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Introduction to recent systematic studies on amphibians of Sarawak by JRCTS and Forest Research Department Sarawak

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Abstract Herpetological researchers in Kyoto University have conducted several systematic studies in recent years in Sarawak by joint research with the Japan Research Consortium for Tropical Forests (JRCTS) and co-operating with the Forest Department Sarawak. As an outcome, several new amphibian species were described during the last decade. Most of these species had been confused with already known species (i.e., had been cryptic species), but were proven to be distinct species largely based on molecular phylogenetic analyses. Systematic work on amphibians of Sarawak is now becoming active, and further collaborative studies are required.

Keywords Amphibian, Systematics, Molecular phylogeny

Introduction

The island of Borneo, including Sarawak State, is famous for its biodiversity, and many amphibian species were recorded there (Inger 1966; Inger and Lian 1992; Malkmus et al 2002; Inger and Stuebing 2005). According to the authors' count, now the total number of amphibian taxa occurring in this region amounts to ca. 190 spp., and the number is still increasing (Fig. 1; see the next section). We, herpetological researchers in Kyoto University, joining the Japan Research Consortium for Tropical Forests (JRCTS) and co-operating with the Forest Department Sarawak (FDS), have conducted several systematic studies in the past decade in Sarawak. In the present article, we will briefly review recent progress in the systematics of amphibians in Borneo Island and describe future prospects.

Recent systematics of amphibians in Borneo

Only one amphibian species was described from Borneo from 2000 until 2007, but the situation changed after 2008; 34 amphibian species from nine families were newly described from 2008 to 2015, and the total number of species/subspecies became 1.2 times the total number known until 2007 (there was an increase of ca. four spp. per year on average: Fig. 1). Among amphibian families, the largest increase of species number was shown in Megophryidae (22.2 % of new species recorded from Borneo within the last 10 years) and the second largest in Rhacophoridae (17.8 %). Approximately two-thirds (21 spp.) of these species were described by researchers belonging to Kyoto University, largely with the help of the Forest Department Sarawak and some

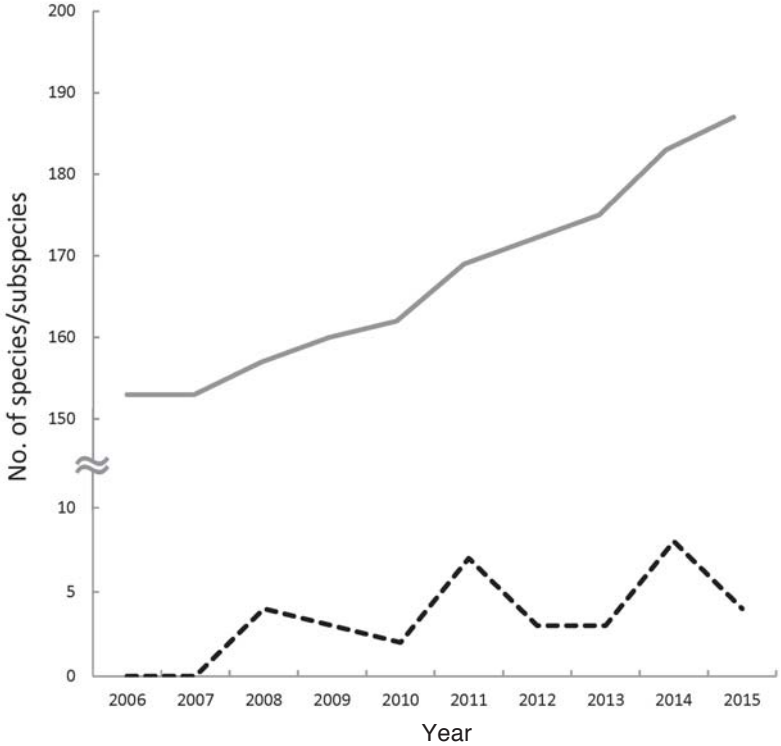

Fig. 1 Changes in the numbers of total amphibian species/subspecies (solid line) and newly described species in each year (broken line) in the last decade.

Fig. 2 An example of morphological similarity between two amphibian species: a megophryid, *Leptobrachella mjobergi* (left), which has been thought to be a widespread species in Sarawak, and recently described *L. juliandringi* (right), which is morphologically quite similar to *L. mjobergi* but has been proven to be a distinct species largely based on molecular data.

institutes in Sabah (e.g., Eto at al. 2015; Shimada et al. 2015; Matsui et al. 2014). The others were identified by studies of Universiti Malaysia Sarawak (UNIMAS) and/or European research groups

(e.g., Das et al. 2014; Hertwig et al. 2014). This indicates that the collaboration between Kyoto Univ. and FDS played a major role in the systematic study of Bornean amphibians.

A large fraction of recently described species are so-called cryptic species, which appear to be similar to other known species. Such species were overlooked until recently, especially until molecular phylogenetic methods had been developed. For example, 18 of 34 original descriptions of species that were described within the last decade used genetic information as a key to judge the species' uniqueness to some extent.

Discussion

It is clear that recent systematic studies on Bornean amphibians have been accelerated largely by the development of molecular techniques. It is often difficult to identify species of some amphibian genera only by morphological traits (Fig. 2), and the use of genetic information for their identification/classification is now becoming common (Hertwig et al. 2014; Matsui et al. 2014). However, molecular techniques are more or less costly and need special facilities, and at present it is not easy to complete such work within Sarawak. Thus, recent amphibian systematics in Sarawak have been done as joint studies between institutes of the state and those of Japan or European countries, as mentioned above. Despite those energetic studies, however, the amphibian diversity of Borneo is thought to be still underestimated (Matsui et al. 2014). The constant increase in the number of newly described species in the last decade (Fig. 1) also supports this idea.

The recent increased activity of systematic studies of amphibians has greatly advanced this field. In contrast, studies in other fields, such as ethology, ecology, and conservation, are still quite limited. Only a few studies in these fields have been done in the last decade (e.g., Das et al. 2007; Zainudin et al. 2010), and almost all of them were basic and descriptive works. Because amphibians go back and forth between water and land, they should play an important role in the circulation of substances and energy between aquatic and terrestrial areas. Thus, ecological studies on amphibians would be essential to understanding the ecosystem of Bornean forests. However, ecological studies generally require periodic data collection, and therefore it would be difficult for foreign researchers to conduct such works solely by themselves. Fortunately, now JRCTS and FDS have a good relationship, which provides a chance to undertake more systematic activities. It is hoped that further collaborative work will lead to much progress in the study of amphibian biology and biodiversity of the forests in Sarawak.

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