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Title: Studies on phylogeny and biogeography of damselflies (Odonata) with emphasis on the Argiolestidae
Issue Date: 2013-12-19

2. ODONATA ENTER THE BIODIVERSITY CRISIS DEBATE:

THE FIRST GLOBAL ASSESSMENT OF AN INSECT GROUP

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

The status and trends of global biodiversity are often measured with a bias towards datasets limited to terrestrial vertebrates. The first global assessment of an insect order (Odonata) provides new context to the ongoing discussion of current biodiversity loss. A randomly selected sample of 1500 (26.4%) of the 5680 described dragonflies and damselflies was assessed using IUCN's Red List criteria. Distribution maps for each species were created and species were assigned to habitat types. These data were analysed in respect to threat level for regions and habitat types. We have found that one in 10 species of dragonflies and damselflies is threatened with extinction. This threat level is among the lowest of groups that have been assessed to date, suggesting that previous estimates of extinction risk for insects might be misleading. However, Odonata only comprise a small invertebrate order, with above-average dispersal ability and relatively wide distribution ranges. For conservation science and policy to be truly representative of global biodiversity a representative cross-section of invertebrates needs to be included.

INTRODUCTION

The loss of biodiversity that the world faces today dominates recent scientific and popular publications (Myers & Knoll 2001, Pimm & Brooks 2000). Long-term projections leave little hope for as many as half the species on earth (Jenkins 2003, Pimm et al. 1995, Pimm & Brooks 2000).
But forecasts of biodiversity change are often based on unrepresentative data sets of limited taxonomic scope. Until recently, the most widely used and comprehensive conservation assessments have been for three vertebrate groups only (i.e. mammals, birds and amphibians) (Ceballos & Ehrlich 2006, Stattersfield & Capper 2000, Stuart et al. 2004), while the highest extinction risk and therefore greatest loss of biodiversity is expected to be suffered by invertebrates (Thomas et al. 2004, Hadfield 1993), specifically insects (Dunn 2005). However, knowledge of the threat status of invertebrates is limited, and therefore rarely considered in measures of global biodiversity change, although evidence suggests they might respond in different ways to anthropogenic threat (Thomas et al. 2004). Since invertebrates are more specious than vertebrates and in most cases less well known, the task of comprehensively assessing their conservation status is both challenging and time-consuming. In the short-term a more feasible sampled

approach has been developed which increases the taxonomic coverage of the Red List through inclusion of representative subsets of invertebrates and plants, so providing a more representative indicator for the status of biodiversity (Baillie et al. 2008).

The IUCN Red List of Threatened Species™, www.iucnredlist.org (herein Red List) (IUCN 2008) has been documenting the threat status of flora and fauna for more than 40 years and is widely considered to be the most comprehensive dataset on the conservation status of species worldwide (Rodrigues et al. 2006). Here we show the status of the first insect order to be assessed on a representative global scale for the IUCN Red List of Threatened Species: A randomly selected subsample (26.4%) of all dragonflies and damselflies (Odonata) (Baillie et al. 2008). Until now only a selection of vertebrate taxa, the reef-building corals (Carpenter et al. 2008), the freshwater crabs (Cumberlidge et al. 2009) and a few plant groups (e.g. cycads and conifers) are adequately represented in the Red List (Baillie et al. 2004). Forty-two percentage of the described vertebrates have been assessed for the Red List, whereas only 0.3% of invertebrates have been assessed to date (IUCN 2007). This discrepancy needs to be rectified if any acceptable level of understanding of the status of the world's species is to be sought. The current focus on vertebrates may provide a limited and highly biased view of species extinction risk. Previous massextinctions have shown that an extrapolation from vertebrates to invertebrates (Labandeira & Sepkoski 1993) may not be applicable.

