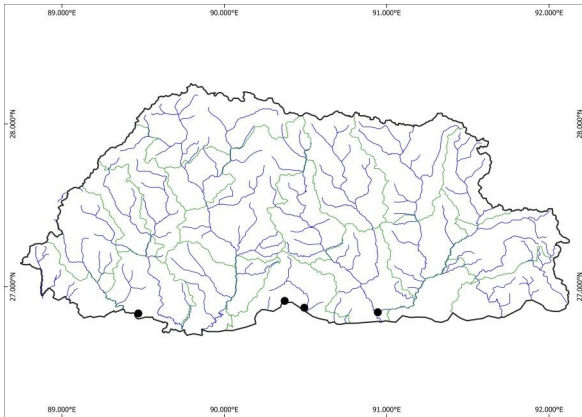


72. *Trithemis aurora*

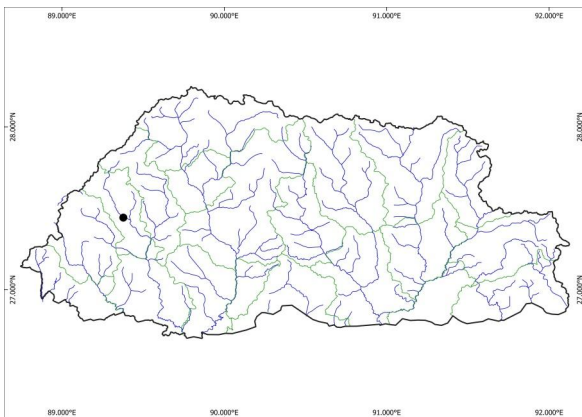




73. *Trithemis festiva*

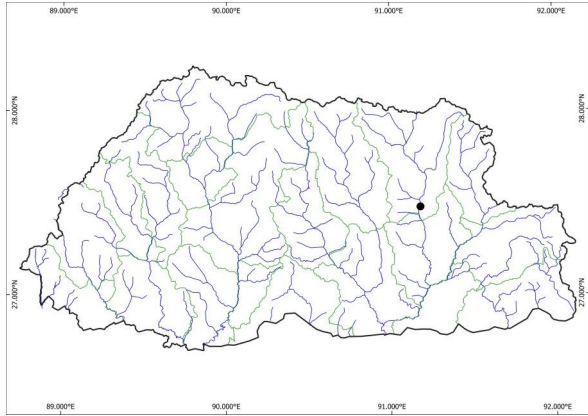


74. *Trithemis pallidinervis*



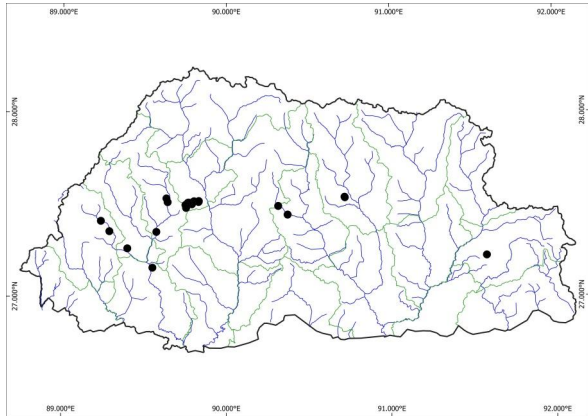
75. *Urothemis signata*

76. *Zygonyx iris*



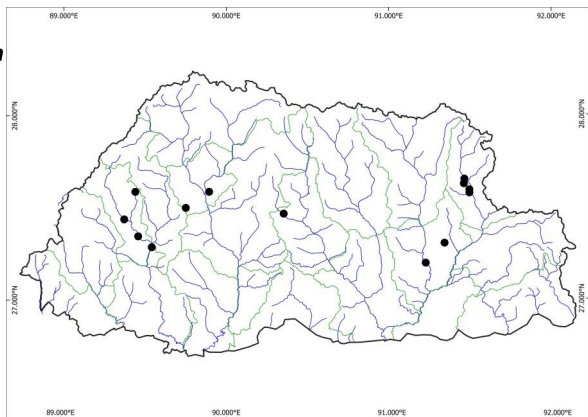
Anisozygoptera: -77

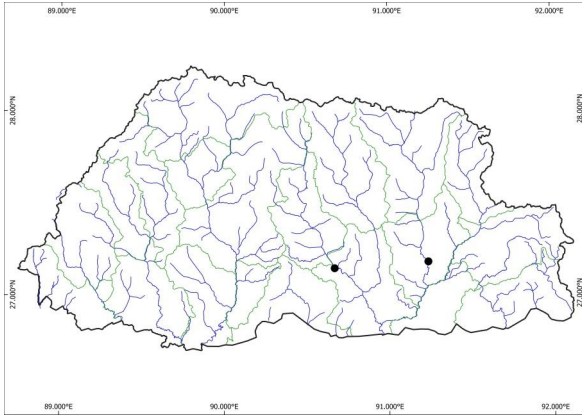
77. *Epiophlebia laidlawi*



