THE DRAGONFLIES AND DAMSELFLIES OF THE GALAPAGOS ISLANDS, ECUADOR (INSECTA: ODONATA)[1]

BY STEWART B. PECK

Department of Biology, Carleton University,
Ottawa K1S 5B6, Canada

INTRODUCTION

The Galapagos Islands of Ecuador are famous as "living laboratories of evolution." Much has been written about the biota of the islands, especially the vascular plants, vertebrates, and marine invertebrates (Berry, 1984, Bowman *et al.* 1983, James 1991, Perry 1984). The insect fauna of the islands was summarized by Linsley and Usinger (1966) and Linsley (1977) and found to contain about 900 species. I have undertaken a program of field studies and am attempting to summarize the taxonomic composition, ecological characteristics, and evolutionary dynamics of the insect fauna of the Galapagos Islands (e.g., Klimaszewski *et al.,* Peck and Kukalova-Peck 1990). As a partial result, the islands are now known to have at least 1600 species of insects (Peck 1991; unpublished). This paper summarizes published and new data on the Odonata, based on 12 months of field work in 1985, 1989, 1991, and 1992, and provides a key for the identification of adults.

Adult Odonata in the Galapagos Islands often fly about fresh water in the highlands of the islands or around coastal brackish mangrove and open saline lagoons. Their predatory larvae have been found in pools in temporary streams near the Media Luna cinder cone, Santa Cruz Island, and in submerged grasses or sedges at the edges of apparently fresh water coastal lagoons (or fresh water lenses on salt water) near Villamil, Isabela Island. Most odonate larvae cannot tolerate saline conditions (Needham and Westfall 1955) so few would be expected to live in saline coastal waters, but some can apparently live in brackish water. Since long distance migrations of many Odonata have been found far at sea (Corbet 1962), their presence on the islands should not be surprising. The

[1]Contribution 476 of the Charles Darwin Research Foundation

Manuscript received 28 December 1992.

depauperate Galapagos fauna is probably a reflection of the limited amount of permanent fresh water available for larval development. The only permanent fresh water is in the highlands of San Cristobal Island at El Junco and La Toma. Mineral-laden lakes exist in active or dormant volcanic craters on other islands. Biological data on most of the species in places other than the Galapagos can be found in Needham and Westfall (1955) and Dunkle (1989, 1990). Corbet (1962, 1980) provides general reviews of Odonata biology.

SYSTEMATIC, DISTRIBUTIONAL, AND BIONOMIC SUMMARY

Linsley (1977) and Linsley and Usinger (1966) catalogue early literature on the Galapagos entomofauna. For each species, I give a statement on general distribution of the species; whether it is endemic to the islands or a native (occurring naturally both elsewhere and in the Galapagos); and a summary of the islands where the species is known. The island summary uses the accepted Ecuadorian names for the islands (Fig. 1). If earlier reports have used the English names, they have been changed here. Detailed label data on specimens is not given, although this information is available from the author and primary literature. Turner (1967) provides label data for important collections of four species made between 1931 and 1964. Included is an account which summarizes habitat associations of the adults and elevational occurrences. The vegetational-habitat zonation of the Galapagos is discussed in many general natural history works on the islands (or see Peck and Kukalova-Peck 1990) and is not repeated here. Finally, a statement gives the months in which adults have been captured or observed.

Little attempt was made to document the presence or absence of larvae in various water-bodies. No detailed or quantative ecological studies exist for Galapagos Odonata. Larvae have been seen in the volcanic crater lake at the summit of the active volcano on Fernandina Island (Eibl-Eibesfeldt 1961:102) and so could also occur in the summit crater-lake on the active volcano of Cerro Azul, Isabela Island, or in lakes in other active volcanic craters. During and following the unusually rainy conditions of the El Niño of January–May 1992, I found hawking dragonflies to be exceptionally abundant along the coasts of many islands.

Voucher material is in the collection of the author, the Canadian Museum of Nature, and the Charles Darwin Research Station (CDRS).