With the exception of Antarctica, Odonata are widespread and abundant on all continents, although centres of species richness typically occur in tropical forests (Kalkman et al. 2008). Odonata spend their larval life in aquatic habitats and use a wide range of terrestrial habitats as adults. The larvae are critical in regard to water quality and aquatic habitat morphology such as bottom substrate and aquatic vegetation structure. Adult habitat selection is strongly dependent on vegetation structure, including degrees of shading. As a consequence dragonflies show strong responses to habitat change such as thinning of forest and increased erosion. Ubiquitous species prevail in disturbed or temporary waters, while pristine streams, seepage and swamp forests harbour a wealth of more vulnerable, often localised species. Different ecological requirements are linked to different dispersal capacities. Species with narrow niches often disperse poorly, while pioneers of temporal habitats (often created by disturbance) are excellent colonisers, making Odonata a particularly good group for evaluating habitat connectivity. In summary, Odonata are an easy-to-study group and are useful for monitor the overall biodiversity of aquatic habitats and have been identified as good indicators of environmental health (Corbet 1999, Kalkman et al. 2008).

METHODS

Red List assessments

From a comprehensive list of the 5680 described extant Odonata (Kalkman et al. 2008), 2000 species were sampled at random, of which 1500 (26.5%) were used for conservation assessment. The selected species were checked for their taxonomic status by specialists and if necessary replaced by another species from the same realm and family from the additionally 500 randomly selected species. The sample size of 1500 is a manageable subset to be assessed, which is taxonomically and geographically representative of the whole group (Baillie et al. 2008). We used the Red List Categories and Criteria of the International Union for Conservation of Nature to determine the global threat status of Odonata species (IUCN 2001). The combined expertise of a large international network of Odonata specialists was employed to assess the species, and then each assessment was peer-reviewed by two independent experts. The Red List Categories and Criteria (IUCN 2001) have been widely used and constitute a well-established system, which in an objective framework determines the threat status of

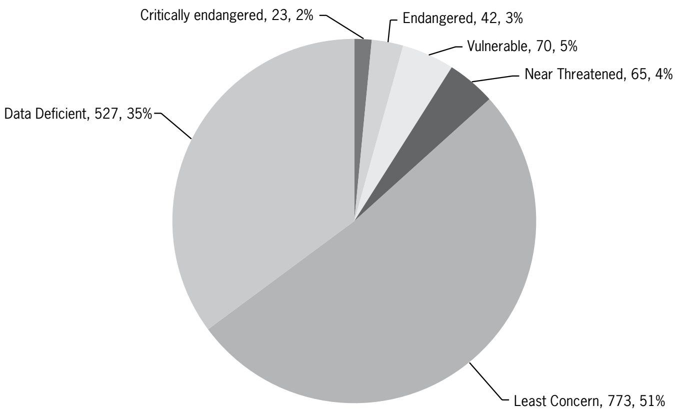

Figure 1. Global extinction risk of Odonata. Total numbers and percentage of Odonata assigned to a Red List Category (n total species = 1500).

a broad range of species (see Mace et al. 2008 for an updated and critical overview). The Red List Categories and Criteria use quantitative measures to classify species into categories of extinction risk according to measures of distribution, population abundance trends, rate of decline, geographic range information, and fragmentation (see Rodrigues et al. 2006). Categories range from "Least Concern" with very little probability of extinction to high risk "Critically Endangered". The "threatened" categories (Vulnerable, Endangered, Critically Endangered) often serve as a key piece of information used in setting priority measures for biodiversity conservation.

