INTERNET-BASED ANT TAXONOMY AND BIODIVERSITY INFORMATICS

The American biologist E.O. Wilson of Harvard University has recently delineated the future of biological taxonomy in a widely regarded article: “Imagine an electronic page for each species of organism on Earth, available everywhere by single access on command” (Wilson 2003a). In this context, the Museum of Comparative Zoology at Harvard University has started an “E-type initiative”, with the ultimate aim of putting detailed pictures of 50% of all species on Earth on the internet (http://insects.oeb.harvard.edu/etypes/about.htm). Currently, the debate about the impact of the internet on taxonomy is in full swing (Andersen 2003; Bisby et al. 2002; Blake and Bult 1996; Farr 2006; Godfray 2004; Godfray and Knapp 2004; Gotelli 2004; Guralnick et al. 2007; Huang 2003; Johnson 2007; Lee 2002; Patterson 2003; Scoble 1997; Scoble 2004), and many initiatives have been started. In order to use the opportunities provided by the World Wide Web for taxonomy, ecology and the study of biodiversity, web-based electronic databases on different taxa have been created. International institutions like the Global Biodiversity Information Facility (GBIF) and the Global Taxonomic Initiative (GTI) coordinate the national efforts of museums and universities, and aim at cross-netting and provision of data on species from all over the world. The challenge is immense: currently more than 1.7 million species are described and more than 1.5 billion specimens are housed in the museums of natural history (http://www.gbif.de). The specimen labels, on which their metadata are recorded, comprise a tremendous source of knowledge that document much of what is known about diversity, geographic distribution and phenology of organisms all over the world. Yet most of this knowledge is hardly accessible for researchers, because data are provided on media that are out of reach for the general community and mostly restricted to taxonomists. With the development of biodiversity informatics a new suite of tools is now available that can effectively address these limitations and enlarge the group of potential users (Johnson 2007). Community ecologists will benefit most directly from better access to taxonomic data (Gotelli 2004).

However, the majority of species on Earth are still undescribed and even the total number of species on earth cannot be estimated (Heywood and Watson 1995). On the other hand, habitat destruction and the resulting species loss proceed with great speed on a global scale, especially due to fragmentation and conversion of the tropical rainforests that provide a high percentage of the world’s biodiversity (Laurance 1997; Turner 1996; Wilson 1992; Wilson and Peter 1988). Ecologists are trying hard to understand the consequences of these losses, but their work is hampered because taxonomic data are often sparse for those taxa that are assigned to ecological key positions, like pollination or seed dispersal. Proper identification of species, however, is the starting point for effective analyses of animal communities and for a scientific discussion about the ecological role of certain species. In the tropics especially, better knowledge of the species involved is necessary, e.g. for the comparison of species richness between tropical forest sites. In tropical insects the high number of unknown species currently results in the use of “morphospecies”. However, those species lists do not allow a comparison of different study sites and a reliable calculation of beta diversity indices (Pfeiffer 2007). Thus comprehensive access by scientists to all available taxonomic descriptions and keys, and the consequent and rapid development and provision of these tools, cover a basic need of biodiversity research in order to keep pace with the rapid destruction of natural environments all over the world (Agosti and Johnson 2002).

In this context the identification of ants may be an especially important element. They play a major role in most terrestrial ecosystems and in different trophic layers, they are taxonomically well studied, easy to catch and - down to genus level - easy to identify; thus they are especially well suited for biodiversity studies (Alonso and Agosti 2000). Together with termites, they dominate all strata of tropical forests and many other habitats in terms of abundance and biomass (Fittkau and Klinge 1973). Ants have special functions as bio-indicators (e.g., Andersen & Majer 2004), and some are efficient invaders of new habitats (Holway et al. 2002). Due to these ecological key functions, ants are increasingly used for biodiversity assessment, and for the comparison of habitats and ecosystems (Agosti et al. 2000; Andersen and Majer 2004; Dunn et al. accepted). A major precondition for this was the comprehensive taxonomic evaluation and cataloguing of the ant fauna, which has made great progress in recent years, resulting in the high number of 12,032 species that are currently

described in the Formicidae[1] (Bolton 1994; Bolton 1995; Bolton 2000; Bolton 2003; Bolton et al. 2006). At the same time the availability of taxonomic literature on ants was much improved by an internet portal (www.antbase.org) and the first photo databases on ants that were developed in Japan (http://ant.edb.miyakyo-u.ac.jp/E/index.html) and the USA (www.antweb.org). These databases show the most important taxonomic features of ants in detailed photographs and aim at permitting reliable species identification without the need to use voucher specimens.

