ODONATA AS INDICATORS OF RIPARIAN ECOSYSTEM HEALTH A CASE STUDY FROM SOUTH WESTERN KARNATAKA, INDIA

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Abstract - The influence of riparian land use on the diversity and distribution were investigated by sampling 113 localities covering 4 districts in south-western Karnataka. A total of 55 species in 12 families were recorded. Streams, rivers and lakes had higher diversity than marshes and sea coast. However, lakes had low endemism than streams and rivers. Streams flowing through evergreen forests had higher diversity and endemism. Human impacted riparian zones such as paddy fields had relatively lower species richness. However, streams flowing through forestry plantations had higher diversity than other natural riparian zones such as dry deciduous, moist deciduous and semi evergreen forests. Myristica swamps-a relict evergreen forest marsh had low diversity and high endemism. Odonate communities of lentic ecosystems, and human impacted streams and rivers were characterized by widespread generalist species. Endemics and habitat specialists were restricted to streams and rivers with undisturbed riparian zone. The study documents possible odonate community change due to human impact. The influence of riparian landuse change on odonate community is also discussed.

Key words - Odonata, Riparian land use, Western Ghats,

Introduction

Information on diversity and distribution of various taxa at habitat, local and regional scale is the key to biodiversity conservation, especially of little known taxa such as Odonata (dragonflies and damselflies). Odonates are aquatic insects and are highly specialized for a specific wetland habitat. At global level, the streams and rivers of the Western Ghats are one of the hyper diverse areas for odonates with 176 species and 68 endemics[1]. Many of these endemics are recorded from the central Western Ghats, spanning Kodagu, Uttarakannada and Dakshinkannada districts of Karnataka[2].

Studies from different parts of the world have shown that insects like odonates are good indicators of ecosystem health. The species assemblages of odonates are influenced by aquatic and terrestrial vegetation[3]. Since larvae and adult odonates respond to change in habitat quality, they are widely recognized indicators for monitoring wetland health[4]. Methodologies for monitoring wetland health using odonates has been developed and currently being used in different parts of the world [5-7]. Unfortunately, no such attempt has been made for Indian wetlands. This is largely due to unavailability of information on distribution and habitat

use of aquatic invertebrate species, including odonates. This in turn, has seriously retarded the development of country wide wetland biomonitoring programmes using aquatic invertebrates, involving conservation managers, scientists, nongovernmental organizations and general public.

The odonate fauna of the Western Ghats is well known taxonomically. Taxonomy of adults is well worked out and descriptions are available for all the reported species [8-16]. Recent studies on the odonate fauna of the region are species checklists based on field surveys[2, 17-27]. Though partial, these published studies give valuable information on geographic and habitat distribution of odonates of the region.

The understanding on ecology, habitat use and diversity of odonate communities of different landuse types is very important in developing a wetland biomonitoring technique. This understanding is crucial to know how odonate communities respond to change in landuse pattern. Present study investigates the influence of riparian landuse on the diversity and distribution of odonate communities of south western Karnataka. The study also explores potential use of odonates as indicators of riparian ecosystem health.

Methodology

Study localities

Dragonflies and damselflies were sampled from 113 localities in Shimoga Uttarakannada, Udupi and Mangalore (formerly Dakshinakannada) (Map-1&2,) districts during August to November, 2006.

Sampling Method-

In each locality different wetland habitats were surveyed between 9-13 hrs. Species which could not be identified in the field were collected and stored in 70% ethyl alcohol for identification. All species were identified following Fraser[10-12]. The sampling sites were georeferenced using hand held Gloabal Positioning System (Garmin GPS). During the field visits the riparian landuse types and threats to wetland habitats in each locality were also recorded.

Riparian landscape and wetland types

Based on predominant vegetation and landuse the riparian zones were classified into 9 types and wetlands were classified into 5 types (Table-1). All the 113 localities were further grouped into 9 landuse or 5 wetland types for analysis.

