IDF

International Dragonfly Fund - Report

Journal of the International Dragonfly Fund

1- 13

Pankaj Koparde, Prosenjit Dawn & Apeksha Darshetkar

Odonates across a tropical urbanization gradient (Mula River, Pune, Maharashtra, India)

Published: 18.02.2019

128

ISSN 1435-3393

The International Dragonfly Fund (IDF) is a scientific society founded in 1996 for the improvement of odonatological knowledge and the protection of species.
Internet: http://www.dragonflyfund.org/

This series intends to publish studies promoted by IDF and to facilitate cost-efficient and rapid dissemination of odonatological data.

Editorial Work:	Rory A. Dow, Milen Marinov, Oleg. E. Kosterin, Frank Suhling, Martin Schorr
Layout:	Martin Schorr
IDF-home page:	Holger Hunger
Printing:	Colour Connection GmbH, Frankfurt
Impressum:	Publisher: International Dragonfly Fund e.V., Schulstr. 7B, 54314 Zerf, Germany. E-mail: oestlap@online.de
Responsible editor:	Martin Schorr

Cover picture:	***Acisoma panorpoides***
Photographer:	Pankaj Koparde

Published 18.02.2019

Odonates across a tropical urbanization gradient (Mula River, Pune, Maharashtra, India)

Pankaj Koparde[1,2,#,*], Prosenjit Dawn[3] and Apeksha Darshetkar[4]

[1]Indian Institute of Science Education & Research Tirupati, Andhra Pradesh, India
[2]Sálim Ali Centre for Ornithology & Natural History, Coimbatore, Tamil Nadu, India
[3]Department of Zoology, Shyampur Siddheswari Mahavidyalaya, Ajodhya, Howrah, West Bengal
[4]Department of Biodiversity, Abasaheb Garware College, Karve Road, Pune, Maharashtra, India
[*]Email: pankajkoparde@gmail.com
[#]Present address

Abstract

Globally urban wetlands are under high anthropogenic pressure of degradation. Urban wetlands are hotspots for species losses and rapid turnover in species assemblages. Therefore, studying such wetlands may provide an estimate of the pace of local extinction, concerning wetland-dependent species such as odonates. We undertook a study to document odonate species across a tropical urbanization gradient. We sampled six localities across the gradient across the Mula River that flows through the Pune City, India. We sampled adult odonates using a newly devised Half-circle Point Count method from September 2016 to March 2017. We took multiple temporal replicates per site. We also sampled larvae across six sites once in November 2016. We measured site characteristics such as canopy cover, solid waste, and water turbidity to understand the level of disturbance at each site. We recorded 41 odonates, six species (primarily Gomphidae members) exclusively from the larval sampling. We did not find the localization of species in a particular site across the urbanization gradient, possibly because we sampled a relatively short stretch of the river to capture the variation. Here, we update the Odonata list of Pune including data on larvae. We demonstrate that larval sampling complements Odonata surveys, especially in recording Gomphids. We recommend future research to include a longer time-span and extensive sampling area.

Key words: Gomphids, Larval sampling, Mula River, Species assemblage, Urban wetlands

Introduction

Globally freshwater wetland habitats are in crisis (Polhemus 1993, Clausnitzer et al. 2009). With an ever-expanding human population in tropical developing countries, anthropogenic pressure on freshwater wetlands is increasing day by day. Therefore, the protection and conservation of freshwater wetlands have become the need of the hour. Protection of such habitats is partially taken care by recommendations pro-