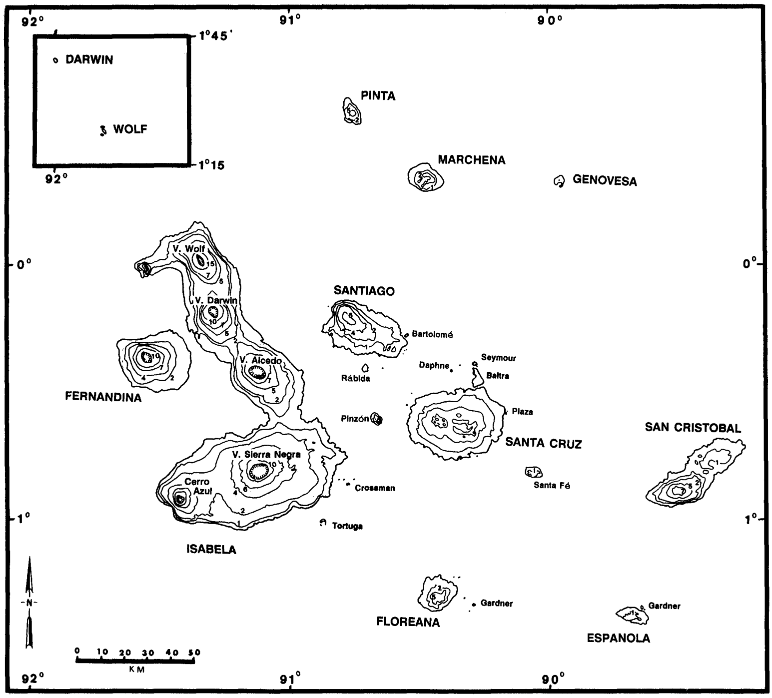


Figure 1. Outline map of Galapagos Archipelago, Ecuador, with names of principal islands.

Suborder Zygoptera (Damselflies)
Family Coenagrionidae
Ischnura (Anomalagrion) hastata (Say)
The Citrine Forktail

Galapagos references. Currie 1901: 382; Calvert 1906: 130; Gloger 1964: 3; Turner 1967: 285, 290; all these references use the name *Anomalagrion hastatum* (Say).

Distribution. United States, West Indies, Central and northern South America; native to Galapagos. Found on Isabela (abundant near Villamil), San Cristobal (abundant around El Junco), Santiago, Santa Cruz (abundant near Media Luna).

Bionomics. Littoral saline meadows to pampa zones, around permanent wet spots and pools; found in January–May, December.

This can be a very abundant species in the Galapagos. It is known elsewhere to frequent salt meadows (Needham and Heywood 1929: 358; Dunkle 1990), as well as ponds, swamps, ditches, and seepages. Nymphs have been collected in brackish lagoons at Villamil, Isla Isabela. The wide distribution results from being carried by winds.

Suborder Anisoptera (Dragonflies)

Key to Galapagos Anisoptera

1a. Triangles (t) in front and hind wing similar in shape and about equidistant from arculus (ar) (Fig. 2); brace vein below proximal end of stigma; hind wing without foot-shaped anal loop (al), "toe" absent (Aeshnidae) 2

1b. Triangles (t) in front and hind wing not similar in shape and not equidistant from arculus (ar) (Fig. 3); no brace vein below proximal end of stigma; hind wing with foot-shaped anal loop (al), with well developed "toe" (Libellulidae) 3

2a. Sector veins (sv) arising from arculus vein (ar) near its middle (Fig. 2); thorax multicolored; male with anal border of hind wing angulate; auricles on male 2nd abdominal segment .... *Aeshna galapagoensis*

2b. Sector veins arising from arculus vein on its upper half; thorax green; anal border of hind wing rounded in both sexes; auricles (lateral earlike projections) absent on male 2nd abdominal segment .... *Anax amazili*