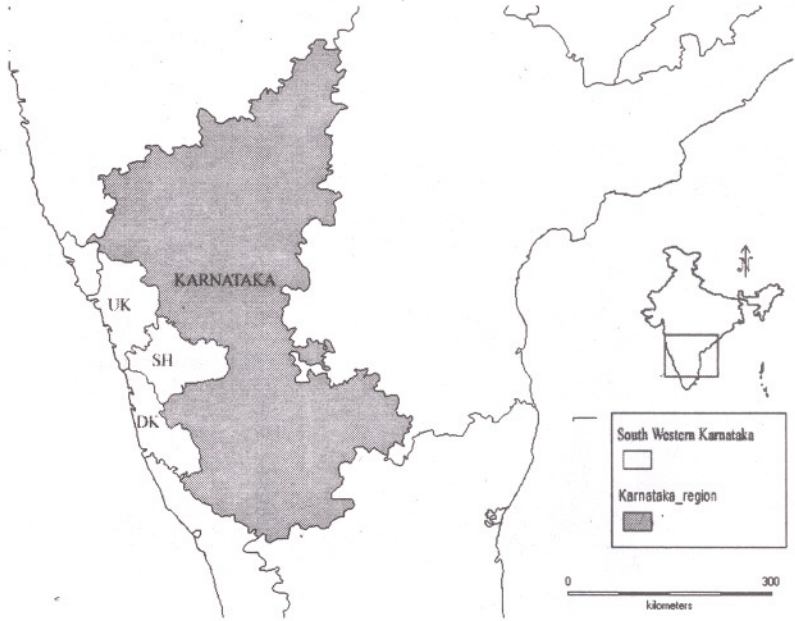
Analysis

Family and species presence/ absence records across landuse and wetland types were used to estimate diversity measurements. All the species records were georeferenced and spatial distribution of species diversity was estimated and plotted using DIVA GIS.

Results

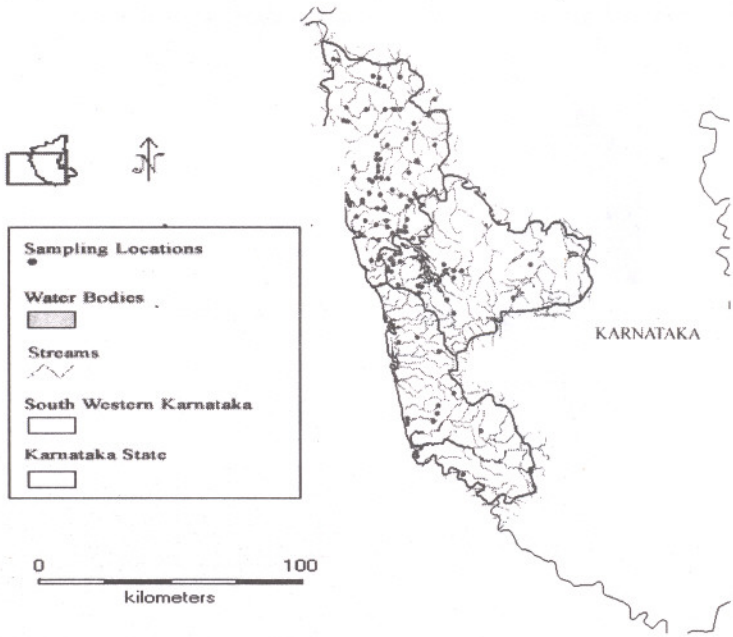
Diversity

A total of 55 species in 12 families were recorded in the study. Six of the species recorded in the study were endemic to the Western Ghats. Study localities such as Mala, Ramsamudra, Koyur and Kukke-Subramanya had high species and family diversity (Maps 3&4). Species