vided through Ecological Impact Assessments (EIAs). Many EIAs and other ecological studies rely on biological indicators for assessing habitat quality. Odonates are used as ecological indicators along with the other invertebrates (Gómez-Anaya & Novelo-Gutiérrez 2015, Valente-Neto et al. 2016, Martins et al 2017) for assessing freshwater habitats, for instance, determining the status of river and floodplain systems (Gerlach et al. 2013). Because of their high sensitivity to multiple environmental stressors such as pollutants and temperature changes, the impacts of urbanization on odonates could be drastic leading to displacement, reduction in population, and local extinction (reviewed in Villalobos-Jiménez et al. 2016). Cities necessarily modify the regional species pools (Goertzen & Suhling 2014). Depending upon the impacts of urbanization on freshwater ecosystems, the Odonata fauna in the cities may vary and therefore, cities have a good potential to host odonate diversity and conserve it. Having said this, species responses to their habitat may vary spatiotemporally. Therefore, it is of primary importance first to test if a species or a species assemblage can be used as a proxy of habitat quality it represents. Till now, most of the studies have focused on understanding the habitat and pollution responses of temperate odonates. There is scanty research material available, especially from tropical Asian countries. Kutcher & Bried (2014) show that for identifying indicator species, a thorough understanding of its habitat and pollution covariates is necessary. Koparde (2016) argue that species responses may change across regions and habitat parameters; therefore, it is mandatory to first understand the response of a range of such potential indicator species, before using them as a proxy of habitat health.

Another much overlooked issue in odonatological studies today is the use of non-standardized counting methods. Especially, in the case of India, there is not a single study mentioning standardization of sampling methods. All of the studies rely on transect and sweep net method which may not be the best-suited methods for standardized sampling of adult odonates. Studies pertaining to odonate diversity in India have so

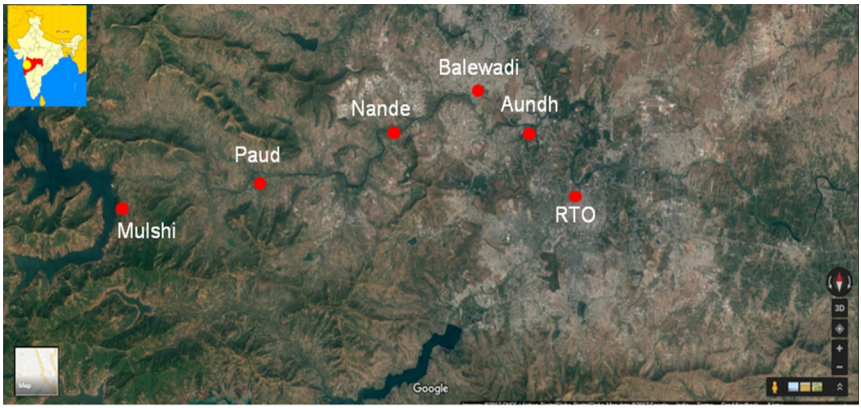

Figure 1. Map of selected sites of Mula River, Pune (Google Inc. 2017). The red dots indicate studied sites. Mulshi is the farthest site from urbanization. The white on the map indicates the built-up area.

far focused on adult odonates, except few on larvae (Prasad & Varshney 1995, Sharma & Rawat 2009). Since odonate larvae are underwater predators, they are the most sensitive odonate life stage when it comes to water quality. Apart from their ecological qualities, adult sampling if coupled with larval sampling can aid in better understanding the diversity of the region (Raebel et al. 2010, Bried et al. 2012, Kutcher & Bried 2014, Jeanmougin et al. 2014). Use of complementary methods in faunistic studies has been suggested to better capture the diversity, especially in the case of elusive groups such as Gomphidae (Almeida et al. 2013).

To further explore these ideas, we chose to work on the Mula River that flows across the metropolitan city of Pune in India. As a part of this project, we conducted a series of surveys to capture Odonata diversity across an urbanization gradient by sampling both adult odonates and larvae.

Material and Methods

1. Study Area

We used Bhuvan Portal maps (<http://bhuvan.nrsc.gov.in/bhuvan_links.php>) to assign the sites. We selected six sites along Mula River, Pune, India from Mulshi to RTO (Figures 1-3, Table 1), spread across a high to low urbanization land-use. Each site was five km apart (linear distance) from its adjacent sites. We assigned these sites considering the land-use around them. Sites which fall in the city centre or near to the city centre, having a heavy built-up area around were considered as highly urbanized (High Urbanization) and likewise we identified the urbanization gradient. We

Figure 2. Representative photograph of one of the sampled sites (Aundh) in a highly urbanized area. This part of the Mula River gets solid waste (including plastic bottles) directly thrown into the water by passersby. The green vegetation is *Lemna* spp. (Photograph: Pankaj Koparde).