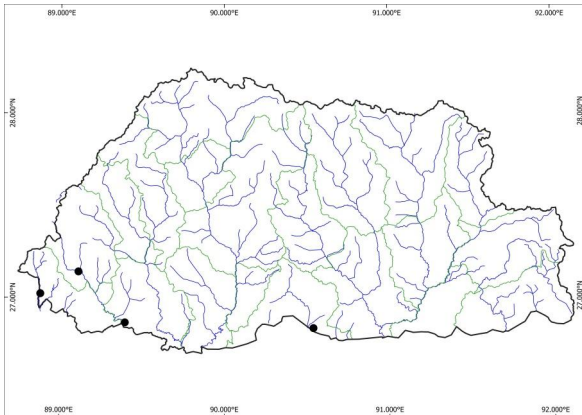
Zygoptera: 78- 123

78. *Aciagrion olympicum*

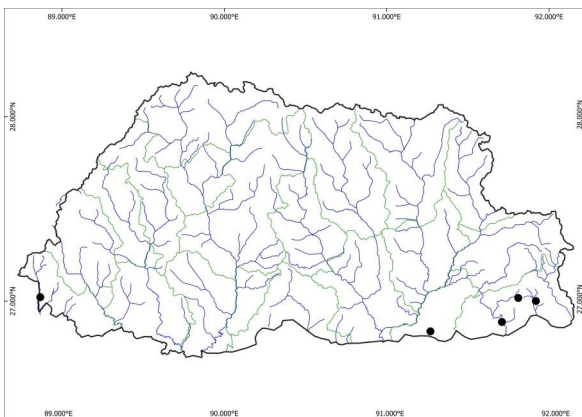




79. *Aciagrion pallidum*

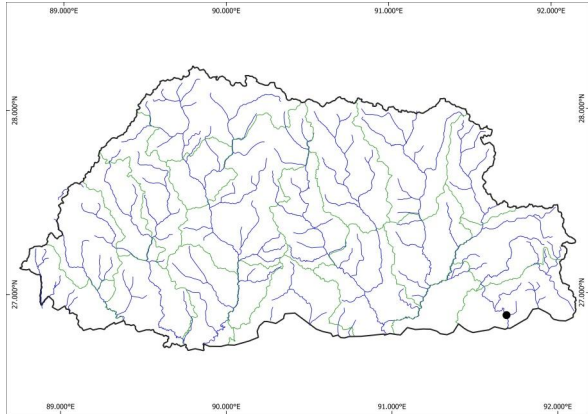


80. *Agriocnemis clauseni*

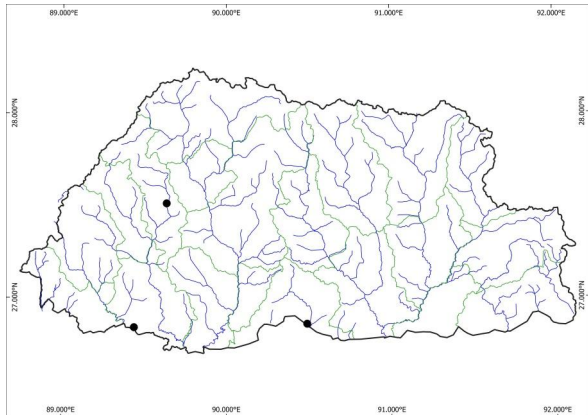


81. *Agriocnemis femina*

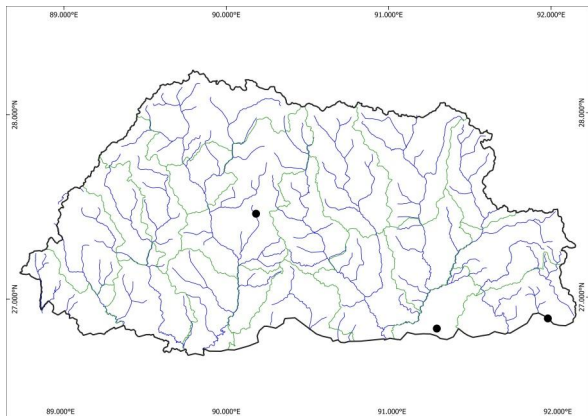
82. *Agriocnemis lacteola*

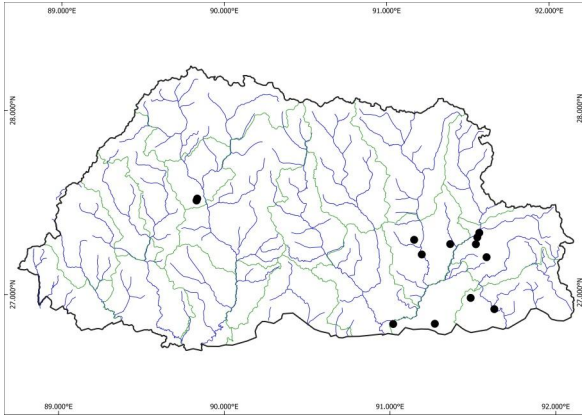


83. *Agriocnemis pygmaea*

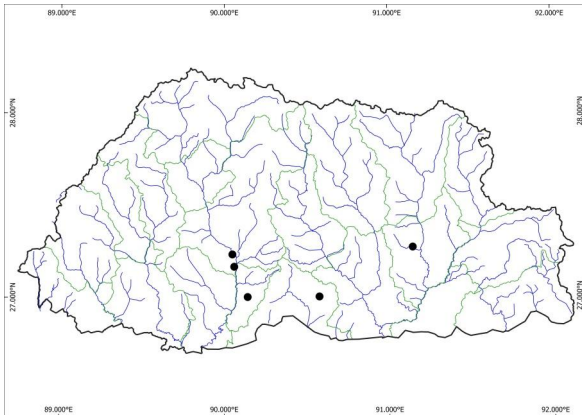