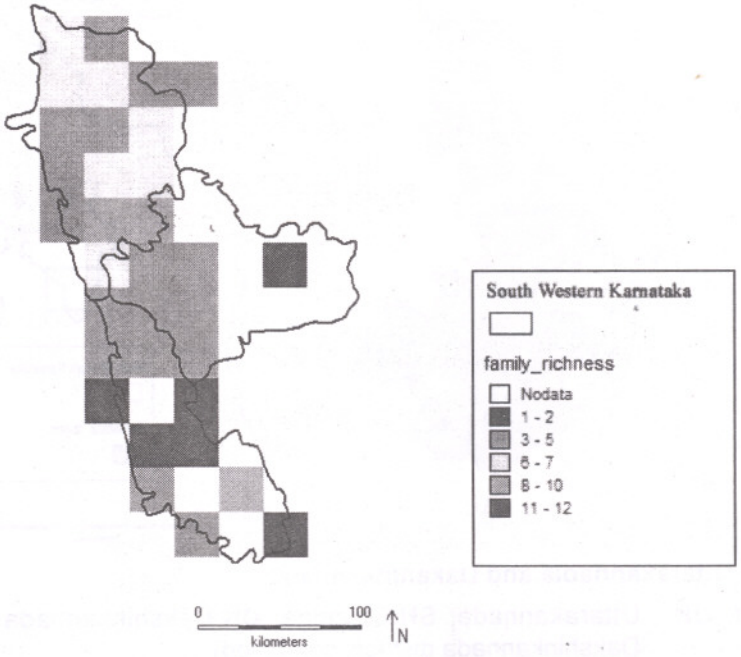


Map 1 : Uttarakannaoia and Dakahinkannaoia

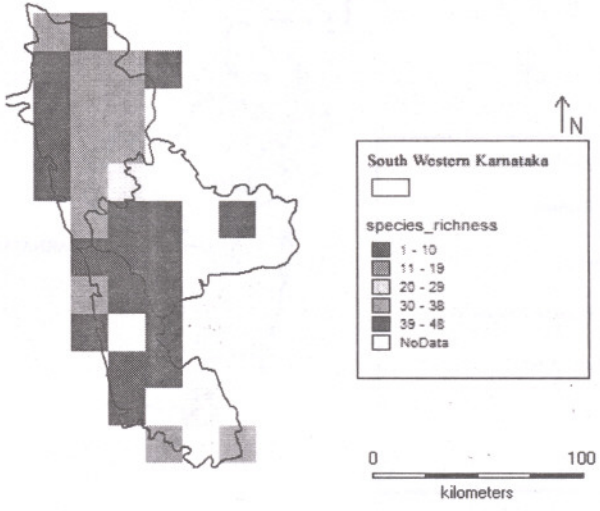
Legend: **UK** : Uttarakannada, **SH**:Shimoga, **DK**:Dakshinkannada (Udupi & Dakshinkannada districts combined)



Map 2 : Uttarakannada and Dakshinkannada (Magnified)/ showing sampling locations.



Map 3 : Distribution of Family Richness in South Western Karnatka



Map 4 : Distribution of Species Richness in South Western Karnatka

such as *Orthetrum sabina* (Drury,1770), *Pantala flavescens* (Fabricius, 1798) *Diplocodes trivialis* (Rambur, 1842) (Libellulidae), *Rhynocypha bisignata* (Selys, 1853) (Chlorocyphidae) and *Euphaea fraseri* (Laidlaw, 1920) (Euphaeidae) were very wide spread across localities. On the other hand, *Dysphaea ethela*, Fraser, 1924e (Euphaeidae), *Epithemis mariae* (Laidlaw, 1915b) (Libellulidae), *Phylloneura westermanni* (Selys, 1860) and *Esme longistyla* Fraser,1931a (Protoneuridae) were recorded from only one or two localities. Frequency distribution of 15 most common odonates is given in Fig-1.

Distribution across wetland types-

Species richness across wetland habitats shows that ponds, streams and lakes have high species diversity. Sea coasts were very poor in species (Fig.2). Species such as *Anax guttatus* (Burmeister, 1839), *Crocothemis servilla* (Drury,1770), *Diplacodes trivialis* (Rambur, 1842), *Ictinogomphus rapax* (Rambur, 1842), *Orthetrum sabina* (Drury,1770)and *Pantala flavescens* (Fabricius, 1798) were widespread across wetlands (Fig.3). On the other hand species such as *Disparoneura quadrimaculata* (Rambur, 1842), *Phylloneura westermanni* (Selys, 1860), *Esme longistyla* Fraser,1931a (Protoneuridae), *Euphaea fraseri* (Laidlaw, 1920) (Euphaeidae), *Vestalis gracilis* (Rambur, 1842), and *V. apicalis* Selys, 1873(Calopterygidae) were restricted to one or two habitats. All the six endemic species were restricted to streams, myristica swamps and rivers. No endemic species were recorded from other habitats such as ponds, lakes, paddy fields and beaches (Fig.4).