Analysis of geographical patterns and habitat associations

Distribution maps for each species were created, based on point locality data, from which broad polygons that join the known locations were drawn (see Schipper et al. 2008 for detailed methods). Range maps were mapped onto a hexagonal grid of the world (each cell approximately 22,300 km^2). This means that data were analysed using a geodesic discrete global grid system, defined on an icosahedron and projected to the sphere using the inverse Icosahedral Snyder Equal Area (ISEA) Projection. This corresponds to a hexagonal grid composed of individual units (cells) that retain their shape and area (approximately 22,300 km^2) throughout the globe. These are more suitable for a range of ecological applications than the most commonly used rectangular grids. Threatened species richness was then calculated for each cell, relative to the richest cell (nine threatened species). Distribution maps were used to assign each species to biogeographic realms. Further data on broad habitat type (lentic and lotic for the aquatic larval habitats; forest, shrubland and grassland for the habitats adjacent to the larval habitats) were collated for each species in the assessment process and number of species per habitat type was analysed.

RESULTS

More than half of the Odonata species were listed as Least Concern (fig. 1). One in 10 species was found to be threatened (assigned an IUCN Red List category of critically endangered, endangered, or vulnerable), while 35% had to be listed as Data Deficient (fig. 1). Odonate species richness is clustered in the Neotropical and Indo-Malayan realms, which contain almost 60% of the world's Odonata diversity (fig. 2). Threatened species are as well clustered in tropical areas, especially in the Indo-Malayan realm (fig. 3). The lowest threat level is found in the Nearctic realm, with about 80% of the species listed in the Least Concern Category. The Oceanic realm harbours the lowest species number, but at the same time the highest number listed as Data Deficient (fig. 2).
The majority of the Odonata species depends on lotic (flowing) waters and on forest (fig. 4).

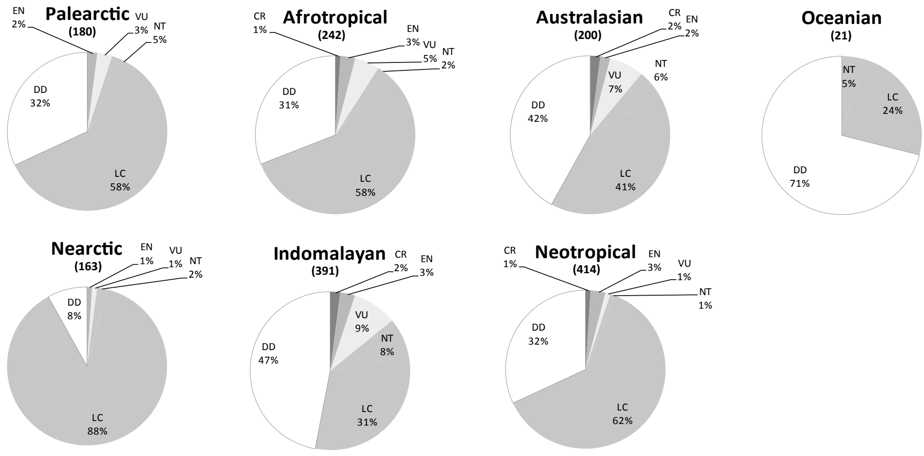

Figure 2. Regional extinction risk of Odonata. Threat levels of Odonata as percentages with respect to the number of species within each biogeographic realm assigned to a Red List Category. Total numbers given in brackets, percentages listed in the table; note: a species can be found in more than one realm.

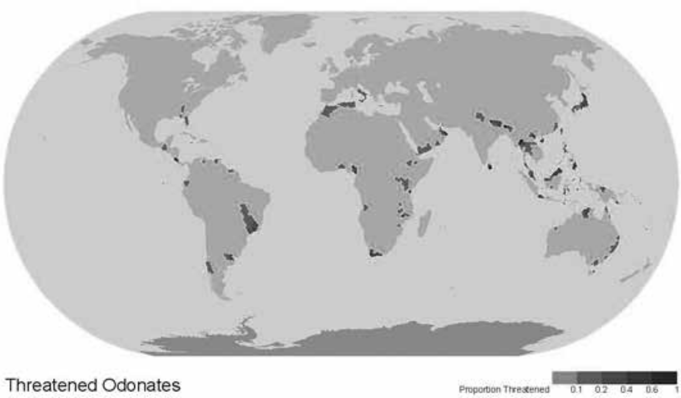

Figure 3. Global map of threatened Odonata. Global species richness map of threatened Odonata, given as a proportion of those species assigned vulnerable, endangered, and critically endangered conservation status, based on the Red List assessment. The apparent absence of threatened species in severely impacted regions as Madagascar and India's Western Ghats is explained by the extreme data deficiency for Odonata in these regions.