84. *Amphialagma parvum*

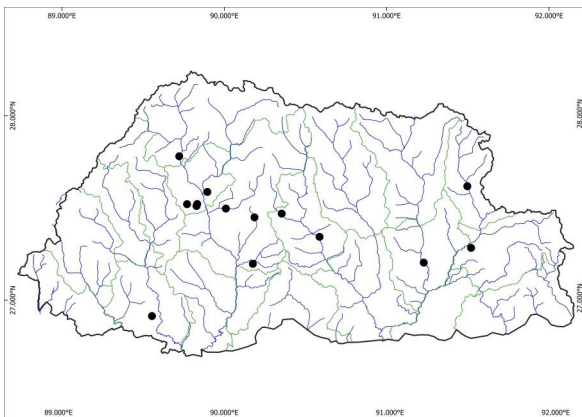




85. *Anisopleura comes*

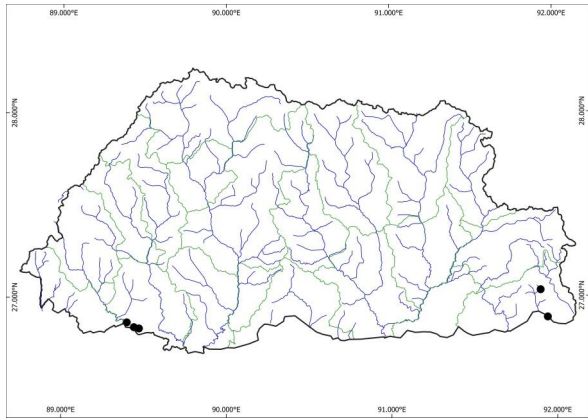


86. *Anisopleura lestoides*

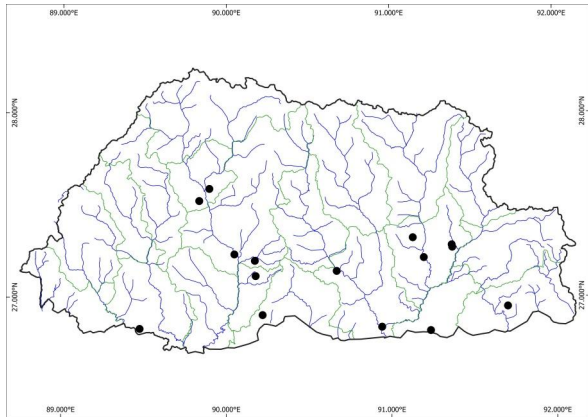


87. *Anisopleura subplatystyla*

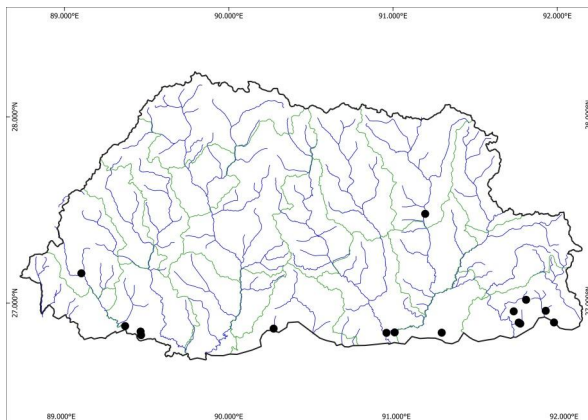
88. *Argiocnemis rubescens*

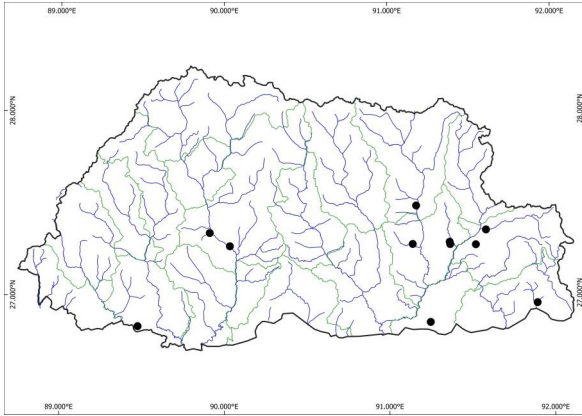


89. *Aristocypha cuneata*

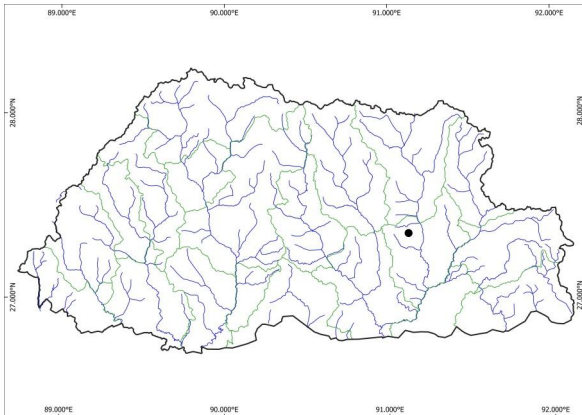