Distribution across riparian landuse types

Species diversity varies across riparian landuse types. High species diversity and endemism were observed in streams flowing through evergreen forests, followed by plantations. Myristrica swamps, dry deciduous forests and beaches had low diversity (fig.5). Species such as *Diplacodes trivialis* (Rambur, 1842), *Ictinogomphus rapax* (Rambur, 1842), *Orthetrum sabina* (Drury,1770), *Agriocnemis pygmaea* (Rambur, 1842), *Copera vittata* Selys, 1863 and *Pantala flavescens* (Fabricius, 1798) were wide spread across riparian landuse types. On the other hand, species such as *Protosticta hearseyi* Fraser, 1922a, *Macromia indica* Fraser, 1924c, *Hylaeothemis frushtorferi* Fraser, 1924e and *Dysphaea ethala* Fraser, 1924e were restricted to one or two riparian landuse types. High endemism were observed in streams flowing through evergreen forests and Myristica swamps. Wetlands with dry deciduous forests and beaches were devoid of any endemic species (Fig.6).

Landuse Change and Odonata Diversity

Field observations reveal that agricultural expansion, riparian deforestation and organic pollution are most wide spread threats to odonate habitats in the region. These drivers of landuse and habitat changes influence the diversity of odonates. The change in Odonata community in different riparian and wetland ecosystems is summarized in Table-1. Families like Protoneuridae and Platystictidae are

very sensitive to habitat modifications and disappear completely when riparian forests are removed in evergreen and semi evergreen forests. On the other hand, Euphaeidae tolerate riparian modifications in evergreen forest zone and disappear completely in modified semievergreen forest zones. Maximum loss of Odonata community occurs due to riparian modifications of moist deciduous forests, where families Calopterygidae, Euphaeidae and Corduliidae disappear.

Dragonflies and Damselflies recorded in the study -

I SUBORDER : ZYGOPTERA

1 Family: Calopterygidae

1. *Neurobasis chinensis* (Linnaeus, 1758)
2 *Vestalis apicalis* Selys, 1873
3 *Vestalis gracilis* (Rambur, 1842)

2 Family: Chlorocyphidae

4 *Libellago lineata* (Burmeister, 1839)
5 *Rhinocypha bisignata* (Selys,1853)

3 Family: Coenagrionidae

6 *Agriocnemis pygmaea* (Rambur, 1842)
7 *Ceriagrion cerinorubellum* (Brauer, 1865)
8 *Ceriagrion coromandelianum* (Fabricius, 1798)
9 *Ceriagrion olivaceum* Laidlaw, 1914
10 *Ischnura aurora* Brauer, 1865
11 *Ischnura senegalensis* (Rambur, 1842)
12 *Pseudagrion microcephalum* (Rambur, 1842)

4 Family: Euphaeidae

13 *Dysphaea ethela* Fraser, 1924e
14 ***Euphaea fraseri*** (Laidlaw,1920)

5 Family: Lestidae

15 *Lestes elatus* Hagen in Selys,1862

6 Family :Platycnemididae

16 *Copera marginipes* (Rambur, 1842)
17 *Copera vittata* Selys,1863

7 Family:Platystictidae

18 ***Protosticta hearseyi*** **Fraser,1922a**

8 Family: Protoneuridae

19 *Disparoneura quadrimaculata* (Rambur,1842)
20 ***Esme longistyla*** Fraser,1931a
21 ***Phylloneura westermanni*** (Selys,1860)

II SUBORDER:ANISOPTERA

22 Family: Aeshnidae

23 *Anaciaeschna jaspidea* (Burmeister, 1839)
24 *Anax guttatus* (Burmeister, 1839)
25 *Anax immaculifrons* Rambur, 1842
26 *Gynacantha dravida* Lieftinck, 1960

10 Family:Gomphidae

27 *Ictinogomphus rapax* (Rambur, 1842)

11 Family:Libellulidae

28 *Acisoma panorpoides* Rambur, 1842
29 *Aethriamanta brevipennis* (Rambur, 1842)

30 *Brachydiplax sobrina* (Rambur, 1842)

31 *Brachythemis contaminata* (Fabricius,1793)

32 *Bradinopyga geminata* (Rambur, 1842)

33 *Cratilla lineata* Foerster,1903

34 *Crocothemis servilia* (Drury, 1770)