3a. Wing vein M2 waved or undulating (Fig. 3) (*Pantala*) 5

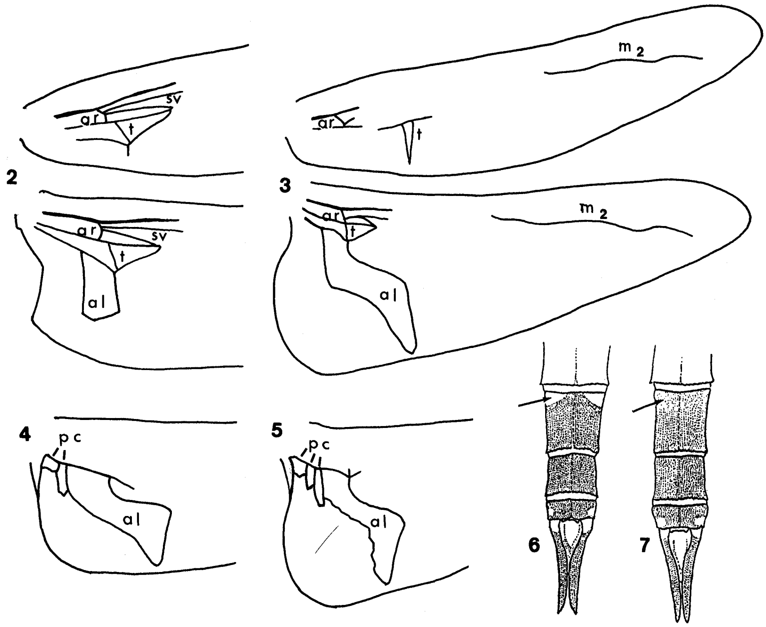
3b. Wing vein M2 smoothly curved 4

4a. Hind wing with 2 paranal cells (pc) (behind anal vein) before the start of the anal loop (al) (Fig. 4); no brown band at hind wing base .... *Brachymesia herbida*

4b. Hind wing with 3 paranal cells (pc) before start of anal loop (al) (Fig. 5); brown band at hind wing base (*Tramea*) 6

5a. Hind wing with large brown spot at base near broadly rounded anal angle .... *Pantala hymenaea*

5b. Hind wing with no spot near base or anal angle .... *Pantala flavescens*



Figures 2-7. Figure 2. Wing base of *Aeshna galapagoensis,* showing similar triangles (t) of Aeshnidae; sv, sector veins; ar, arculus; al, anal loop. Figure 3. Wings of *Pantala hymenaea;* M_2, undulating M_2 vein. Figure 4. Hind wing of *Brachymesia herbida,* showing two paranal cells before start of anal loop. Figure 5. Hind wing of *Tramea cophysa* showing three paranal cells (pc) before start of anal loop (al). Figure 6. Male abdominal tip of *T. calverti.* Figure 7. Male abdominal tip of *T. cophysa.* Figs 6 and 7 from De Marmels and Racenis 1982.

6a. Underside of abdomen black; abdominal segment 8 all black (Fig. 7); hindwing clear with sharply edged dark basal band; male at maturity with frons all violet, male face black ....*Tramea cophysa*

6b. Underside of abdomen brown to red; abdominal segment 8 with a semicircular pale basal-lateral spot (Fig. 6); hindwing tinged brown with an amber-edged basal band; male with only broad band on top of frons violet; female band on frons top narrower, lower frons and face otherwise pale; male at maturity with lower frons and face red....................*Tramea calverti*

Family Aeshnidae
Aeshna galapagoensis Currie
The Galapagos Darner

Galapagos references. Currie 1901: 382; Needham 1902: 695; Calvert 1952: 258 as *Neureclipta;* 1956: 137; Asahina 1961: 1; Gloger 1964: 4; Turner 1967: 288, 290.

Distribution. Endemic species. Found on Isabela, San Cristobal (La Toma), Santa Cruz.

Relationships. Schmidt (1938) states that this species is near *A. cornigera* and *A. californica* (both of California).

Bionomics. Arid to pampa zones; January, March–May, December. A nymph has been taken in a brackish pool at the bottom of Grieta Iguana (a cave) at CDRS.

Anax amazili (Burmeister)
The Ringed Darner

Galapagos references. Asahina 1961: 1; Gloger 1964: 4; Turner 1967: 288, 290

Distribution. Southern USA (vagrant), Mexico and West Indies, S. to Argentina; native to Galapagos. Found on Bartolomé, Floreana, San Cristobal, Santa Cruz, Santiago.

Bionomics. Arid to pampa zone; January, March–May; it breeds in weedy ponds and ditches, and can breed in brackish water (Dunkle 1989). Nymphs have been collected in brackish lagoons at Villamil, Isla Isabela.

Family Libellulidae
Brachymesia herbida (Gundlach)
The Tawny Pennant

Galapagos references. Kirby 1889: 341 as *Cannacria batesii;* Currie 1901: 387; Calvert 1906: 326; Turner 1967: 290 as *Cannacria fumipennis.*

Distribution. Texas to West Indies, south to Argentina; Native to Galapagos. Found on Isabela, Santa Cruz.

Bionomics. Arid and littoral zones; January–March; it breeds in ponds, ditches, and marshes, and nymphs can live in brackish water (Dunkle 1989). Although there have been no new literature records of the species since 1901 it was the most abundant species during my 1989 field work.

Pantala flavescens (Fabricius)
The Wandering Glider

Galapagos references. Currie 1901: 385; Calvert 1906: 307; 1947: 227; Turner 1967: 289

Distribution. Cosmopolitan (including Hawaii) (but not breeding in Europe); Native to Galapagos. Found on Baltra, Floreana, Isabela, San Cristobal (La Toma), Santa Cruz, Santiago.

