「森林総合研究所研究報告」(Bulletin of FFPRI), Vol.4, No.1 (No.394), 45 - 51, Mar. 2005

論　文（Original article）

# A decrease in endemic odonates in the Ogasawara Islands, Japan

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**Abstract**

There are many endemic species in the Japanese Ogasawara Islands. However, many of these endemic species are likely to disappear as a result of reduction of habitat and the introduction of exotic species. Odonates are included within this category of species at risk. If the decrease in endemic odonates is due to a decrease in aquatic habitat, we have only to provide arti" ficial ponds to conserve these species. In this study, we provided artificial ponds as a habitat for odonates in Chichi-jima and Ani-jima, Ogasawara Islands. We then examined the possibility of protection and enhancement of odonate populations. Endemic odonates were found in the natural ponds of Ani-jima and Ototo-jima. In Ani-jima, they could be collected both in the artificial and natural ponds. The artificial pond could provide habitat for endemic odonates. However, in Chichi-jima, few odonates could be collected both in the artificial and natural ponds. Here, invasive species, such as *Gambusia affinis* and *Anolis carolinensis*, are found, which considered to prey upon odonate larvae and adults. Extermination of invasive species may be necessary to conserve the endemic odonates in Chichi-jima.

**Key words :** *Anolis carolinensis*, endemic species, oceanic islands, odonates, Ogasawara Islands, predator, conservation

## Introduction

In Japan, the Ogasawara Islands consist of many small islands, including Chichi-jima, Ani-jima, Ototo-jima, Haha-jima and Iou-jima, and are located about 1,000 km south of the Japanese mainland. These islands are often referred to as "the Galapagos of the Orient". As in many other oceanic islands, many endemic species inhabit the Ogasawara Islands. However, recently many of these endemic species, including odonates, are threatened with extinction (Karube, 2004). Five endemic odonates, *Boninagrion ezoin*, *Hemicordulia ogasawarensis*, *Indolestes boninensis*, *Rhinocypha ogasawarensis* and *Boninthemis insularis* inhabit the Ogasawara Islands. From 1930-1975, adults of endemic odonates could often be found in Chichi-jima (Table 1). Asahina (1976) indicated that many odonates, including endemic species, could be observed on the larger islands, such as Chichi-jima and Haha-jima, which had forest and stream habitat, though on the very smaller islands only more common, non-endemic species could be observed. However, about 1992 it became difficult to find endemic odonates in Chichi-jima, although these species could still be found in Ani-jima and Ototo-jima (Table 1). Most of the endemic odonates are likely to disappear, and this trend is most pronounced in Chichi-jima.

This decline has been blamed on environmental destruction. In Chichi-jima, road construction began in the 1970s. Stream bottoms and banks were lined with concrete blocks, especially at road intersections, and drainage projects along the lengths of the roads were completed. As a result, natural percolation of rainfall through soils decreased, which resulted in reduced natural ponding and pooling of runoff. Construction of complete equipment of water service to the houses also resulted in the diminution of the small water reservoir near the village and then other habitats for odonates have diminished. In addition, introduced plant species that has great fertilization prompts the destruction of endemic plants with decrease in suitable habitat for adult odonates.

If the decrease in endemic odonates is due to a decrease in aquatic habitat, we have only to provide artificial ponds to conserve these species. In this study, we attempted to conserve and increase populations of threatened endemic odonates by providing plastic artificial ponds for habitat in Chichi-jima and Ani-jima, Ogasawara Islands. We also verify the effectiveness of these efforts and discuss the possibility of conservation and enhancement of declining odonates.

原稿受付：平成 16 年 9 月 22 日 Received Sep. 22, 2004　原稿受理：平成 16 年 11 月 26 日 Accepted Nov. 26, 2004
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Table 1. Odonates found in the Ogasawara Islands