In both habitat types the percentage of Data Deficient species is higher than in the other habitat types. Species in lotic waters were found to be at greater risk than those in lentic (standing) waters (fig. 4), while the threat level between the terrestrial habitat types is more or less identical.

DISCUSSION

The global threat status of Odonata

Only 10% of the assessed Odonata were found to be threatened, a relatively low figure compared with 31% of amphibians and 20% of mammals (IUCN 2007), but similar to the level of threat for birds at 12% (IUCN 2007). However, a relatively high proportion (35%) of the species is Data Deficient (DD), akin to that for amphibians (Stuart et al. 2004). Many species in tropical forest habitats in particular are poorly studied and often known only from the type specimen. Expert judgement, e.g. IUCN (2007) on the status of those habitats where most DD species are found (e.g. large forest blocks such as the Amazon and

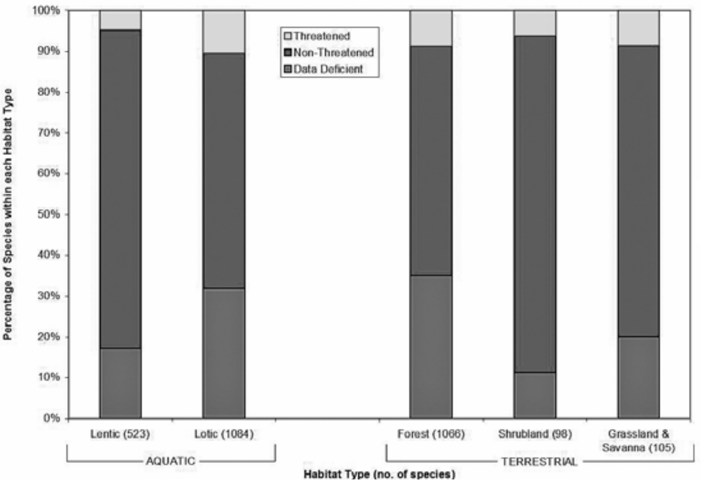

Figure 4. Extinction risk of Odonata in habitat types. Odonata threat levels in aquatic habitats as percentages with respect to all species within each habitat type. Threatened species are categorised as critically endangered, endangered, or vulnerable; and non-threatened species are categorised as near threatened or least concern. Total numbers given in brackets; note: a species can be found in more than one habitat type (ntotal species = 1492; for eight species no habitat information was available).

Congo) suggests that 10-20% of these species are likely to be threatened, thus bringing the overall percentage of threatened species close to 15%.

Areas and habitats with a high threat level

Threatened species appear to be clustered in the Indo-Malayan and Australian realms (fig. 2). This is largely due to the high percentage of endemics in the Indonesian archipelagos combined with the anthropogenic threat to the species of large scale logging of lowland forest on many islands, while in Australia, climate change is having an especially strong impact on freshwater systems (for a global review on threats affecting Odonata see articles in Clausnitzer & Jödicke, 2004). As in many other taxa, island endemic species of Odonata are the most threatened. This is true not only for species restricted to islands such as the Philippines, but also for those species restricted to terrestrial habitat islands such as remnant forest patches in Sri Lanka (see fig. 3). In fact, the only two documented extinctions of Odonata have occurred on islands: *Megalagrion jugorum* (Perkins 1899) from Maui in the Hawaiian Islands, and *Sympetrum dilatatum* (Calvert 1892) from Saint Helena.