Bionomics. Littoral and arid to pampa zones; March–May. It is often taken on vessels far at sea. The species breeds in open temporary ponds, including brackish waters. It drifts with the wind and feeds on aerial plankton (Dunkle 1989).

Pantala hymenaea (Say)
The Spot-winged Glider

Galapagos references. McLachlan 1877: 84; Currie 1901: 385; Calvert 1906: 309; Gloger 1964: 5; Turner 1967: 289

Distribution. North, Central, and South America, and the West Indies; Native to Galapagos. Found on Española, Floreana, Isabela.

Bionomics. March, April, June–October. Breeds in open temporary pools, including brackish waters. Nymphs have been collected in temporary ponds on Isla Santa Cruz. Larval development may be as quick as five weeks (Dunkle 1989).

Tramea calverti Muttkowski, 1910
The Striped Glider

Galapagos references. Dunkle (1989: 115, no specific islands mentioned).

Distribution. A vagrant in Florida, USA, and resident in southern Texas, Mexico, the West Indies, Central and South America to Argentina; native to Galapagos. Found on Floreana, Isabela, Santa Cruz, Santiago.

Bionomics. Littoral and arid to pampa zones; January–June, August, December. Breeds in temporary or permanent pools and quiet waters, and probably in brackish water (Dunkle 1989).

Nymphs have been collected in brackish lagoons at Villamil, Isla Isabela, and temporary ponds on Isla Santa Cruz.

Tramea cophysa Hagen 1867

Tramea darwini Kirby, 1889: 315 "Galapagos Islands"; Currie 1901: 386.

Tramea cophysa, Calvert, 1906: 301; De Marmels & Racenis 1982: 112.

Tramea (Trapezostigma) cophysa darwini Calvert 1947: 227; Asahina 1961: 2; Turner 1967: 288.

Distribution. In South America from Venezuela through Ecuador to Argentina. Native to Galapagos. Reported from Española, Floreana, Isabela, San Cristobal.

Notes. This species may have been confused with *T. calverti,* and its literature records may refer to *T. cophysa.* De Marmels and Racenis (1982) clarify the characters and distributions of *T. calverti* and *T. cophysa,* and list only *T. cophysa* from the Galapagos. The key in De Marmels and Racenis (1982) should be consulted. Dunkle (1989, and pers. comm.) has seen material of *T. calverti* but not *T. cophysa* from the Galapagos. My material contains only specimens of *T. calverti.* I have examined Galapagos specimens in USNM and CAS collections and found specimens of *T. calverti* which had been labeled as *T. cophysa.* If *T. cophysa* was actually once present and is now absent in the Galapagos it represents a case of natural extripation of island populations.

Discussion

Although there is a very rich odonate fauna in mainland South America, that of the Galapagos is impoverished. For instance, Venezuela is known to have 449 species, 116 genera, and 14 families of Odonata (De Marmels 1990). No such list has been prepared for adjacent mainland areas such as Ecuador. In the Galapagos, only seven native and one endemic species are known. The native species all have very large New World distributions, and the fauna is clearly derived from continental tropical America (Schmidt 1938). The 1000 km separating the islands and the mainland is not likely to be much of an effective barrier for wandering or migratory Odonata species. Rather, it is the seasonal and harsh aridity of the islands which must limit colonization. The highlands of most of the large islands may have seasonal streams or pools for reproduction but these can completely vanish in a dry season. Larvae of some species may pass the dry season by burrowing into the mud. If an island population does not survive a dry season, the recolonization of the island is necessary. Permanent fresh water occurs only on Isabela Island at El Junco Lake, its outlet stream, and the reservoir and stream at La Toma.

The low level of endemism (one species) in the archipelagos' fauna may be explained by the relative youth of the islands (about 3 million years at most), and sufficient nearness to the mainland to permit continued gene-flow and recolonization from the continent, and between islands. With this in mind, the "endemic" status of *Aeshna galapagoensis* might bear re-evaluation.

There appears to be no recent general discussion in the literature about the odonate fauna of oceanic islands. Schmidt (1938) summarizes data from over 50 years ago. I present some additional data (Table 1). It seems that comparatively few odonate species can reach and establish themselves on distant, semi-arid, oceanic islands. Schmidt (1938) tabulated only 162 species and subspecies in all of Oceania. His listing indicates that the dragonflies (Anisoptera) are the better or more frequent dispersers and colonizers than The Zygoptera, and they show comparatively lower (44%) endemism in Oceania. The damselflies (Zygoptera) are weaker fliers and would thus be expected to be poorer dispersers, but they do have some long-distance dispersal potential. They were able to reach Hawaii, but the 29 endemic species of *Megalagrion* which occur in Hawaii are descended from only a single ancestral colonist. The fact that there is a higher proportion of endemic species of island damselflies (86%, Schmidt 1938) shows that they are more likely to become isolated populations after the initial and infrequent colonization event. Within the Hawaiian Island chain, the older more northwestern islands have more endemic species which are limited to a single island (Kennedy 1930).