Figure 3. Representative photograph of one of the sampled sites (Mulshi) in a low urbanized area, which is also the farthest site from the city centre. This part of the Mula River was cleanest as compared to all other sites. The site is surrounded by moist deciduous forest in hilly terrain. (Photograph: Pankaj Koparde).

Table 1. Site locations. On an urbanization gradient, Mulshi is the farthest from the Pune City centre.

Site	Lat	Long	Alt (masl)	Adult odonates sampled on	Number of samples
RTO	18.5351	73.8643	547	1 January 2017, 20 January 2017, 21 March 2017	3
Aundh (Fig. 2)	18.5687	73.8198	551	13 November 2016, 5 December 2016, 17 December 2016, 3 January 2017, 23 January 2017, 21 February 2017	6
Balewadi	18.5746	73.7512	551	21 November 2016, 8 January 2017, 14 January 2017, 29 January 2017, 19 March 2017	5
Nande	18.5577	73.7130	559	15 January 2017, 24 January 2017	2
Paud	18.5256	73.5999	566	14 November 2016, 17 January 2017, 5 February 2017, 23 March 2017	4
Mulshi (Fig. 3)	18.5269	73.5140	574	15 November 2016, 17 January 2017, 5 February 2017, 24 March 2017	4

Lat: Latitude; **Long:** Longitude; **Alt:** Altitude; **masl:** Meters above sea level.

measured the linear distance of each site from the city centre using the distance tool in Google Earth Pro 7.3.0.3832 (Google Inc. 2017). The number of sites was determined to best capture the identified urbanization gradient starting from pristine areas such as Mulshi (Low Urbanization) to highly polluted areas such as RTO (High Urbanization) over 25 km long stretch of the river.

2. Data Collection – Adult Odonates

We used Half-circle Point Count (HCPC) method to sample adult odonates after due standardization at one of the study sites (Aundh). We found that the HCPC technique as the most efficient technique in capturing the accurate estimate of species richness among four techniques compared, Full-width Belt Transect (FWBT), Half-width Belt Transect (HWBT), Full-circle Point Count (FCPC), and Half-circle Point Count (HCPC) (details in Darshetkar et al. unpublished data). We sampled adult odonates during 0900-1100 hrs (September 2016 to April 2017), following Kulkarni & Subramanian (2013).

Figure 4. The scoop-net method was used to catch odonate larvae. In the photograph above, PD is sampling larvae at Paud site. (Photograph: Pankaj Koparde).

Figure 5. The debris collected in the scoop-net was transferred to a white porcelain tray and odonate larvae were picked using a pair of pointed forceps. In the photograph, PK and PD are sorting odonate larvae caught at Aundh site. (Photograph: Apeksha Darshetkar).

Figure 6. The yield of a scoop obtained at Paud site. The tray contains Libellulidae and Macromiidae members, along with *Pseudagrion* and *Agriocnemis* (Photograph: Pankaj Koparde).

We took multiple temporal replicates at each site. For identification, we followed Fraser (1933, 1934, 1936).

3. Data Collection – Larvae and Exuviae

For sampling larvae, we used scoop-net method (Figure 4). At each site we sampled larvae at three places taking two scoops of 3 m in length, making it six scoops at each site. We transferred the contents of the scoop to a tray and then slowly removed the debris. We picked odonate larvae using a pair of pointed forceps and transferred them to another tray containing water (Figures 5, 6). Finally, we transferred individual larvae to a vial containing Ethanol for preservation purpose. We also collected exuviae occasionally. Due to a limited budget, we could sample odonate larvae only once (November 2016) across the six sites. We followed Kumar (1973a, b), Fraser (1919) and reference specimens reared by PD for identification.

4. Data Collection – Site Characteristics

We collected data on canopy cover, solid waste, and water turbidity at five point count stations randomly picked per visit per site. We measured the canopy cover using a densitometer. For estimating water turbidity, we collected the surface water in a glass flask, allowed the water to settle for two minutes, and then estimated water turbidity on a categorical scale (absent, low, medium, and high). For calculating solid waste we counted floating garbage piles and categorized the degree of solid waste into four categories – absent (no piles), low (0-5 piles), medium (5-20 piles), high (>20 piles).