35 *Diplacodes trivialis* (Rambur,1842)

36 ***Epithemis mariae*** (Laidlaw,1915b)

37 ***Hylaeothemis fruhstorferi*** Fraser,1924e

38 *Lathrecista asiatica* (Fabricius, 1798)

39 *Neurothemis fulvia* (Drury, 1773)

40 *Neurothemis tullia* (Drury, 1773)

41 *Orthetrum glaucum* (Brauer, 1865)

42 *Orthetrum luzonicum* (Brauer, 1868)

43 *Orthetrum pruinosum* (Rambur, 1842)

44 *Orthetrum sabina* (Drury, 1770)

45 *Pantala flavescens* (Fabricius, 1798)

46 *Potamarcha congener* (Rambur, 1842)

47 *Rhyothemis variegata* (Linnaeus, 1763)

48 *Tetrathemis platyptera* Selys, 1878

49 *Tholymis tillarga* (Fabricius, 1798)

50 *Tramea limbata* Rambur,1842

51 *Trithemis aurora* (Burmeister, 1839)

52 *Trithemis festiva* (Rambur, 1842)

53 *Trithemis pallidinervis* (Kirby, 1889)

54 *Zyxomma petiolatum* Rambur, 1842

12 Family:Macromiidae

55 *Macromia indica* Fraser,1924c

(*Species marked in bold are endemic to the Western Ghats)

Discussion

The odonate fauna of coastal districts of Karnataka was extensively explored by Fraser[8,9]. During the present study, 55 species with[6] Western Ghats endemics were recorded. Frequency distribution of species shows that globally wide spread species such as *Pantala flavescens* (Fabricius, 1798), *Diplocodes trivialis* (Rambur, 1842), *Orthetrum sabina* (Drury,1770) (Libellulidae) are most common in all the study localities. In addition to this species such as *Rhynocypha bisignata* (Selys, 1853) (Chlorocyphidae) and *Euphaea fraseri* (Laidlaw, 1920) (Euphaeidae), which are restricted to the peninsular India, are locally very common. On the other hand, species such as *Dysphaea ethela* Fraser, 1924e (Euphaeidae), *Epithemis mariae* (Laidlaw, 1915b) (Libellulidae) and *Phylloneura westermanni* (Selys, 1860) (Protoneuridae) were recorded from only one locality. Highly restricted distribution of these species could be due to their specific habitat requirement. Species such as *Epithemis mariae* (Laidlaw, 1915b) (Libellulidae) and *Phylloneura westermanni* (Selys, 1860) are found