That species inhabiting lotic waters are at greater risk than those in lentic waters (fig. 4) may be partly due to lentic habitats being less predictable in space and time. Species in lentic systems tend to be more generalised and have a higher dispersal capacity (Corbet 1999), resulting in larger ranges and wider ecological preferences, and therefore lower extinction risk (see articles in Clausnitzer & Jödicke 2004, Hof et al. 2005). Higher environmental pressure on lotic waters may also be responsible for the increased risk to species in these habitats, but this remains uncertain.

Comparison with other taxa

The relatively low level of threat to Odonata when compared to other groups assessed by IUCN is unexpected, as freshwater habitats are often considered as "particularly at risk" (Dudgeon et al. 2006, Dunn 2005, Naiman et al. 2006). There are several possible factors to explain this. Many Odonata species are able to live in partially degraded habitats, are capable of rapidly colonising new or restored habitats, and when compared with birds, mammals, and amphibians, can maintain viable populations in relatively small remnants of habitat. Odonata are also largely unaffected by hunting or trade, unlike birds, mammals or other invertebrates, notably butterflies. It will be interesting to see whether other freshwater invertebrates will show similar results, once assessed in a representative way. In addition, the highest diversity of Odonata is found in tropical forests, which are not considered to be the most endangered habitat types (Hoekstra et al. 2005, Wright & Muller-Landau 2006) and which are also thought to be under less immediate impact of climatic change (Wright & Muller-Landau 2006). Although threat level is higher for forest species (fig. 4), this is most often due to increased human pressures on those species restricted to forest fragments, mountaintops, and island localities, while those species inhabiting large forest blocks are assessed as being at lower risk. Species inhabiting peatland bogs are also considered to be at a low risk as many of these habitats, such as those in Scandinavia, remain still widely unaffected (Sahlén et al. 2004). However, as climate change is predicted to have a significant impact in these habitats and associated species in the future (Hoekstra et al. 2005), the level of threat is likely to rise, which eventually will be shown by the RLI.

Research needed

Odonata are currently the only insect group for which a representative global assessment of conservation status has been completed and analysed. This assessment succeeds in providing an indication of the level of global threat across a freshwater invertebrate group but it also identifies a high level of Data Deficiency, meaning there is insufficient information to assess their status. Given the current lack of representation for invertebrates in global biodiversity assessments the importance in obtaining a comprehensive assessment for odonates has to be a priority, requiring extensive new field surveys. This holds especially true for most forests in tropical areas. The data gap in tropical countries is a taxa-wide problem and does not only apply to Odonata (see Collen et al. 2008). Invertebrates have been insufficiently represented not only when gauging the status of biodiversity but also when estimating rates of change in species status. The approach of the Red List Index (Baillie et al. 2008, Butchart et al. 2004, 2007) will allow for the first time the opportunity to monitor the global status according to the Red List criteria. It will be used to calculate the movement of species between threat categories over time and generate trends in extinction risk. The RLI can currently be calculated for birds, as all described species in this taxonomic group have been assessed for the Red List on at least two separate occasions. The RLI has been adopted by the Convention on Biological Diversity to measure progress toward its 2010 target of significantly reducing the current rate of biodiversity loss by the year 2010 (decision VI/26) (Balmford et al. 2005) and more recently as a measure for the UN Millennium Development Goals [7.7 Proportion of species threatened with extinction (www United Nations Development Goals)]. However, it will only succeed as an informative measure of the status of global biodiversity if non-vertebrate species are also included in a representative way. Thus the Odonata need to be re-assessed in future in regular intervals. Ongoing assessments of Odonata, for instance as part of the IUCN African freshwater assessment, will increase the amount of odonate species for which RLI can be applied in due course.