| | Chichi-jima | | | | Ani-jima | | Ototo-jima | |
|---|---|---|---|---|---|---|---|---|
| | 1930s[1)] | 1975[2)] | 1992[3)] | 1997-2000[4)] | 1992[3)] | 1997-2000[4)] | 1992[3)] | 1997 ～ 2000[4)] |
| ***Boninagrion ezoin*** | * | * | - | - | * | * | * | * |
| ***Hemicordulia ogasawarensis*** | * | * | - | - | * | * | * | * |
| ***Indolestes boninensis*** | * | * | - | - | - | - | * | * |
| ***Rhinocypha ogasawarensis*** | * | * | - | * | * | * | - | * |
| ***Boninthemis insularis*** | * | * | - | * | * | * | * | * |
| *Ischnura senegalensis* | * | * | * | | * | | * | |
| *Diplacodes bipunctatus* | * | * | - | | * | | * | |
| *Pantala flavescens* | * | * | * | | * | | * | |
| *Tramea transmarina* | | * | * | | - | | * | |
| *Tramea virginia* | * | | | | | | | |
| *Anax guttatus* | | | - | | - | | * | |
| *Anax parthenope* | * | * | | | | | | |

1): Asahina (1952), 2): Ishida & Kojima (1978), 3): Hirose (1993), 4): Karube (2001), *: Affirmation of living, -: Negation of living, Blank: Not try to be found, Bold letters: endemic species

## Materials and methods

The study areas (Chichi-jima, Ani-jima, Ototo-jima) are located on the Ogasawara Islands, about 1,000 km south from Honshu in Japan. In Chichi-jima, one natural pond (CN1) in Yoake-yama (27°05´N, 142°11´E) and one natural pond (CN2) in Mikazuki-yama (27°06´N, 142°10´E) were selected as sampling stations. In Ani-jima, two natural ponds (AN1, AN2) near the shore were selected (27°07´N, 142°11´E) as sampling stations, and in Ototo-jima, two natural ponds (ON1, ON2) were selected (27°11´N, 142°10´E) (Fig. 1). In Chichi-jima, a large (CA1, 3.0 × 1.4 × 0.5 $m^3$) and a small (CA2, 1.8 × 1.2 × 0.5 $m^3$) plastic artificial pond were installed at Kiyose (27° 06´N, 142° 11´E) in September, 2000. In Ani-jima, one artificial pond (AA1, 3.0 × 1.4 × 0.5 $m^3$) was installed near the natural ponds in June, 2001. These installed artificial ponds were left under natural condition.

Collection of aquatic invertebrates was done four times in 2001, 2002 and 2003. In 2001, collections were on September 18 and November 25 at the natural ponds, September 16 and November 22 at the artificial ponds in Chichi-jima, September 17 and November 29 in Ani-jima and September 14 and November 24 in Ototo-jima. In 2002, collections were on July 18 in Chichi-jima, July 20 in Ani-jima and July 19 in Ototo-jima. In 2003, collections were on June 11 in Chichi-jima, and June 8 in Ani-jima and Ototo-jima.

At each collection, a "D"-frame net was placed at the base of vegetation growing on the pondbed near the bank and was swung back and forth. Collections in the natural pond were done about 10 m along the bank for five minutes. In the artificial ponds, all the invertebrates in the pond were collected. Aquatic invertebrates were preserved in 80% ethanol and later identified.

Aquatic invertebrate presence-absence data were pooled according to the nine sampling stations through the four collection events, and similarities were assessed with Sorensen's similarity coefficient. The unweighted pair-group method using an arithmetic average (UPGMA) was used to cluster the data.

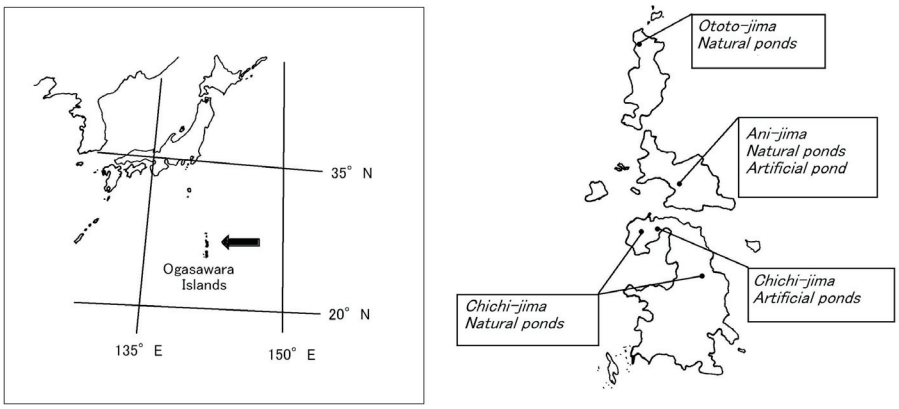


Fig. 1. Map of the Ogasawara Islands and study ponds

## Results

We collected seventeen families of aquatic invertebrates and vertebrates over three years in the natural ponds of Ogasawara Island (Table 2). Most of the species were found on every island. However, odonates were not found only in Chichi-jima.