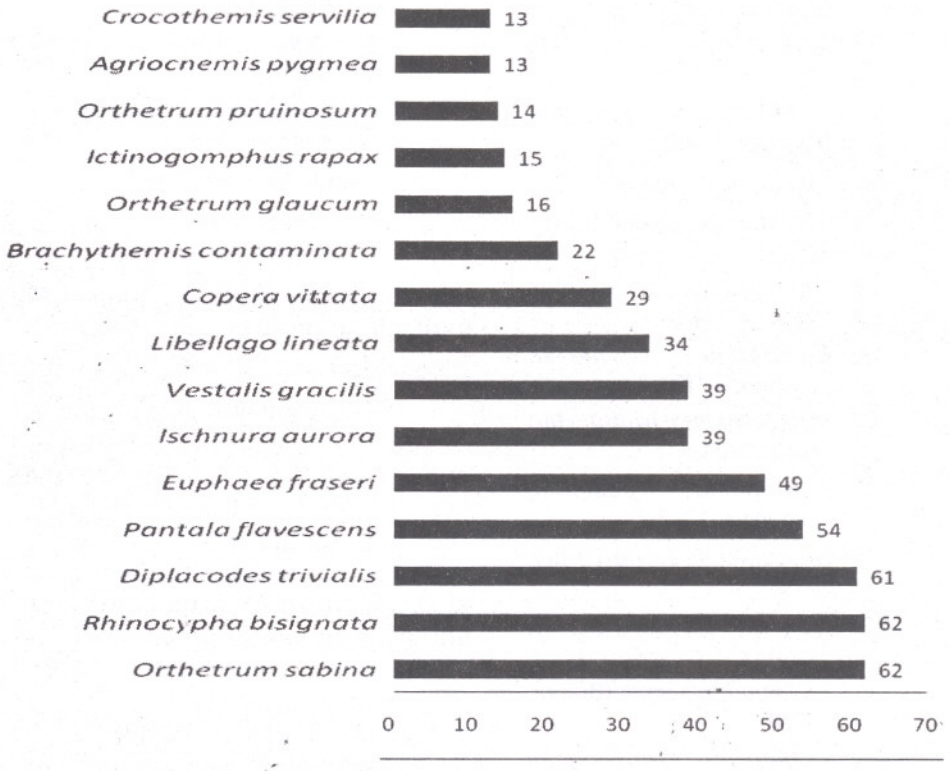


Fig .1. Frequency distribution of 15 most common species

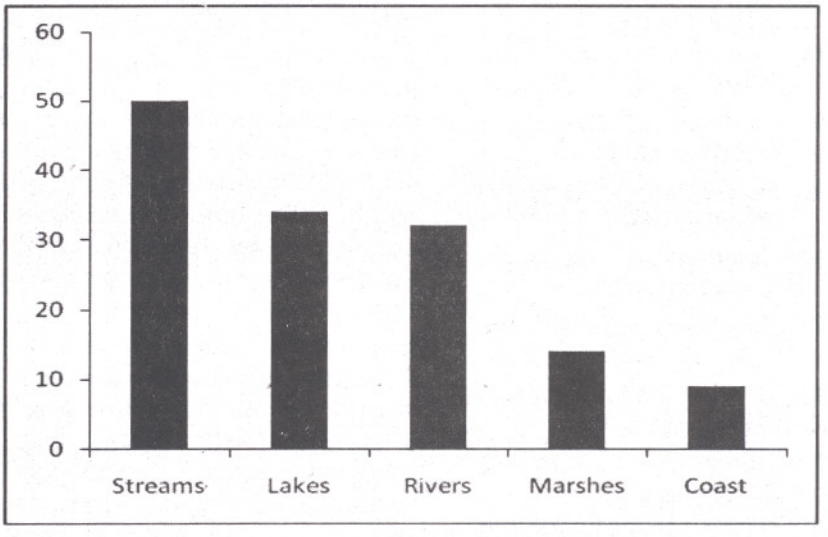


Fig. 2. Species richness across wetland types

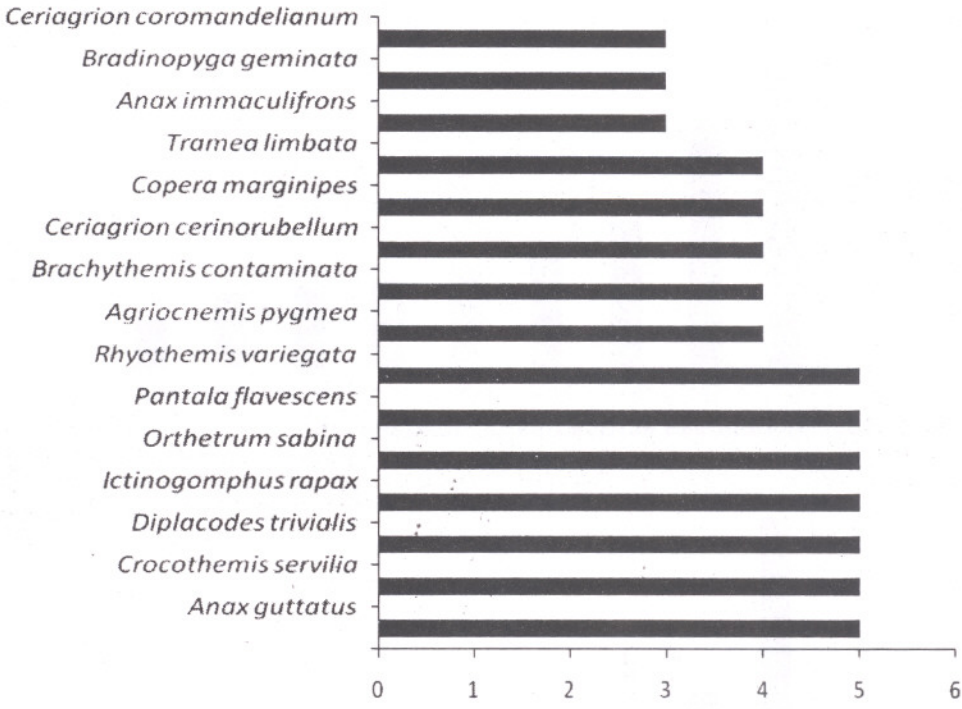


Fig. 3. Frequency distribution of 15 most common species across wetland habitats

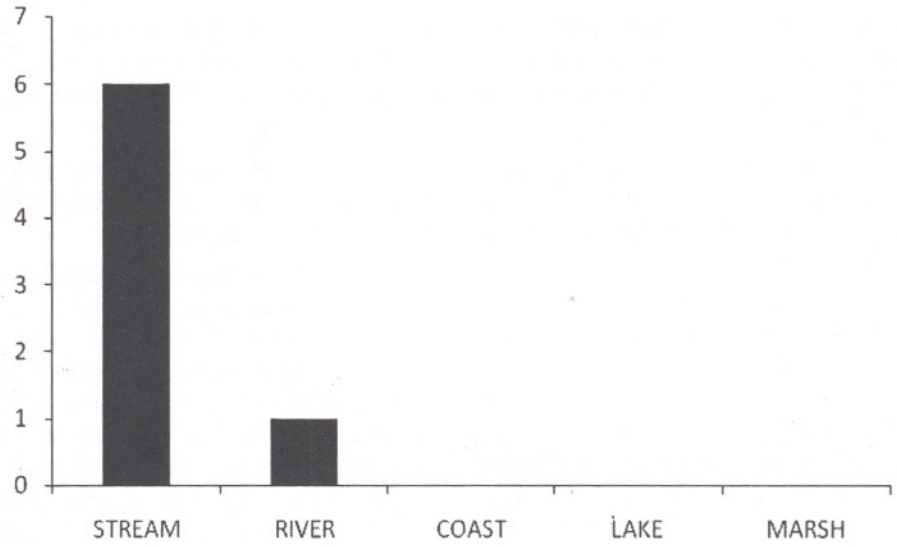


Fig . 4. Endemic species richenss across wetland types

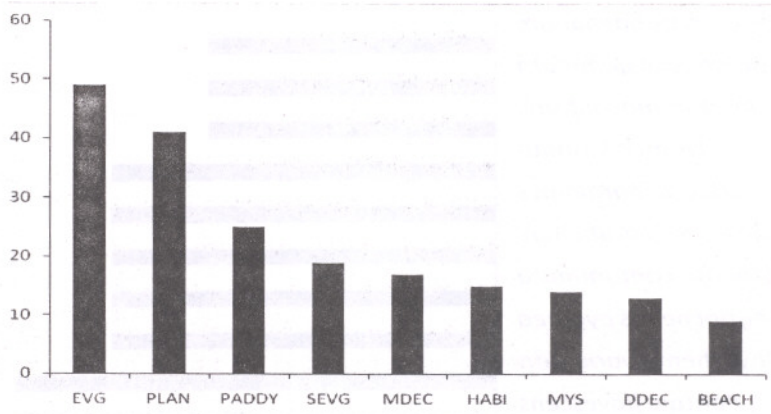