Table 2: Site characteristics.

Site	Linear distance from the city centre (km)	Surrounding land-use	Average canopy cover (%)	Water turbidity	Solid waste	Adult odonate species recorded	Odonate larvae species recorded
RTO	2	Highly populated built-up zone	2	High	High	21	10
Aundh (Fig. 2)	7	Highly populated built-up zone	11	High	Medium	17	9
Balewadi	13	Less populated rural zone	36	Medium	Low	16	5
Nande	16	Agricultural farmland and less populated rural zone	58	High	Low	17	8
Paud	27	Agricultural farmland and less populated rural zone	6	Low	Medium	15	11
Mulshi (Fig. 3)	36	Agricultural farmland	38	Low	Low	15	6

Lat: Latitude; **Long:** Longitude; **Alt:** Altitude; **masl:** Meters above sea level.

Discussion and Results

Average data of canopy cover and modal values of solid waste and water turbidity per site are presented in Tab. 2. The values for water turbidity and solid waste changed from high to low with respect to the distance of the site from the city centre. During the adult odonate sampling, we recorded 22 odonates (dragonflies = 13, damselflies = 9) on point counts. From our casual observations outside sampling at the sites, we gathered data for fifteen additional species. From our larval sampling, we recorded 19 species (dragonflies = 13, damselflies = 6) including two species that we could not identify. A complete list of odonates observed is provided in Table 3 (see appendix). From the larval sampling, we recorded six taxa which we could not prove through adult odonate sampling. These taxa are *Burmagomphus* cf. *pyramidalis*, *Macrogomphus annulatus*, *Macromia* sp., *Paragomphus lineatus*, *Zyxomma petiolatum*, and *Pseudagrion* sp. (other than *P. decorum*, *P. microcephalum*, and *P. rubriceps*). Data for these species except *M. annulatus* is only available from the old literature (Fraser 1934, Prasad 1996), recent studies (Kulkarni & Subramanian 2013, Koparde 2016) have not recorded these species from Pune. Even for the present study with extensive and repetitive adult odonate sampling at six sites, we could not capture the species data that we did by larval sampling. Therefore, our results underscore the need to include complementary method/s such as larval sampling in Odonata diversity studies to capture an accurate representation of the species richness as done elsewhere (Almeida et al. 2013).

Most gomphids found during the study were in the early instars. Despite being the most populated and polluted with solid wastes RTO site shows a high number of adult odonate species, whereas Mulshi being situated in the comparatively cleaner region has less number of species recorded. This may be due to the disparity in the habitats present and the prey base supported in the different sites. One possibility is that adult

odonates do not perceive the water quality strongly and therefore may persist in polluted sites. We found that in comparatively polluted areas there is an indication of species aggregation near the pockets with comparatively better condition. We found that presence of leaf-litter and plenty of aquatic vegetation caused number of damselfly species to be more in Nande but in Mulshi where sandy and rocky riverbed predominates, despite being far from the city and being less polluted the larval density and diversity is considerably less. Based on broader material, e.g. Souza et al. (2015) found that high (γ-)diversity and distribution of Odonata were associated with habitat heterogeneity in streams. However, the abiotic variables also seem to affect the distribution of Odonata species, in view of the impact of the land use in the vicinity of streams.

Some species such as *Tholymis tillarga* and *Brachythemis contaminata* were frequently found in turbid polluted water. Both the species breed in standing water such as weedy ponds and sluggish water (Fraser 1936, Subramanian 2009). In a river system, turbidity may introduce sluggishness and that is possibly the reason these species occur in such areas. Another possibility is their prey base which could be weed-related insects.