Conservation actions

Conservation actions need to be implemented especially for tropical island species. Habitat degradation and pollution put especially great pressure on species confined to a small area. If we are to better understand the status of biodiversity in freshwater ecosystems then odonates provide an excellent easy-to-use indicator group (Clausnitzer 2004, Sahlén & Ekestubbe 2001, Samways & Steytler 1996, Suhling et al. 2006) with which to start. Specific conservation action plans for every threatened dragonfly can neither be achieved nor realized. Still a canon of general conservation measures do cover many of the threatened species in most areas, especially the most threatened forest species of lotic tropical habitats:

(1) Prevention of any further deforestation. Forests should be regarded as a natural resource with high conservation priority.
(2) Afforestation with indigenous trees. This is not only of conservation value for odonates, biodiversity and/or centres of endemism, but also resource management and prevention of flooding, landslides, etc. Afforestation programmes

should focus on the local community level as well as on a large scale governmental level.

(3) Fire control. Frequent and uncontrolled fires, especially in tropical and subtropical countries, prevent any kind of regeneration. A fire control programme would be quite effective, allowing natural succession.

(4) Leaving a strip of natural riparian vegetation of at least 20 m on either side of streams and rivers in cultivated and mined landscapes. This would increase landscape heterogeneity, decrease the destructive impact of flooding and increase biodiversity. Such measures would not only benefit heliophobic odonate species of the streams but also forest species which are highly isolated at the moment, as they could use such corridors for dispersal between forest patches.

(5) Water pollution control measures, e.g. sewage works mining run-off and factory effluent treatment. Restricting and controlling the amount of insecticides and pesticides.

(6) Protection of watersheds, floodplains, water retention sites, swamps, etc., against adverse impacts of damming and other alterations, such areas are important to prevent flooding and function as water-catchment areas.

ACKNOWLEDGEMENTS

We would like to thank the Esmée Fairbairn Foundation for funding the sampled approach to the Red List Index. Parts of the study were funded by grants from the BMBF (German Ministry for Science and Education) BIOLOG programme (01LC0025, 01LC0404, V. Clausnitzer; 01LC0024, F. Suhling), the Aquashift core-programme of DFG (F. Suhling), SYNTHESIS (K.-D.B. Dijkstra, K. Schütte) and the Rufford Maurice Laing Foundation (B. Collen). Jean Legrand helped during collection work in MNHN (K. Schütte) and The National Museum of Natural History Naturalis, Leiden provided working facilities for K.-D.B. Dijkstra. This document has been produced in part with the financial assistance of the European Union under project EuropeAid/ENV/2004-81917.

REFERENCES

Baillie, J.E.M., C. Hilton-Taylor, S.N. Stuart 2004. 2004 IUCN Red List of Threatened Species: A Global Species Assessment. – IUCN, Gland Switzerland.

Baillie, J.E.M., B. Collen, R. Amin, H.R. Akcakaya, S.H.M. Butchart, N. Brummitt, T.R. Meagher, M. Ram, C. Hilton-Taylor, G.M. Mace 2008. Towards monitoring global biodiversity. – Conservation Letters 1: 18-26.

Balmford, A., L. Bennun, B. ten Brink, D. Cooper, I.M. Côté, P. Crane, A. Dobson, N. Dudley, I. Dutton, R.E. Green, R.D. Gregory, J. Harrison, E.T. Kennedy, C. Kremen, N. Leader-Williams, T.E. Lovejoy, G. Mace, R. May, P. Mayaux, P. Morling, J. Phillips, K. Redford, T.H. Ricketts, J.P. Rodríguez, M. Sanjayan, P.J. Schei, A.S. van Jaarsveld, B.A. Walther 2005. The convention on biological diversity's 2010 target. – Science 307: 212-213.

Butchart, S.H.M., A.J. Stattersfield, L.A. Bennun, S.M. Shutes, H.R. Akcakaya, J.E.M. Baillie, S.N. Stuart, C. Hilton-Taylor, G.M. Mace 2004. Measuring global trends in the status of biodiversity: Red List indices for birds. – PLoS Biology 2: 1-11.