90. *Aristocypha quadri-maculata*

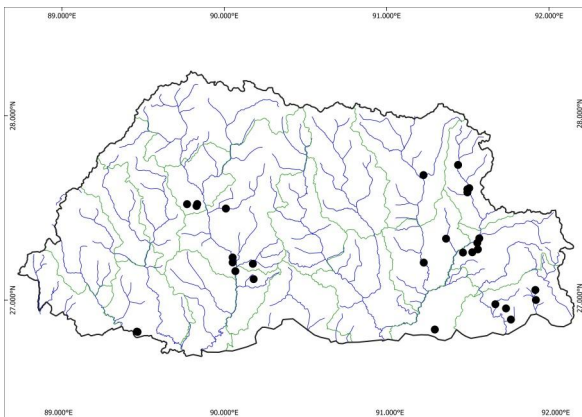




91. *Bayadera indica*

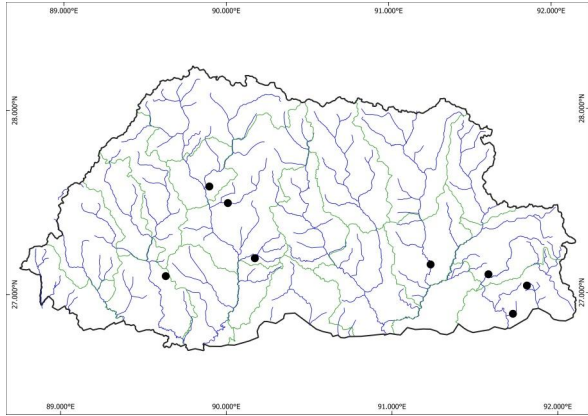


92. *Bayadera longicauda*

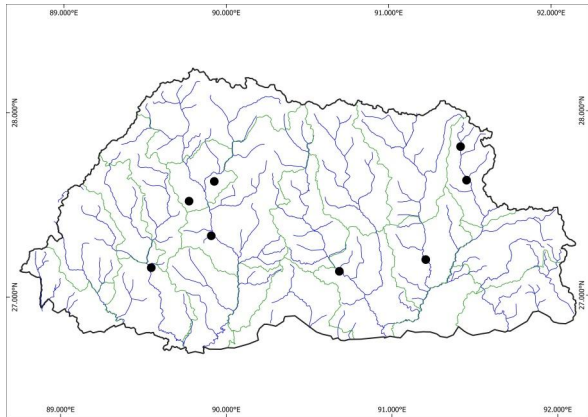


93. *Calicnemia eximia*

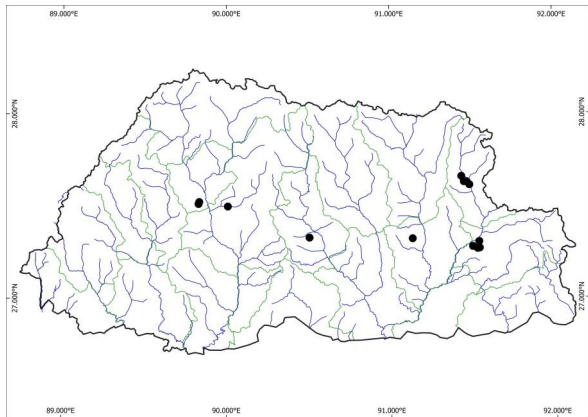
94. *Calicnemia miniata*

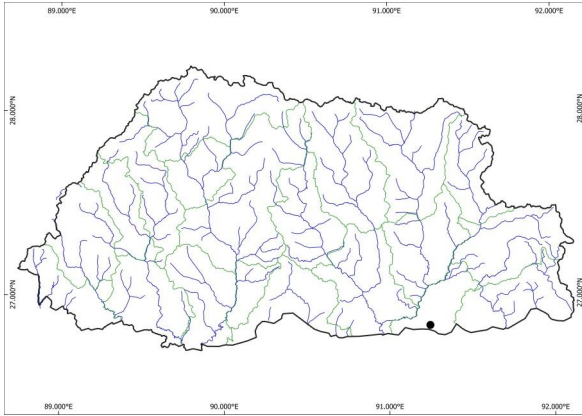


95. *Calicnemia mortoni*

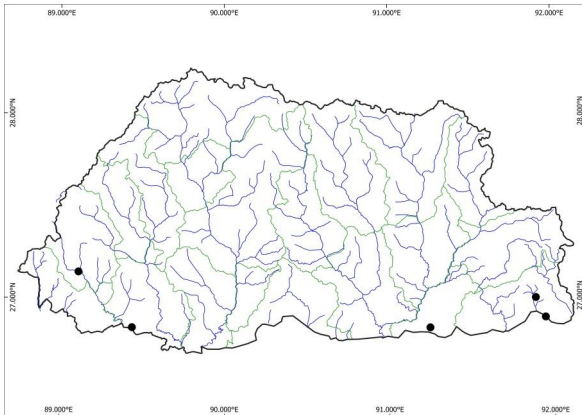


96. *Caliphaea confusa*