Cluster analysis showed that the aquatic invertebrate assemblage of natural ponds on Ani-jima and Ototo-jima was similar within the islands, but there was little in common between the islands (Fig. 2). The aquatic invertebrate assemblage in artificial ponds was also similar to that of natural ponds in Ani-jima. In Chichi-jima, the aquatic invertebrate assemblage was different depending upon the pond. Many individuals of *Gambusia affinis* and *Bufo marinus* were found in CN2 and its aquatic invertebrate assemblage was greatly different from other ponds.

Odonates could not be found (except for one individual) in Chichi-jima, though they could be found in Ani-jima and Ototo-jima (Fig. 3). Most of the species collected in Ani-jima and Ototo-jima were common, oceanic odonates, and only one endemic, *Boninagrion ezoin*, was collected. This endemic species could be collected both in natural ponds at Ani-jima and Ototo-jima and also in

Table 2. Aquatic invertebrates and vertebrates found in the natural ponds of the Ogasawara Islands

| | | Chichi-jima | | Ani-jima | | Ototo-jima | |
|---|---|---|---|---|---|---|---|
| | | CN1 | CN2 | AN1 | AN2 | ON1 | ON2 |
| Diptera | | | | | | | |
| Chironomidae | *Chironomus* sp. | ** | | ** | | ** | ** |
| | *Polypedilum* sp. | * | | * | ** | | |
| Culicidae | *Culex tritaeniorhynchus* | *** | * | *** | ** | ** | * |
| | *Culex boninensis* | | | ** | * | * | |
| Hemiptera | | | | | | | |
| Veliidae | *Microvelia* sp. | *** | | ** | | ** | |
| | *Xiphovelia boninensis* | | * | | | | |
| Notonectidae | *Anisops ogasawarensis* | ** | | ** | ** | *** | *** |
| Mesoveliidae | *Mesovelia* sp. | | | * | | | |
| Corixidae | *Nipponasellus* sp. | | | | | * | * |
| Coleoptera | | | | | | | |
| Dytiscidae | *Copelatus* sp. 1 | * | | | | | |
| | *Copelatus* sp. 2 | * | | | | | |
| | *Rhantus* sp. | * | | | * | | |
| | *Copelatus ogasawarensis* | * | | | | * | |
| Hydrophilidae | *Borosus signaticollis* | * | | | * | | * |
| | *Coelostoma stultum* | | | | * | | * |
| Odonata | | | | | | | |
| Libellulidae | *Diplacodes bipunctatus* | | | ** | ** | | ** |
| | *Tramea* spp. | | | * | ** | | * |
| | *Pantala flavescens* | | | | | | ** |
| Coenagrionidae | *Ischnura senegalensis* | | | * | ** | ** | *** |
| | *Boninagrion ezoin* | | | ** | ** | ** | ** |
| | *Ischnura aurora* | | | | | ** | * |
| Aeschnidae | *Anax guttatus* | | | | | | * |
| | *Anax parthenope* | | | | | | * |
| Collembola | | | | | | | |
| Hypogastruridae | *Hypogastruridae* Gen. sp. | | * | | | | |
| Entomobryidae | *Entomobryidae* Gen. sp. | | | * | | | |
| Podocopa | | | | | | | |
| Cypridae | *Cypridae* Gen. sp. | *** | | | | * | * |
| Decapoda | | | | | | | |
| Atyidae | *Caridina typus* | | ** | | | | |
| Cyprinodontiformes | | | | | | | |
| Poeciliidae | *Gambusia affinis* | | ** | | | | |
| | *Poecilia reticulate* | * | | | | | |
| Anura | | | | | | | |
| Bufonidae | *Bufo marinus* | | ** | | | | |