Butchart, S.H.M., H.R. Akçakaya, J. Chanson, J.E.M. Baillie, B. Collen, S. Quader, W.R. Turner, R. Amin, S.N. Stuart, C. Hilton-Taylor 2007. Improvements to the Red List Index. – PLoS One e140. DOI: 110.1371/journal.pone.0000140.

Carpenter, K.E., M. Abrar, G. Aeby, R.B. Aronson, S. Banks, A. Bruckner, A. Chiriboga, J. Cortés, C. Delbeek, L. DeVantier, G.J. Edgar, A.J. Edwards, D. Fenner, H.M. Guzmán, B.W. Hoeksema, G. Hodgson, O. Johan, W.Y. Licuanan, S.R. Livingstone, E.R. Lovell, J.A. Moore, D.O. Obura, D. Ochavillo, B.A. Polidoro, W.A. Precht, M.C. Quibilan, C. Reboton, Z.T. Richards, A.D. Rogers, J. Sanciangco, A. Sheppard, C. Sheppard, J. Smith, S. Stuart, E. Turak, J.E.N. Veron., C. Wallace, E. Weil, E. Wood 2008. One-third of reef-building corals face elevated extinction risk from climate change and local impacts. – Science 321: 560-563.

Ceballos, G., Ehrlich, P.R. 2006. Global mammal distributions, biodiversity hotspots, and conservation. – Proceedings of the National Academy of Sciences 103: 19374-19379.