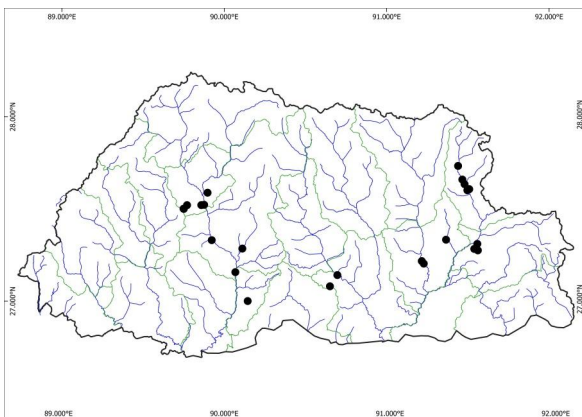




97. *Ceriagrion azureum*

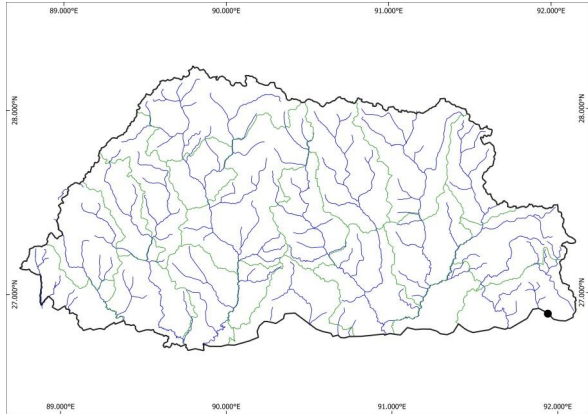


98. *Ceriagrion coromandelianum*

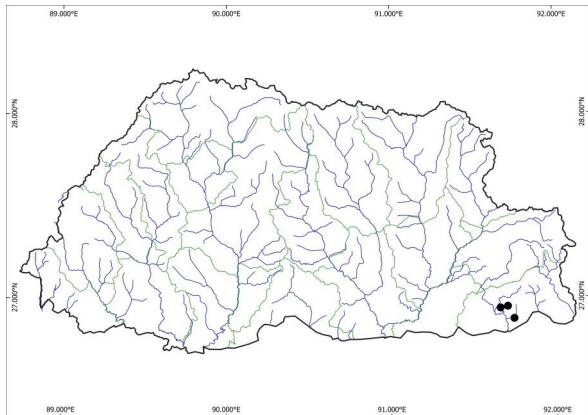


99. *Ceriagrion fallax*

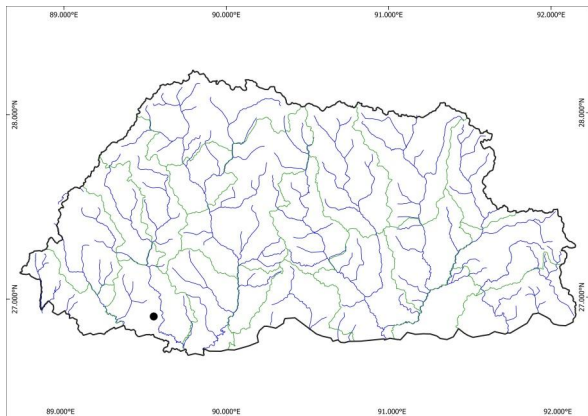
100. *Ceriagrion rubiae*

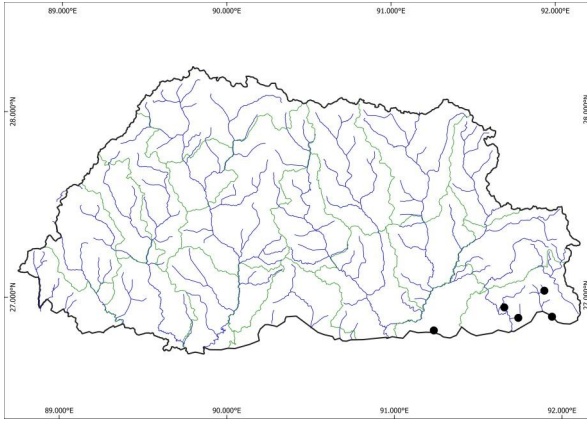


101. *Coeliccia svihleri*

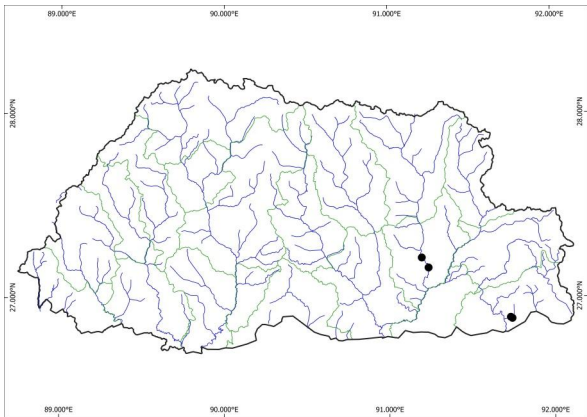


102. *Coenagrion exclamationis*

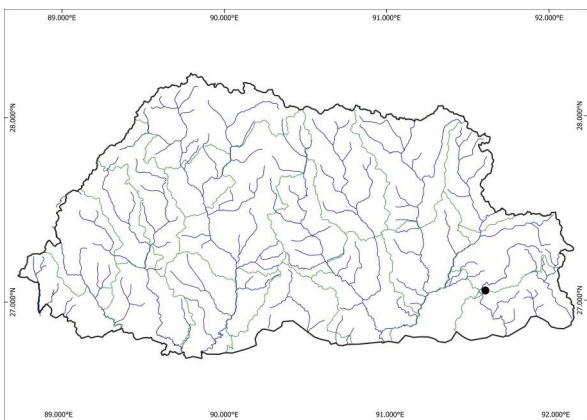