A TAXONOMIC ANT DATABASE

In an attempt to contribute to these ongoing efforts, in 2003 the author started a taxonomic photo database (www.antbase.de), dealing with the taxonomy and ecology of ants in a particularly neglected region from which little information on ant taxonomy had been available, seriously hampering scientific research. The major aims of the ANTBASE project are: 1) provision of a source of reliable taxonomic data for the ecological projects in that area; 2) documentation of the overwhelming ant species richness of the Southeast Asian region, and 3) improvement of international cooperation among ant researchers. This virtual museum is based on the large ant collection of the University of Würzburg that houses the specimens of more than 10 years of field work in the primary rain forests of Kinabalu National Park on Borneo, a famous hot spot of diversity (Luping et al. 1978), below the summit of the highest mountain in Southeast Asia (e.g., Aug 1995; Brühl 1996; Floren 1995; Götzke 1994; Malsch 2002; Pfeiffer 1996). The area near the small village of Poring contains, according to current knowledge, the highest species richness of ants on Earth (Brühl et al. 1998)[2].

In many Asian countries, museums of natural history are mostly in the developing phase; taxonomists are rare, and the same is true for scientifically sound identification manuals. This lack of essential scientific infrastructure is also reflected in the number of described insect species, which is clearly below that of the Neotropics (M. Verhaagh, personal communication). In order to strengthen communication and to improve capacity-building, ant researchers have formed a cooperation group ANeT, the international network for ant research in Asia, which is funded by the Japanese Ministry for Cooperation. Besides conducting yearly congresses in different Asian countries, the initiative recently published the first issue of a scientific journal named ASIAN MYRMECOLOGY , which is co-edited by the author.

ANeT is the basis for the cooperation of scientists from 18 countries who are devoted to research on Asian Formicidae (see Fig. 2). This research initiative is supported by the myrmecological site www.antbase.de. The positive impact of this website on Asian ant research has been asserted by several authors who have included the site in their reviews (Agosti 2005; Klingenberg and Verhaagh 2005).

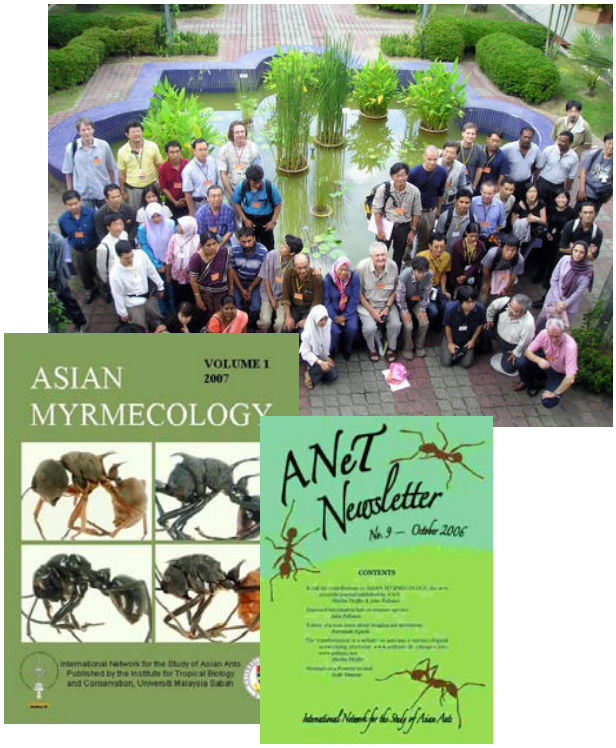

Fig. 2 Above: Members of ANeT at their annual meeting 2006 in Kuala Lumpur. Below: Titles of ANeT publications.

Starting in July 2006, www.antbase.de is now funded by DFG - Scientific Library Services and Information Systems (LIS) within the framework of the Thematic Information Networks program of the German Research Foundation (DFG). This program specifically targets the development of efficient information services and information infrastructures that are essential for the growing demand of the research community for easily accessible information. Since then, the site has been relaunched and renamed as www.antbase.net.

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* A pdf of this chapter with active hyperlinks is available at www.antbase.net.

[1] Number downloaded on 31.08.2007 at http://atbi.biosci.ohio-state.edu:210/hymenoptera/tsa.sppcount?the_taxon=Formicidae

[2] A continually updated species list is available at www.antbase.net in pdf format.