Clausnitzer, V. 2004. Dragonfly communities in coastal habitats of Kenya: indication of biotope quality and the need of conservation measures. – Biodiversity and Conservation 12: 333-356.
Clausnitzer, V. & R. Jödicke (Eds.) 2004. Guardians of the watershed global status of dragonflies: critical species, threat and conservation. – International Journal of Odonatology 7: 111-430.
Collen, B., M. Ram, T. Zamin, L. McRae 2008. The tropical biodiversity data gap: addressing disparity in global monitoring tropical conservation. – Science 1: 75-88.
Corbet, P.S. 1999. Dragonflies: Behaviour and Ecology of Odonata. – Harley Books, Colchester.
Cumberlidge, N., P.K.L. Ng, D.C.J. Yeo, C. Magalhaes, M.R. Campos, F. Alvarez, T. Naruse, S.R. Daniels, L.J. Esser, B. Collen, F.Y.K Attipoe, F.-L. Clotilde-Ba, W. Darwall, A. McIvor, M. Ram 2009. Freshwater crabs and the biodiversity crisis: importance, threats, status, and conservation challenges. – Biological Conservation 142: 1665-1673.
Dudgeon, D., A.H. Arthington, M.O. Gessner, Z.-I. Kawabata, D.J. Knowler, C. Lévêque, R.J. Naiman, A.-H. Prieur-Richard, D. Soto, M.L.J. Stiassny, C.A. Sullivan 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. – Biological Reviews 81: 163-182.
Dunn, R.R. 2005. Modern insect extinctions, the neglected majority. – Conservation Biology 19: 1030-1036.
Hadfield, M.G. 1993. Introduction to the symposium: the crisis in invertebrate conservation. – American Zoologist 33: 497-498.
Hoekstra, J.M., T.M. Boucher, T.H. Ricketts, C. Roberts 2005. Confronting a biome crisis: global disparities of habitat loss and protection. – Ecology Letters 8: 3-29.
Hof, C., M. Brändle & R. Brandl 2005. Lentic odonates have larger and more northern ranges than lotic species. – Journal of Biogeography 33: 63-70.
IUCN 2001 IUCN Red List Categories and Criteria: Version 3.1, Commission, ISS ed. – IUCN, Gland, Switzerland and Cambridge UK.
IUCN 2007 2007 IUCN Red List of threatened species. <www.iucnredlist.org> (downloaded on 07.04.08).
Jenkins, M. 2003. Prospects for biodiversity. – Science 302: 1175-1177.
Kalkman, V.J., V. Clausnitzer, K.D.B. Dijkstra, A.G. Orr, D.R. Paulson, J. van Tol 2008. Global diversity of dragonflies (Odonata) in freshwater. – Hydrobiologia 595: 351-363.
Labandeira, C.C. & J.J. Sepkoski 1993. Insect diversity in the fossil record. – Science 261: 310-315.
Mace, G.M., N.J. Collar, K.J. Gaston, C. Hilton-Taylor, H.R. Akcakaya, N. Leader- Williams, E.J. Milner-Gulland, S.N. Stuart 2008. Quantification of extinction risk: IUCN's system for classifying threatened species. – Conservation Biology 22: 1424-1442.
Myers, N. & A.H. Knoll 2001. The biotic crisis and the future of evolution. – Proceedings of the National Academy of Sciences USA 98: 5389-5392.
Naiman, R.J., A.-H. Prieur-Richard, A. Arthington, D. Dudgeon, M.O. Gessner, Z. Kawabata, D. Knowler, J. O'Keeffe, C. Lévêque, D. Soto, M. Stiassny, C. Sullivan 2006. Freshwater biodiversity: challenges for freshwater biodiversity research. – DIVERSITAS Report No. 5, pp. 1-48.
Pimm, S.L. & T.M. Brooks 2000. The sixth extinction: how large, where, and when? In Raven, P.H., Williams, T. (Eds.), Nature and Human Society: The Quest for a Sustainable World. – National Academy Press, Washington, DC, pp. 46-62.
Pimm, S.L., G.L. Russell, J.L. Gittleman, T.M. Brooks 1995. The future of biodiversity. – Science 269: 347-350.
Rodrigues, A.S.L., J.D. Pilgrim, J.F. Lamoreux, M. Hoffmann, T.M. Brooks 2006. The value of the IUCN Red List for conservation. – Trends in Ecology and Evolution 21: 71-76.
Sahlén, G. & K. Ekestubbe 2001. Identification of dragonflies (Odonata) as indicators of general species richness in boreal forest lakes. – Biodiversity and Conservation 10: 673-690.
Sahlén, G., R. Bernard, A. Coerdero Rivera, R. Ketelaar, F. Suhling 2004. Critical species of Europe. – Odonatologica 7: 385-398.
Samways, M.J. & N.S. Steytler 1996. Dragonfly (Odonata) distribution patterns in urban and forest landscapes, and recommendations for riparian management. – Biological Conservation 78: 279-288.
Schipper, J. et al. 2008. The status of the world's land and marine mammals: diversity, threat, and knowledge. – Science 322: 225-230.

Stattersfield, A. & D. Capper 2000. Threatened Birds of the World. Lynx Editions and Birdlife International, Barcelona and Cambridge.

Stuart, S.N., J.S. Chanson, N.A. Cox, B.E. Young, A.S.L. Rodrigues, D.L. Fischman, R.W. Waller 2004. Status and trends of amphibian declines and extinctions worldwide. – Science 306: 1783-1786.

Suhling, F., G. Sahlén, A. Martens, E. Marais, C. Schütte 2006. Dragonfly assemblage composition and diversity in arid tropical environments: a case study from western Namibia. – Biodiversity and Conservation 15: 311-332.

Thomas, C.D., A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F.N. Erasmus, M.F. de Siqueira, A. Grainger, L. Hannah, L. Hughes, B. Huntley, A.S. van Jaarsveld, G.F. Midgley, L. Miles, M.A. Ortega-Huerta, A.T. Peterson, O.L. Phillips, S.E. Williams 2004. Extinction risk from climate change. – Nature 427: 145-148.

Wright, S.J. & H.C. Muller-Landau 2006. The future of tropical forest species. – Biotropica 38: 287-301.

www United Nations Millennium Development Goals 2008. Official List of MDG Indicators.