103. *Copera vittata*

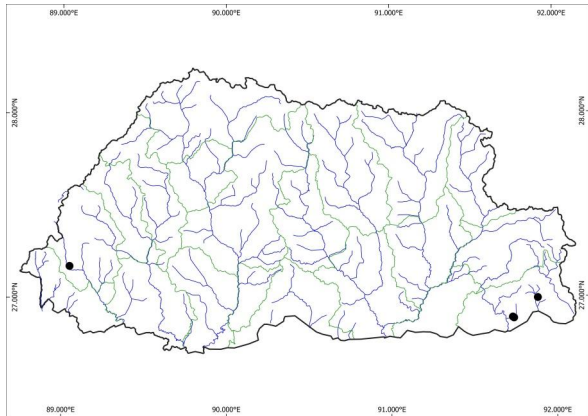


104. *Drepanosticta carmichaeli*

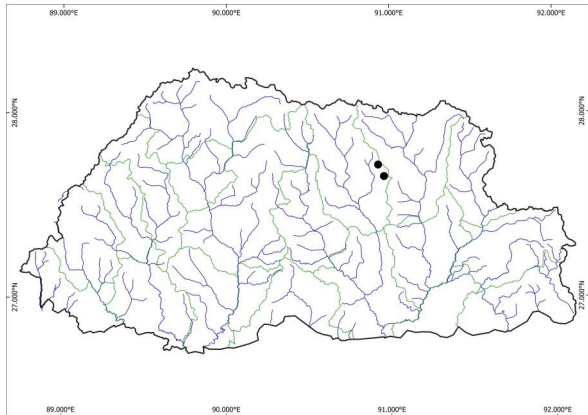


105. *Dysphaea gloriosa*

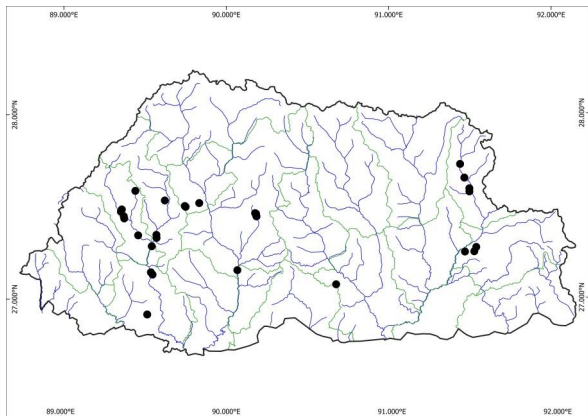
106. *Euphaea ochracea*

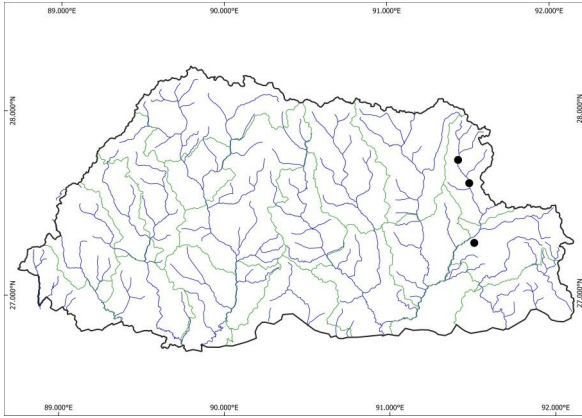


107. *Huosoma tinctipenne*

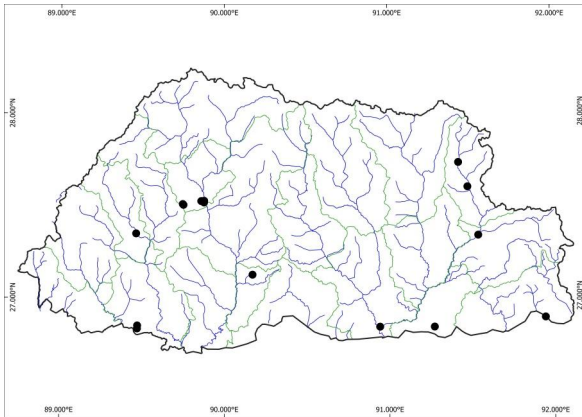


108. *Indolestes cyaneus*

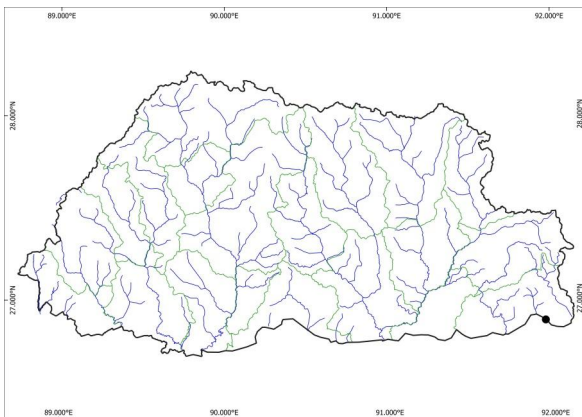




109. *Ischnura forcipata*