We expected that habitat sensitive species such as endemic species (Babu et al. 2013, Koparde et al. 2015) will aggregate in areas with cleaner water, away from the city, and pollution tolerant species will be encountered across all the sites. We did not find clustering of species or species exclusivity at any site, in adult odonate sampling (Darshetkar et al. unpublished data). Most of the species were observed at all the sites (Table 3). Most of the species recorded were generalists and widespread as per Fraser (1933, 1934, 1936) and Subramanian (2009). For a few species, there was no information available. We took multiple temporal replicates (2 to 6) at each site, separated by a month's interval, to avoid sampling error. The pattern observed here is possible because we chose sites which are in a similar land-use type for such a study. Across all the sites, although the degree of urbanization changed, the bio-climate, elevation, and macro-habitats were comparable. In the case of larval sampling, since the sampling duration was small and we could not take temporal replicates, no conclusions can be drawn from the data.

The present study was successful in recording and updating the list of odonates of the Pune City, and supporting the role of larval data in Odonata diversity studies. This study can be further improvised by including a larger area in sampling and taking temporal replicates in larval sampling. We hope to continue the research and would like to ask others to replicate this study at other locations to gather information on the role of urbanization in influencing odonate assemblages.

Acknowledgements

We would like to thank the International Dragonfly Fund for the project funds. We are thankful to various concerned citizens who helped us raise additional funds through BitGiving. We would like to thank Arjit Jere, Vedant Dixit, and Sachin Kamble for their help on the field. Thanks are due to Dr Ankur Patwardhan and the staff at the Department of Biodiversity, Abasaheb Garware College (Pune, India) to provide lab-support.

References

Almeida, M.V.O.D.; Pinto, Â.P.; Carvalho, A.D.L.; Takiya, D.M. (2013). When rare is just a matter of sampling: unexpected dominance of clubtail dragonflies (Odonata, Gomphidae) through different collecting methods at Parque Nacional da Serra do Cipó, Minas Gerais State, Brazil. Revista brasileira de Entomologia 57(4): 417-423.

Babu, R.; Subramanian, K.A.; Supriya Nandy. (2013). Endemic Odonates of India, Records of Zoological Survey of India, Occasional Paper No. 347: 1-60.

Bried, J.T.; D'Amico, F.R.A.N.K.; Samways, M.J. (2012). A critique of the dragonfly delusion hypothesis: why sampling exuviae does not avoid bias. Insect Conservation and Diversity 5(5): 398-402.

Clausnitzer, V.; Kalkman, V.J.; Ram, M.; Collen, B.; Baillie, J.E.M.; Bedjanic, M.; Darwall, W.R.T.; Dijkstra, K.D.; Dow, R.; Hawking, J.; Karube, H.; Malikova, E.; Paulson, D.; Schütte, K.; Suhling, F.; Villanueva, R.J.; von Ellenrieder, N.; Wilson, K. (2009): Odonata enter the biodiversity crisis debate: The first global assessment of an insect group. Biological Conservation 142(8): 1864-1869.

Fraser, F. C. (1933). The fauna of British India, including Ceylon and Burma. Odonata Vol. I. Taylor and Francis, England. 439 pp.

Fraser, F. C. (1934). The fauna of British India, including Ceylon and Burma. Odonata Vol. II. Taylor and Francis, England. 430 pp.

Fraser, F. C. (1936). The fauna of British India, including Ceylon and Burma. Odonata Vol. III. Taylor and Francis, England. 485 pp.

Fraser, F.C. (1919). Description of new Indian Odonata larvae and Exuviae. Records of the Indian Museum 16: 459-467.

Gerlach, J.; Samways, M.; Pryke, J. (2013). Terrestrial invertebrates as bioindicators: an overview of available taxonomic groups. Journal of Insect Conservation 17(4): 831-850.

Goertzen, D.; Suhling, F. (2015). Central European cities maintain substantial dragonfly species richness–a chance for biodiversity conservation? Insect Conservation and Diversity 8(3): 238-246.

Gómez-Anaya, J.A.; Novelo-Gutiérrez, R. (2015). A case of successful restoration of a tropical wetland evaluated through its Odonata (Insecta) larval assemblage. International Journal of Tropical Biology and Conservation 63(4): 1043-1058.

Google Inc. (2017). Google Earth Pro 7.3.0.3832. Accessed from <https://www.-google.com/earth/download/gep/agree.html> on 19 January 2017.