Number of individuals ***: ≥ 100; **: < 100, ≥ 10; *: <10

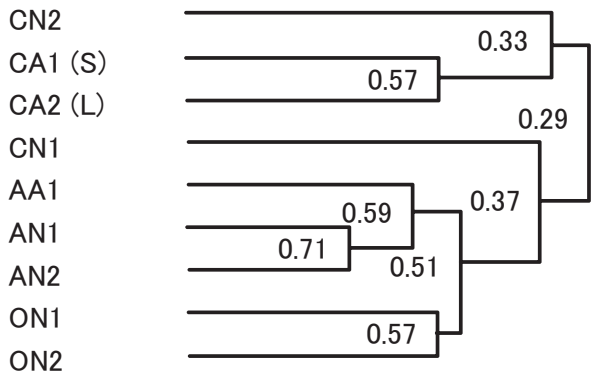


Fig. 2. Cluster analysis of aquatic invertebrates assemblages among nine sampling stations. Similarities assessed with Sorensen's similarity coefficient. The unweighted pair-group method using an arithmetic average (UPGMA) was used to cluster the data.

artificial ponds at Ani-jima. In May 2002, we could find molts of endemic species, *Hemicordulia ogasawarensis* and *Boninthemis insularis*, at the artificial pond in Ani-jima.

## Discussion

In this study, we found odonates in both natural and artificial ponds at Ani-jima, including three endemic species. We have shown that artificial ponds could provide habitat for odonates. It is considered that serving water place would be the most expedient way to conserve odonates. However, in Chichi-jima, we found no odonates in either natural or artificial ponds, except for one individual in the artificial pond in November, 2001.

The aquatic invertebrate assemblages of natural and artificial ponds in Chichi-jima were largely different from ponds on other islands. Since people reside only on Chichi-jima, the observed differences in assemblages here may be partly due to human activities beginning in the 1970's. *Gambusia affinis* was introduced to Chichi-jima for mosquito control after reversion of the Ogasawara Islands to Japan. Many *Gambusia affinis* and *Bufo marinus* were found in CN2 of Chichi-jima. While *Gambusia affinis* preys upon mosquitoes, they prey upon many other organisms (Rupp, 1996; Offill & Walton, 1999). They eat treefrog tadpoles (Goodsell & Kats, 1999), and they may eat odonate larvae also. The lack of odonates in Chichi-jima might be partially explained by predation by exotic species.

Only in Chichi-jima, many individuals of introduced predator lizard, *Anolis carolinensis*, could be found (Miyashita, 1991). Numbers of *Anolis carolinensis* have been increasing and their range expanding (Miyashita, 1991) since they were introduced to Chichi-jima in the 1960s (Hasegawa, 1986). Only one native lizard, *Cryptoblepharus boutoni nigropunctatus*, also inhabits Chichi-jima. Both lizards are insectivorous and diurnal. However, as a result of competition between the two species, *Cryptoblepharus boutoni nigropunctatus* tends to be found in habitat where it is difficult for *Anolis carolinensis* to survive (Miyashita, 1991; Suzuki, 1999).

*Anolis carolinensis* eats various kinds of small insects, including odonates (Makihara et al., 2004; Karube & Suda, 2004). One individual can eat more than two dragonflies per day (Makihara et al., 2004). An endemic cicada (*Meimuna boninensis*) is eaten

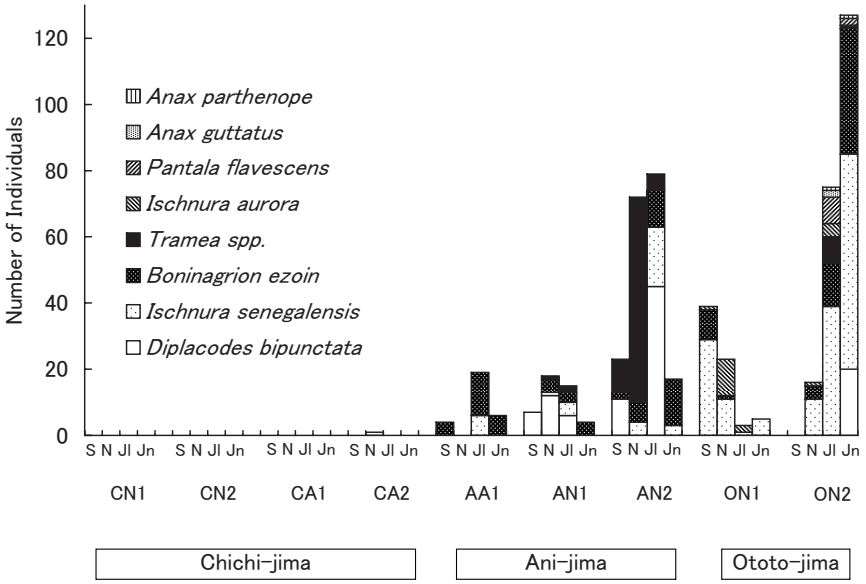


Fig. 3. Number of odonate individuals collected in nine sampling stations of three islands. S: September, N: November, Jl: July, Jn: June.