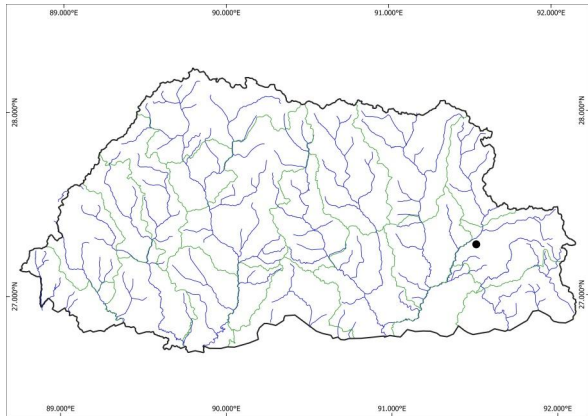


110. *Ischnura rubilio*

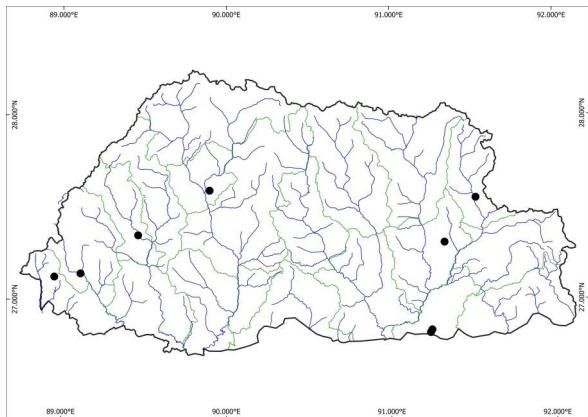


111. *Lestes concinnus*

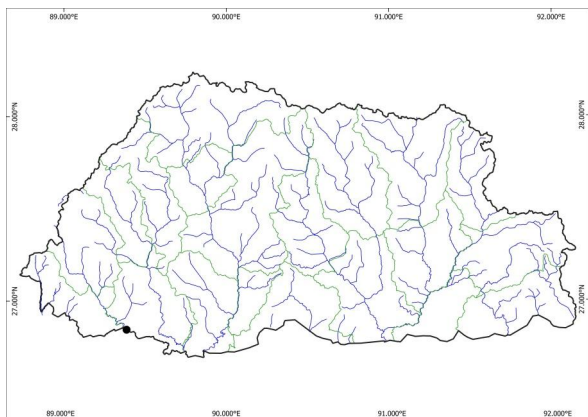
112. *Lestes dorothea*

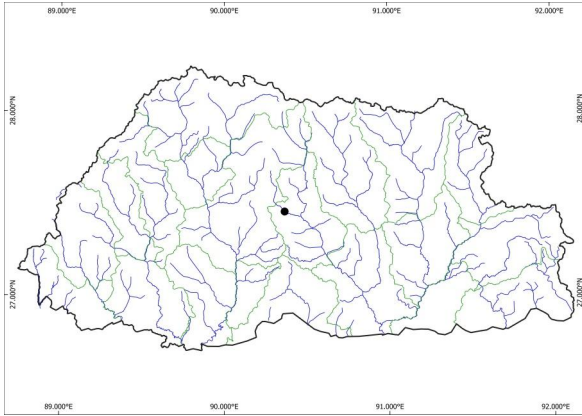


113. *Lestes praemorsus*

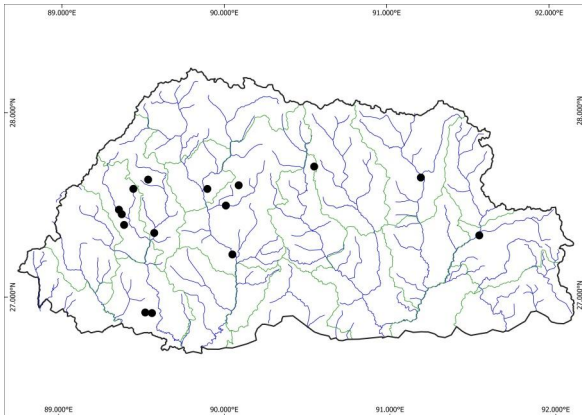


114. *Libellago lineata*

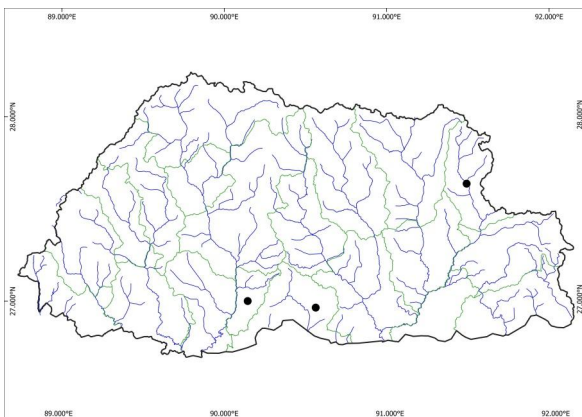




115. *Megalestes gyalsey*

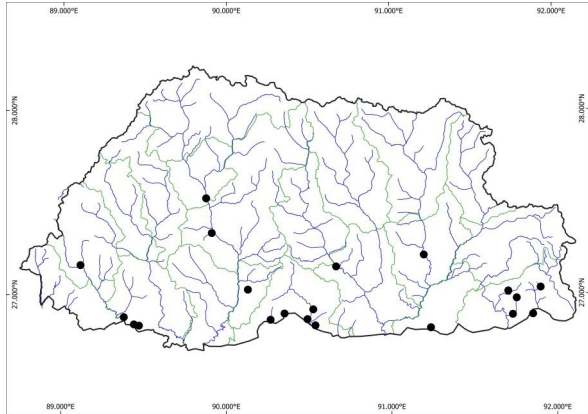