Summary

The Odonata fauna of the Galapagos Islands consists of three families, six genera, and eight species (one of which is endemic). A key for identification is given to the seven Anisoptera species.

Table 1. Data on Odonata fauna of some island regions compared with peninsular Florida, giving number of species and subspecies (endemics in parentheses), and references. Other data are in Schmidt (1938).

Area or Island	Odonata	Zygoptera	Anisoptera	Reference
Florida	134 (3)	42 (0)	90 (3)	Dunkle (1989, 1990)
Bermuda	9 (0)	4 (0)	5 (0)	Ogilvie (1928)
Bermuda	9 (0)	2 (0)	7 (0)	Dunkle (1989, 1990)
Bahamas	33 (0)	6 (0)	27 (0)	Dunkle (1989, 1990)
Canaries	10 (1)	1 (0)	9 (1)	Báez (1986)
Hawaii	34 (29)	29 (27)	5 (2)	Zimmerman (1948)
Hawaii	39 (31)	32 (29)	7 (2)	Howarth (1990), Nishida (1992)
Samoa	29	13 (10)	16 (2)	Zimmerman (1948)
Micronesia	46 (25)	16 (12)	30 (13)	Lieftinck (1962)
Oceania	162 (109)	94 (80)	67 (29)	Schmidt (1938)

Species distribution and habitats are summarized for each species. Seven of the species are widely distributed in North, Central, and South America, and are able to tolerate the seasonally arid conditions or brackish waters of the islands.

ACKNOWLEDGEMENTS

It is a pleasure to offer this paper as a contribution to this issue of *Psyche* in honor of Professor F. M. Carpenter and in recognition of his many contributions to entomology, including his support of my desire to work on island insects when I was his graduate student. Field work in the Galapagos was permitted by the authorities of the Galapagos National Park Service (A. Izurieta, Superintendat), Department of Forestry, Ministry of Agriculture, Republic of Ecuador. Field work was facilitated by the Charles Darwin Research Station, Santa Cruz Island (C. Blanton, Director), and partly supported by research grants from the Natural Sciences and Engineering Research Council of Canada. Nancy House helped determine specimens of nymphs. Nancy House and Sid Dunkle provided many helpful suggestions on an earlier draft of the manuscript.

Literature Cited

Asahina, S.

1961. Dragonflies taken by Dr. Sekiguchi in the Galapagos Islands. Publication of the Entomological Laboratory, College of Agriculture, University of Osaka Sakai, no. **6**, pp. 1–3, 1 fig.

Báez, M.

1986. Las Libellulas de las Islas Canarias. Aula de Cultura, Cabildo Insular de Tenerife, Islas Canarias. 67 pp.

Berry, R. J. (ed.)

1984. Evolution in the Galapagos. Academic Press, London. 260 pp. Reprinted from Biol. J. Linnean Soc. (London) **21**: No. 1 and 2. 1984.

Bowman, R. I., Benson, M., Leviton, A. E. (eds.)

1983. Patterns of evolution in Galapagos organisms. Pacific Division, AAAS, California Acad. Sci., San Francisco. 568 pp.

Calvert, P. P.

1906. Insecta. Neuroptera. Odonata. Biologia Centrali-Americana, pp. i–xxx + 17–411.

1947. Odonata of Voyages under the auspices of the New York Zoological Society. Entomol. News **58**: 227–230.

1952. New taxonomic entities in Neotropical *Aeshnas* (Odonata: Aeshnidae). Entomol. News **63**: 253–264.

1956. The Neotropical species of the "subgenus *Aeschna*" *sensu* Selysii 1883 (Odonata). Mem. Amer. Entomol. Soc. **15**: 1–251; 47 pls., 19 tables, maps I–IV.

Corbet, P. S.

1962. A biology of dragonflies. H. F. and G. Witherby Ltd., London. 247 pp.

1980. Biology of Odonata. Ann. Rev. Entomol. **25**: 189–217.

Currie, R. P.