Fig. 5. Species richness across riparian landuse types

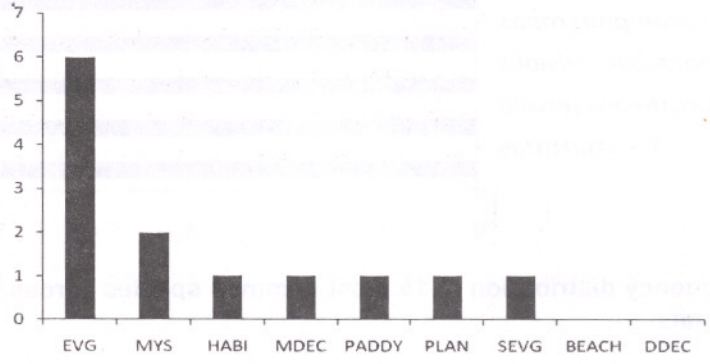


Fig.6. Endemic Species Richenss Across Riparian Landuse Types (EVG:Evergreen forests; PLAN:Plantations; SEVG:Semievergreen forests; MDEC: Moist Deciduous Forests; HABI: Habitations; MYS: Myristica Swamps; DDEC: Dry Deciduous Forests).

only in Myristica swamps and *Dysphaea ethela* Fraser, 1924e (Euphaeidae) in unpolluted fast flowing stream and rivers.