116. *Megalestes major*

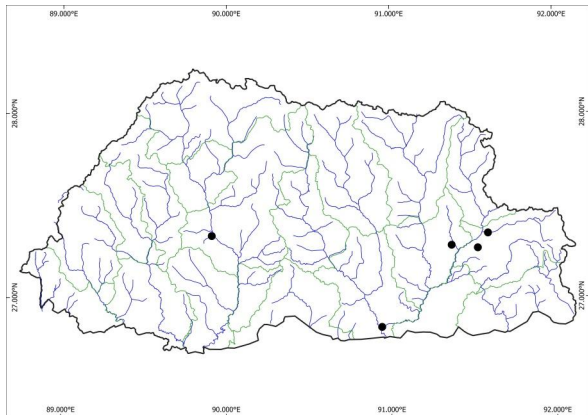


117. *Megalestes micans*

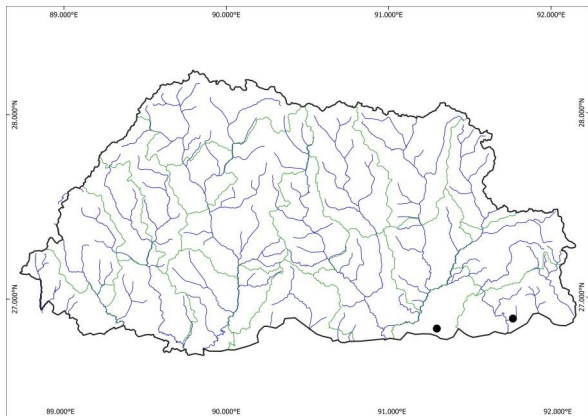
118. *Neurobasis chinensis*

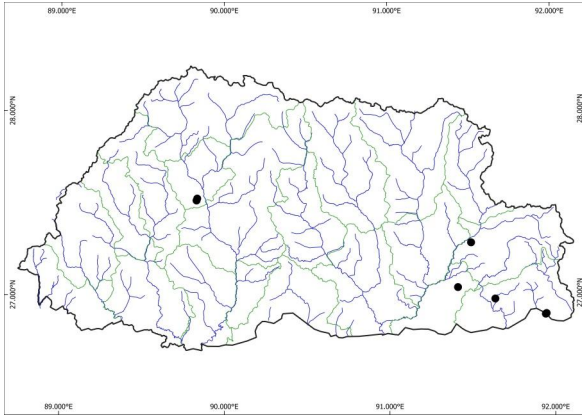


119. *Paracypha unimaculata*

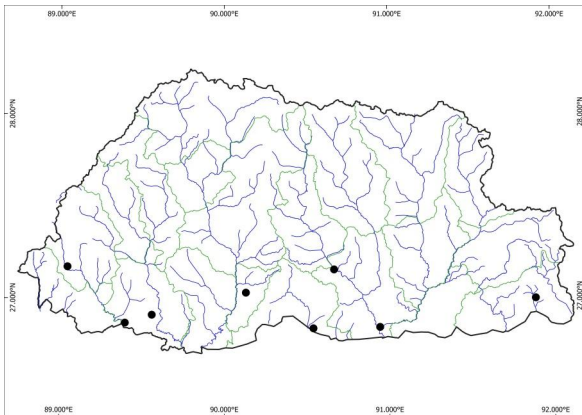


120. *Philoganga montana*

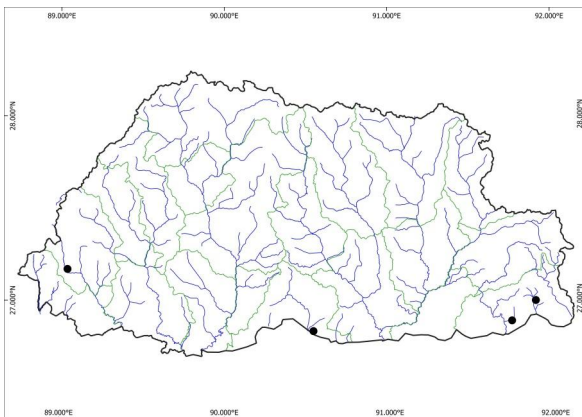




121. *Protosticta himalaica*



122. *Pseudagrion rubriceps*



123. *Vestalis gracilis*