1901. Papers from the Hopkins Stanford Galapagos Expedition, 1898–1899. Entomological Results (3): Odonata. Proc. Washington Acad. Sci. **3**: 381–389.

De Marmels, J.

1990. An updated checklist of the Odonata of Venezuela. Odonatologica **19**: 333–345.

De Marmels, J. and J. Rácenis

1982. An analysis of the *Cophysa*-group of *Tramea* Hagen, with descriptions of two new species (Anisoptera: Libellulidae). Odonatologica **11**: 109–128.

Dunkle, S. W.

1989. Dragonflies of the Florida peninsula, Bermuda, and the Bahamas. Scientific Publishers, Gainesville, Florida. 154 pp.

1990. Damselflies of Florida, Bermuda and the Bahamas. Scientific Publishers, Gainesville, Florida. 148 pp.

Eibl-Eibesfeldt, I.

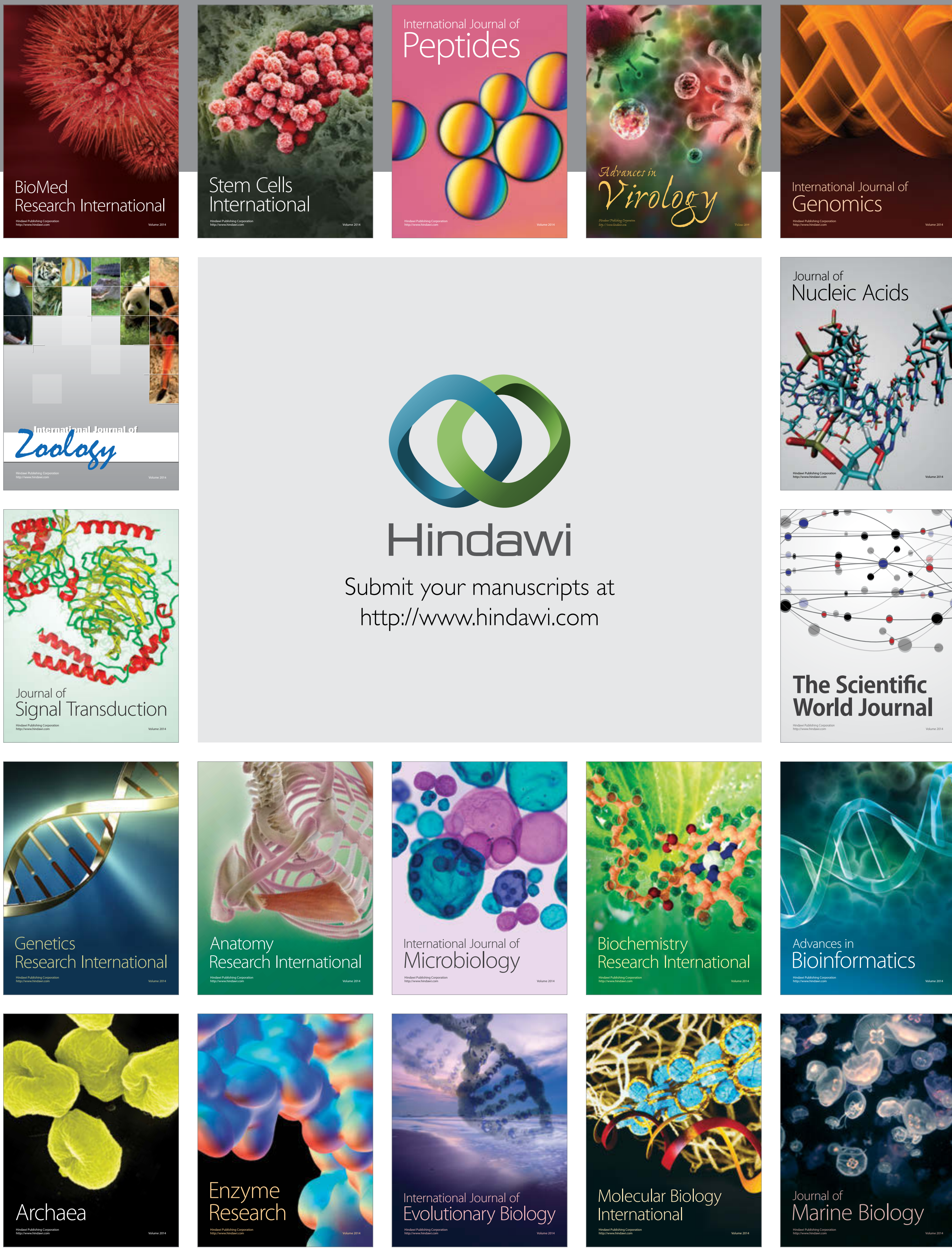
1961. Galapagos, the Noah's ark of the Pacific. Doubleday and Co., Garden City, N. Y. 192 pp.