High species diversity was observed in streams and lakes. High diversity of lakes was due to the presence of wide spread species from Libellulidae. On the other hand, the streams were characterized by the presence of endemics and all the six endemics reported in the current study were recorded here. This pattern of high diversity and endemism in streams is very prevalent throughout the Western Ghats and the biological reasons remain elusive[1,2].

The family Libellulidae which was most species rich family (27 species) in the current study uses lentic habitats. High species richness and wide geographic spread of this family is probably related to its lentic habitat, which is widely available. This may be generalized to infer that lentic habitats, though may increase species richness of an area, can potentially encourage colonization of widespread generalists

Table 1: Odonata community change in relation to riparian landuse and wetland modifications.

Natural Riparian Ecosy-stem	Natural Wetland Ecosy-nity	Natural Odonata Commu-Ecosystem	Human Modified Riparian Ecosystem	Human Modified Wetland	Odonata Community Families)	Loss (No. Families)	Gain (No. stem
Evergreen Forests	Streams and Rivers	Protone -uridae, Plat-ystictidae, Euphaeidae Caloptery-gidae, Gomphidae, Corduliidae	Horticulture and Spice Plantations	Check Dams	Euphaeidae, Calopterygidae, Gomphidae, Corduliidae	2	0
Semi Evergreen Forests	Streams and Rivers	Euphaei-dae, Caloptery-gidae, Gomphidae, Corduliidae	Forestry Plantations, Agriculture	Check Dams	Calopterygidae, Coenagrionidae Gomphidae, Libellulidae.	1	1
Moist Deciduous Forests	Streams and Rivers	Euphaei-dae,Calop-terygidae, Aeshnidae, Gomphidae, Corduliidae, Libellulidae.	Forestry Plantations, Agriculture, Pastures	Check Dams	Aeshnidae Coenagrionidae Gomphidae, Libellulidae.	3	1
Coastal Swamps	Marshes	Aeshnidae Coenagrion-idae Gomphidae, Libellulidae.	Agriculture	Ponds and paddy fields	Aeshnidae Coenagrionidae Gomphidae, Libellulidae.	0	0

Methodologies for monitoring wetland health using odonates has been developed and currently being used in different parts of the world (Oertli, 2008; Chovanec and Waringer, 2001, Paul, 2005).

species such as libellulids.

High diversity and endemism were observed in streams flowing through evergreen forests. Though Myristica swamps had low diversity, it had high endemism with species such as Epithemis *mariae*, *Hylaeothemis frushtorferi* Fraser, 1924e (Libellulidae) and *Phylloneura westermanni* (Selys, 1860) (Protoneuridae) restricted to it.

This study shows that how Odonata community responds to change in riparian landuse. Recent

studies have shown that inland wetlands of the region are facing serious threats [28]. Regional scale destruction of riverine habitats by hydro-electric and irrigation projects threatens the survival of endemic odonates, which depend on fast flowing torrential streams. Many of the endemic odonates such as *Disparoneura apicalis* Fraser, 1924e (Protoneuridae), *Idionyx* sps (Cordulidae) and *Calocypha laidlawii* Fraser, 1924e (Chlorocyphidae) (not reported in the current study but reported in literature) are very narrowly distributed within the Western Ghats and destruction of alteration of a small catchment essentially means extinction of these species. Local scale impacts on riverine habitats such as check dams, draining of swamps, canalization, dumping of wastes and pesticide pollution alters the quality of habitats and promotes the colonization of generalist species such as libellulids. These small local scale habitat alterations are very wide spread throughout the study area and are very difficult to assess its long term impact on the endemic odonates.

In summary, the conservation of endemic odonates is directly linked to the conservation of riverine ecosystem of the region. Current conservation management measures of the region need to consider the importance of riverine ecosystems, especially the natural riparian zone. A conservation management programme focusing on threatened odonate habitats such as Myristica swamps and forest streams are very essential for long term conservation.

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