Jeanmougin, M.; Leprieur, F.; Loïs, G.; Clergeau, P. (2014). Fine-scale urbanization affects Odonata species diversity in ponds of a megacity (Paris, France). Acta Oecologica 59: 26-34.

Koparde, P. (2016). Damsels in distress–seasons, habitat structure and water pollution changes damselfly diversity and assemblage in urban wetlands. Animal Biology 66(3-4): 305-319.

Koparde, P.; Mhaske, P.; Patwardhan, A. (2015). Habitat correlates of Odonata species diversity in the northern Western Ghats, India. Odonatologica 44(1): 21-43.

Kulkarni, A.; Subramanian, K.A. (2013). Habitat and seasonal distribution of Odonata (Insecta) of Mula and Mutha river basins, Maharashtra, India. Journal of threatened Taxa 5: 4084-4095.

Kumar, A. (1973a). Description of the last instar larvae of Odonata from Dehra Dun Valley (India), with notes on biology I. (Suborder: Zygoptera). Oriental Insects 7(1): 83-118.

Kumar, A. (1973b). Description of the last instar larvae of Odonata from Dehra Dun Valley (India), with notes on biology II. (Suborder: Anisoptera). Oriental Insects 7(2): 291-331.

Kutcher, T.E.; Bried, J.T. (2014). Adult Odonata conservatism as an indicator of freshwater wetland condition. Ecological Indicators 38: 31-39.

Martins, R.T.; Couceiro, S.R.M.; Melo, A.S.; Moreira, M.P.; Hamada, N. (2017). Effects of urbanization on stream benthic invertebrate communities in Central Amazon. Ecological Indicators 73: 480-491.

Polhemus, D.A. (1993). Conservation of aquatic insects: worldwide crisis or localized threats? American Zoologist 33: 588-598.

Prasad, M. (1996). An account of the Odonata of Maharashtra state, India. Records of the Zoological Survey of India 95(3-4): 305-327.

Prasad, M.; Varshney, R.K. (1995). A check-list of the Odonata of India including data on larval studies. Oriental Insects 29(1): 385-428.

Raebel, E.M., Merckx, T.; Riordan, P.; Macdonald, D.W.; Thompson, D.J. (2010). The dragonfly delusion: why it is essential to sample exuviae to avoid biased surveys. Journal of Insect Conservation 14(5): 523-533.

Sharma, R.C.; Rawat, J.S. (2009). Monitoring of aquatic macroinvertebrates as bioindicator for assessing the health of wetlands: A case study in the Central Himalayas, India. Ecological Indicators 9(1): 118-128.

Souza, A.M.; Fogaça, F.N.O.; Cunico, A.M.; Higuti, J. (2015). Does the habitat structure control the distribution and diversity of the Odonato fauna? Brazilian Journal of Biology 75(3): 598-606.

Subramanian, K.A. (2009). Dragonflies of India – a Field Guide. Vigyan Prasar, New Delhi. 180 pp.

Subramanian, K.A.; Babu, R. (2017). A checklist of Odonata (Insecta) of India. Version 3.0. Accessed from <https://www.zsi.in> on 19 January 2017.

Valente-Neto, F.; Roque, F.; Rodrigues, M.E.; Juen, L.; Swan, C.M. (2016). Toward a practical use of Neotropical odonates as bioindicators: Testing congruence across taxonomic resolution and life stages. Ecological Indicators 61(2): 952-959.

Villalobos-Jimenez, G.; Dunn, A.; Hassall, C. (2016). Dragonflies and damselflies (Odonata) in urban ecosystems: a review. European Journal of Entomology 113: 217-232.

Figure 7. River Heliodor *Libellago lineata* male specimen photographed at Nande. The occurrence of *L. lineata* was occasional and rare during the study. (Photograph: Pankaj Koparde)

Figure 8. Black-winged Bambootail *Disparoneura quadrimaculata* male specimen photographed at Nande. *D. quadrimaculata* was sighted in a small rocky patch at Nande locality exclusively. (Photograph: Pankaj Koparde).

Figure 9. Trumpet Tail *Acisoma panorpoides* male specimen photographed at Aundh. (Photograph: Pankaj Koparde).