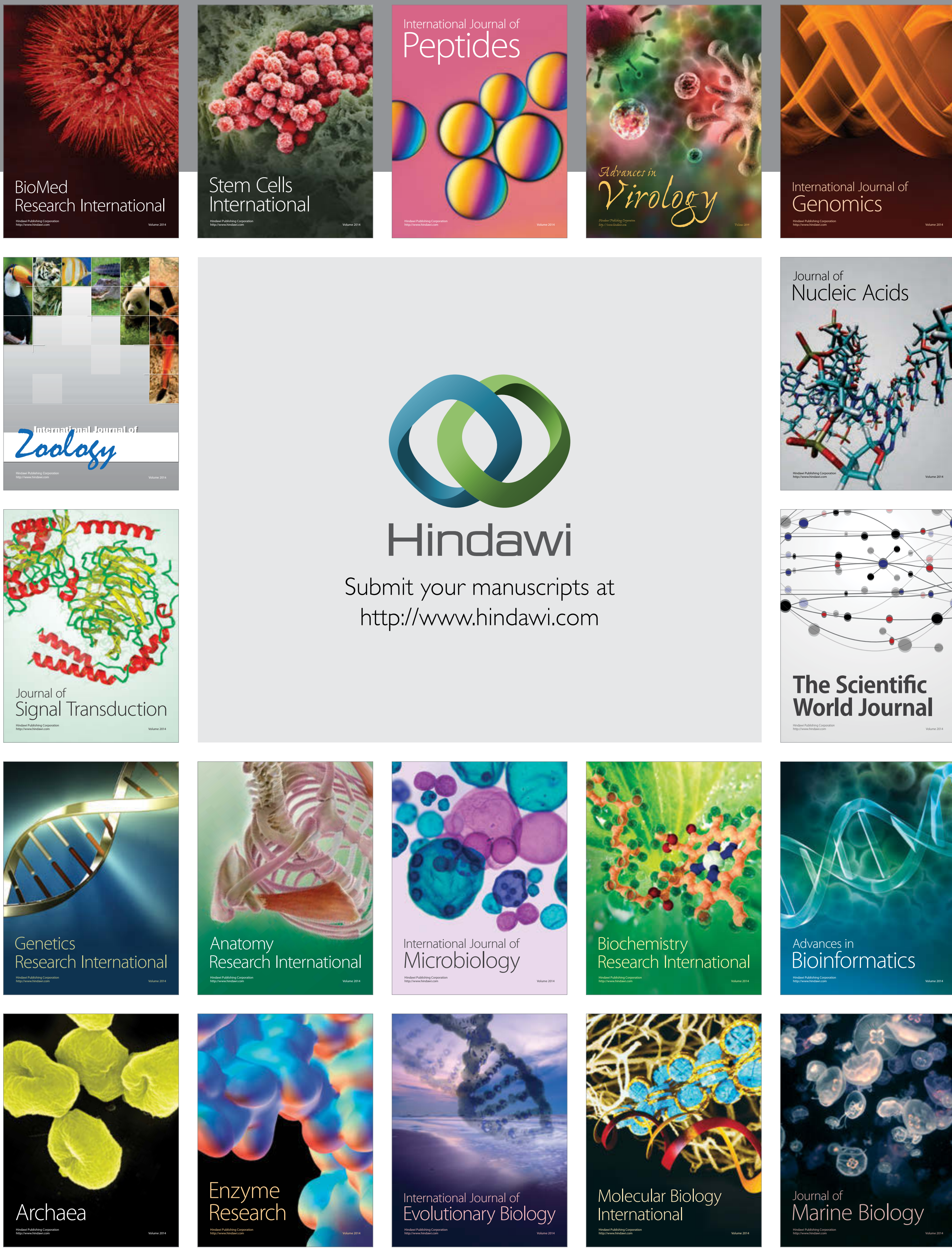
Gloger, H.

1964. Bermerkungen uber die Odonaten-Fauna der Galapagos-Inselin nach der Ausbeute von Juan Foerster, 1959. Opusc. Zool. (Muenchen) **74**: 1–6.