by *Anolis carolinensis* in the field (Oobayashi, 2001). Under laboratory conditions, another cicada (*Meimuna opalifera*) is usually injured by the mouth of *Anolis carolinensis* although they are not eaten (Makihara et al., 2004). The number of diurnal longicorn beetles has been decreasing while that of nocturnal ones has been almost constant in the field (Makihara et al., 2004). They considered the reason of this decrease as the predation by *Anolis carolinensis*. All the odonates are diurnal species, so odonates might be also eaten by this lizard in Chichi-jima. Therefore, the decrease in the odonate population in Chichi-jima could be largely explained by *Anolis carolinensis* predation.

This lizard was also introduced to Okinawa, Guam and Hawaii (Ota et al., 1995). However, at these sites impacts upon insect populations by predation have not been reported. In the Ogasawara Islands, the lizard fauna is impoverished. Although some birds, such as *Monticola solitarius* and *Buteo buteo*, eat *Anolis carolinensis* (Miyashita, 1991), predation pressure from birds is thought to be low. Therefore, it is possible that the density of *Anolis carolinensis* may be higher in the Ogasawara Islands than in Okinawa, Guam and Hawaii. Sword (2001) reports that a species of grasshopper (*Schistocerca emarginata*) that eats *Ptelea trifoliata* escapes predation by *Anolis carolinensis*, though individuals not feeding upon this plant are caught and eaten by the lizard. Apparently, grasshoppers eating *Ptelea trifoliata* are distasteful and lizards reject them. However, insects in the Ogasawara Islands have not developed this kind of anti-predation strategy against *Anolis carolinensis*.

In Chichi-jima, a priority before providing suitable aquatic habitat for odonates should be to minimize the effects of predation by *Anolis carolinensis*. At present, even if we provide aquatic habitat in Chichi-jima, the ponds would not facilitate conservation and enhancement of odonate populations. In this study, we did not investigate the southern part of Chichi-jima, where human impacts to the environment are fewer. Though Miyashita (1991) reports the range of *Anolis carolinensis* now expanding to southern Chichi-jima, many odonates may still be found there. Accordingly, we see a need to confirm the existence of viable odonate populations in this relatively untouched part of Chichi-jima.

**Acknowledgements**

We would like to thank to T. Oobayashi, for helping the collection of aquatic invertebrate. Collection of endemic and natural monumental odonatan species was done with the permission of Ogasawara broad of education, Tokyo Metropolis and the Agency for Cultural Affairs. This work was supported by a grant funded by the Japan Environmental Agency.

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# 小笠原諸島における固有トンボの減少

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**要旨**

小笠原諸島には多くの固有種が生息している。しかし、環境破壊による生息地の減少や外来種の侵入による個体数の減少によって、多くの固有種が消滅している。固有トンボも絶滅の危機に瀕している種の一つである。環境破壊により幼虫の生息地である水域が減少し、その結果、固有トンボが絶滅の危機に瀕しているのであれば、人工的に水域を設けることによって個体数の減少を食い止め、固有種の絶滅の危機を救うことが出来る。そこで、トンボの生息地として小笠原諸島の父島と兄島に人工的な池を造り、トンボの個体数を増やすことが可能かどうか検証した。自然の池では、兄島と弟島でのみ固有トンボの生息を確認することが出来た。兄島に設置した人工の池にも固有種が生息していたことから、人工の池は固有トンボに生息場所を提供できると考えられた。しかし、父島ではトンボ類の生息を確認することが出来なかった。この島には外来種であるカダヤシやグリーンアノールが生息しており、これらがトンボの幼虫や成虫を捕食しているものと考えられた。父島での固有トンボの保全には外来種の駆除が必要と考えられた。

**キーワード**：グリーンアノール、固有種、海洋島、トンボ、小笠原諸島、捕食者、保全

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