Figure 10. Coral-tailed Cloud-Wing *Tholymis tillarga* male specimen photographed at RTO (Photograph: Pankaj Koparde). Plenty of *Tholymis* larvae were found emerging from the water near a highly polluted water treatment plant at this site.

Figure 11: *Macromia* sp. larva from the Paud site. The spidery long legs indicate its family Macromidae and a horn like projection between two antennae and spoon like labium indicates its genus to be *Macromia*. (Photograph - Prosenjit Dawn).

Appendix

Table 3. List of species recorded during the survey. PTS: Pollution Tolerance Status – TOL: Tolerant, SEN: Sensitive, MR: Moderate Response. *off-sampling observations, A = presence as adult odonate, L = presence as odonate larva. The list follows Subramanian (2017).

Family name	Species name	Aundh	Balewadi	Nande	Mulshi	Paud	RTO	PTS
Zygoptera – Damselflies (n=16)								
Chlorocyphidae (n=2)	*Heliocypha bisignata* (Hagen in Selys, 1853)*			A				SEN
	Libellago lineata (Burmeister, 1839) (Fig. 7)			A				SEN
Coenagrionidae (n=10)	*Ceriagrion coromandelianum* (Fabricius, 1798)	A	A	A	A	A	A	TOL
	Agriocnemis pygmaea (Rambur, 1842)	A	A	A	A, L	A, L	A, L	TOL
	Agriocnemis splendidissima (Laidlaw 1919)*			A		A		SEN
	Ischnura senegalensis (Rambur, 1842)			A	A		A	TOL
	Ischnura aurora (Brauer, 1865)*	L		L	A	A	L	TOL
	Pseudagrion decorum (Rambur, 1842)	A	A	L		A, L	A, L	TOL
	Pseudagrion hypermelas Selys, 1876					A		SEN
	Pseudagrion microcephalum (Rambur, 1842)*			A				SEN
	Pseudagrion rubriceps Selys, 1876	A, L	A	A	A, L	A, L	A, L	TOL
	Pseudagrion sp.					L		SEN
Platycnemididae (n=4)	*Elattoneura nigerrima* (Laidlaw, 1917)*				A			SEN
	Disparoneura quadrimaculata (Rambur, 1842) (Fig. 8)			A	A			SEN
	Copera vittata Selys, 1863*				A	A		MR
	Copera marginipes (Rambur, 1842)*		A	A, L	A, L		L	TOL
Anisoptera – Dragonflies (n=25)								
Aeshnidae (n=1)	*Anax guttatus* (Burmeister, 1839)	A	A	A		A	A	TOL
Gomphidae (n=4)	*Burmagomphus pyramidalis Laidlaw, 1922*					L		SEN
	Ictinogomphus rapax (Rambur 1842)	A, L	A, L			L	A	TOL
	Macrogomphus annulatus (Selys, 1854)					L		SEN
	Paragomphus lineatus (Selys, 1850)			L	L			SEN
Libellulidae (n=18)	*Acisoma panorpoides* Rambur, 1842* (Fig. 9)	A					A	TOL
	Brachythemis contaminata (Fabricius, 1793)	A, L	A, L	L	A	A, L	A, L	TOL
	Bradinopyga geminata (Rambur, 1842)*		A					MR
	Crocothemis servilia (Drury, 1770)	A, L	A, L	A, L	A	A, L	A, L	TOL
	Diplacodes trivialis (Rambur, 1842)*	A					A, L	TOL
	Orthetrum pruinosum (Burmeister, 1839)	A	A	A	L	A	A, L	TOL
	Orthetrum sabina (Drury, 1770)	A	A	A	A	A	A	TOL
	Orthetrum taeniolatum (Schneider, 1845)*		A					MR
	Pantala flavescens (Fabricius, 1798)	A	A	A	A	A	A	TOL
	Rhyothemis variegata (Linnaeus, 1763)	A					A	TOL
	Tholymis tillarga (Fabricius, 1798)* (Fig. 10)	L	L	L			A	TOL
	Tramea basilaris (Palisot de Beauvois, 1805)	A					A	TOL
	Tramea limbata (Desjardins, 1832)*						A	TOL
	Trithemis aurora (Burmeister, 1839)	L	A, L	A	A	A	A	TOL
	Trithemis festiva (Rambur, 1842)	L	A	A		L	A	TOL
	Trithemis pallidinervis (Kirby, 1889)	A						TOL
	Urothemis signata (Rambur, 1842)*						A	TOL
	Zyxomma petiolatum Rambur, 1842	L		L	L		L	TOL
Macromiidae (n=2)	*Epophthalmia vittata* Burmeister 1839*	A			A			MR
	Macromia sp. (Fig. 11)					L		SEN