HOWARTH, F. G.
1990. Hawaiian terrestrial arthropods: an overview. Occ. Pap. Bishop Museum **30**: 4–26.
JAMES, M. J. (ed.)
1991. Galapagos Marine Invertebrates: Taxonomy, Biogeography, and Evolution in Darwin's Islands. Plenum Press, New York. 474 pp.
KENNEDY, C. W.
1930. The origin of the Hawaiian Odonata fauna and its evolution within the islands. pp. 978–981. In: Proceedings of the Fourth International Congress of Entomology. Ithaca, NY, August 1928. Edited by K. Jordan and W. Horn.
KIRBY, W. F.
1889. A revision of the subfamily Libellulinae, with descriptions of new genera and species. Trans. Zool. Soc. London **12**: 249–348, pls. 51–57.
KLIMASZEWSKI, J., D. E. MCE. KEVAN, AND S. B. PECK
1987. A review of the Neuroptera of the Galapagos Islands with a new record for *Sympherobius barberi* (Banks) (Hemerobiidae). Can. J. Zool. **65**: 3032–3040.
LIEFTINCK, M. A.
1962. Odonata. Insects of Micronesia (B. P. Bishop Mus.) **5**: 1–95.
LINSLEY, E. G.
1977. Insects of the Galapagos (supplement). Occas. Pap. Calif. Acad. Sci. No. **125**. pp 1–50.
LINSLEY, E. G. AND R. L. USINGER
1966. Insects of the Galapagos Islands. Proc. Calif. Acad. Sci. **33**: 113–196.
MCLACHLAN, R.
1877. IX. Neuroptera. In Gunther, A. Account of the zoological collection made during the visit of H.M.S. 'Petrel' to the Galapagos Islands. Proc. Zool. Soc. London **1877**: 84–86.
NEEDHAM, J. G. AND H. B. HEYWOOD
1929. A handbook of the dragonflies of North America. C. C. Thomas Publ., Springfield, Illinois. 388 pp.
NEEDHAM, J. G., AND M. J. WESTFALL, JR.
1955. A manual of the Dragonflies of North America (Anisoptera) including the Greater Antilles and the provinces of the Mexican Border. Univ. California Press, Berkeley, Ca., 615 pp.
NISHIDA, G. M.
1992. Hawaiian Terrestrial Arthropod Checklist. Bishop Museum Technical Report no. MS-092192. 262 pp.
OGILVIE, L.
1928. The Insects of Bermuda. Bermuda Dept. Agric. 52 pp.
PECK, S. B.
1991. Evolution in Island Archipelagos. The Galapagos Islands, Ecuador: with an emphasis on terrestrial invertebrates, especially insects, and an outline for research. Proc. 4th Int. Cong. Syst. Evol. Biol. Dioscorides Press, Portland, OR. pp. 319–336.
PECK, S. B., AND J. KUKALOVA–PECK
1990. The origin and biogeography of the beetles (Coleoptera) of the Galapagos Archipelago, Ecuador. Can. J. Zool. **68**: 1617–1638.

PERRY, R.
1984. Galapagos. Key Environments. Pergamon Press, New York. 336 pp.
SCHMIDT, E.
1938. Check-list of Odonata of Oceania. Ann. Entomol. Soc. Amer. **31**: 322–344.
TURNER, P. E., JR.
1967. Odonata of the Galapagos Islands. Pan-Pac. Entomol. **43**: 285–291, figs. a–j, 1 table.
ZIMMERMAN, E. C.
1948. Apterygota to Thysanoptera. Insects of Hawaii vol. 2, Univ. Hawaii Press, Honolulu. 475 pp.


BioMed Research International
Stem Cells International
International Journal of Peptides
Advances in Virology
International Journal of Genomics
International Journal of Zoology
Journal of Nucleic Acids
Hindawi
Submit your manuscripts at
http://www.hindawi.com
Journal of Signal Transduction
The Scientific World Journal
Genetics Research International
Anatomy Research International
International Journal of Microbiology
Biochemistry Research International
Advances in Bioinformatics
Archaea
Enzyme Research
International Journal of Evolutionary Biology
Molecular Biology International
Journal of Marine Biology


BioMed
Research International
Stem Cells
International
International Journal of
Peptides
Advances in
Virology
International Journal of
Genomics
International Journal of
Zoology
Hindawi
Submit your manuscripts at
http://www.hindawi.com
Journal of
Nucleic Acids
Journal of
Signal Transduction
The Scientific
World Journal
Genetics
Research International
Anatomy
Research International
International Journal of
Microbiology
Biochemistry
Research International
Advances in
Bioinformatics
Archaea
Enzyme
Research
International Journal of
Evolutionary Biology
Molecular Biology
International
Journal of
Marine Biology