PTS: Pollution Tolerance Status – **TOL:** Tolerant, **SEN:** Sensitive, **MR:** Moderate Response. *off-sampling observations, **A** = presence as adult odonate, **L** = presence as odonate larva. The list follows Subramanian (2017).

INSTRUCTION TO AUTHORS

International Dragonfly Report is a journal of the International Dragonfly Fund (IDF). It is referred to as the journal in the remainder of these instructions. Transfer of copyright to IDF is considered to have taken place implicitly once a paper has been published in the journal.

The journal publishes original papers only. By original is meant papers that: a) have not been published elsewhere before, and b) the scientific results of the paper have not been published in their entirety under a different title and/or with different wording elsewhere. The republishing of any part of a paper published in the journal must be negotiated with the Editorial Board and can only proceed after mutual agreement.

Papers reporting studies financially supported by the IDF will be reviewed with priority, however, authors working with Odonata from the focal area (as defined on the back page of the front cover) are encouraged to submit their manuscripts even if they have not received any funds from IDF.

Manuscripts submitted to the journal should preferably be in English; alternatively German or French will also be accepted. Every manuscript should be checked by a native speaker of the language in which it is written; if it is not possible for the authors to arrange this, they must inform the Editorial Board on submission of the paper. Authors are encouraged, if possible, to include a version of the abstract in the primary language of the country in which their study was made.

Authors can choose the best way for them to submit their manuscripts between these options: a) via e-mail to the publisher, or b) on a CD, DVD or any other IBM-compatible device. Manuscripts should be prepared in Microsoft Word for Windows.
While preparing the manuscript authors should consider that, although the journal gives some freedom in the style and arrangements of the sections, the editors would like to see the following clearly defined sections: Title (with authors names, physical and e-mail addresses), Abstract, Introduction, Material & Methods, Results, Discussion, Acknowledgments and References. This is a widely used scheme by scientists that everyone should be familiar with. No further instructions are given here, but every author should check the style of the journal.

Authors are advised to avoid any formatting of the text. The manuscripts will be stylised according to the font type and size adopted by the journal. However, check for: a) all species names must be given in italic, b) the authority and year of publication are required on the first appearance of a species name in the text, but not thereafter, and c) citations and reference list must be arranged following the format below.

Reference cited in the text should read as follows: Tillyard (1924), (Tillyard 1924), Swezey & Williams (1942).

The reference list should be prepared according to the following standard:
Swezey, O. & F. Williams, 1942. Dragonflies of Guam. Bernice P. Bishop Museum Bulletin 172: 3-6.
Tillyard, R., 1924. The dragonflies (Order Odonata) of Fiji, with special reference to a collection made by Mr. H.W. Simmonds, F.E.S., on the Island of Viti Levu. Transactions of the Entomological Society London 1923 III-IV: 305-346.

Citations of internet sources should include the date of access.

The manuscript should end with a list of captions to the figures and tables. The latter should be submitted separately from the text preferably as graphics made using one of the Microsoft Office products or as a high resolution picture saved as a .jpg .tif or .ps file. Pictures should be at least 11 cm wide and with a minimum 300 dpi resolution, better 360 dpi. Line drawings and graphics could have 1200 dpi for better details. If you compose many pictures to one figure, please submit the original files as well. Please leave some space in the upper left corner of each picture, to insert a letter (a, b, c...) later. Hand-made drawings should be scanned and submitted electronically. Printed figures sent by the post could be damaged, in which case authors will be asked to resubmit them.

Manuscripts not arranged according to these instructions may also be accepted, but in that case their publication will be delayed until the journal's standards are achieved.