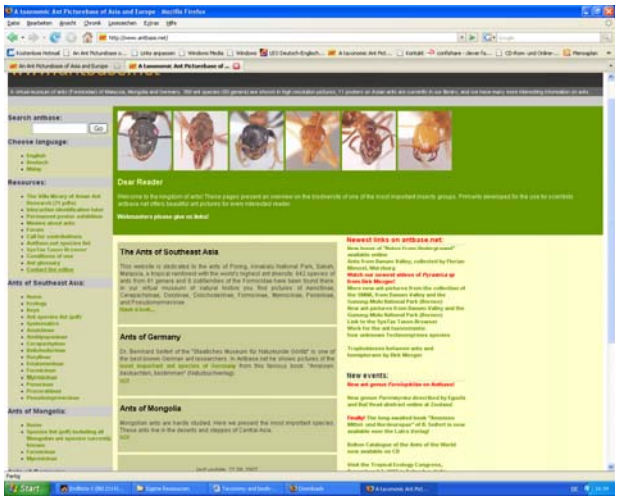

Fig. 3 Screenshot of the front page of www.antbase.net

This recent development and acceptance shows that the website is developing into a myrmecological networking platform (Fig. 3) that includes a much improved photo database, with most species being shown in high-resolution photographs (Fig. 4, 8), and a link to taxonomic information on the species from the Bill Brown Memorial Digital Library (via www.antbase.org) (see Fig. 5). The website is linked to the SysTax database system that is situated at the University of Ulm (AG Jürgen Hoppe) and is the German provider for GBIF, the international network on biodiversity data. All species pages of www.antbase.net are generated from the SysTax database, and most biodiversity and taxonomical data included in SysTax will soon be available, also through the GBIF sites.

Any user with Internet connectivity can utilize this global biodiversity data service and access the GBIF online resources (Edwards 2004). As of April 2007, the GIBIF data portal mediates access to approximately 120 million species-occurrence records from over 1000 collections housed in c. 200 institutions in c. 34 countries (Guralnick et al. 2007). However, a megadata-base like GBIF does not include the benefits of a taxon-specific database like www.antbase.net that provides a better overwiew, additional data sets and information, faster queryable data, quicker updates, and photographs of higher resolution. Moreover, access is planned to all data on ants from GBIF via a portal directly on www.antbase.net. The distribution data may be visualized by "mash-up" information onto Google Earth (Butler 2006), a service already provided at the SysTax portal.

Additional features of our trilingual website (English, German, and Malay) are a web-based pdf library on Asian ants, taxonomic keys for the ant fauna of Borneo (provided by Yoshiaki Hashimoto, University of Hyogo, Japan, see Fig. 6), overview articles on the ecology of Bornean ant species, an exhibition of scientific posters, and a collection of ant videos.

Each specimen is shown in three photographs (frontal, from above, and from the side), and additionally the label is presented (see Fig. 8). Most of the pictures are automontage photographs, consisting of up to 80 single pictures that had been taken with a Leica® camera and processed by the automontage® software (Leica/Synchroscopy) in order to obtain a single high-resolution picture, with an "ultimate depth of field". As the morphology of the specimen is shown on a single picture down to the finest details, the picture provides more information at one glance than the specimen by itself, which in traditional analysis has to be explored by focussing on the different details of the reference specimen with a microscope. Thanks to this outstanding technology, species identification is possible in most cases without the study of the irreplaceable specimens, which can stay in their respective museums without the need for risky journeys to the research lab. Instead of specimens, the ant identifier will study the high-resolution pictures that are freely available via the World Wide Web. This new technique saves much work, time, and the cost of the international lending networking between museums, and allows more people to access specimens at the same time. Although the expertise of the identifier is still needed for the proper identification of the entomological material, the provision of keys and voucher specimens via internet allows us to significantly shorten the processing time.

To overcome the problem of morphospecies during the identification process, standard morphospecies numbers for common Asian species will be provisionally classified by ant experts organized in ANeT. This will be especially valuable in those groups where revisions are overdue and are not likely in the near future (e.g., the extremely species-rich genus *Camponotus*). The "ANeT numbers" will be presented in www.antbase.net and its later use will allow large-scale comparisons of the species data of different researcher groups.

A major step towards the development of a comprehensive web portal for the study of ants will be the inclusion of the FoCol data into the photo database. This data set has been established by Manfred Verhaagh and Christiana Klingenberg of the Natural History Museum of Karlsruhe and includes automontage photographs of all type specimens of ant species that have been deposited in German museums (www.anttypes.org).

Fig. 4 The three-level photodata base on www.antbase.net provides screen-filling ant pictures.

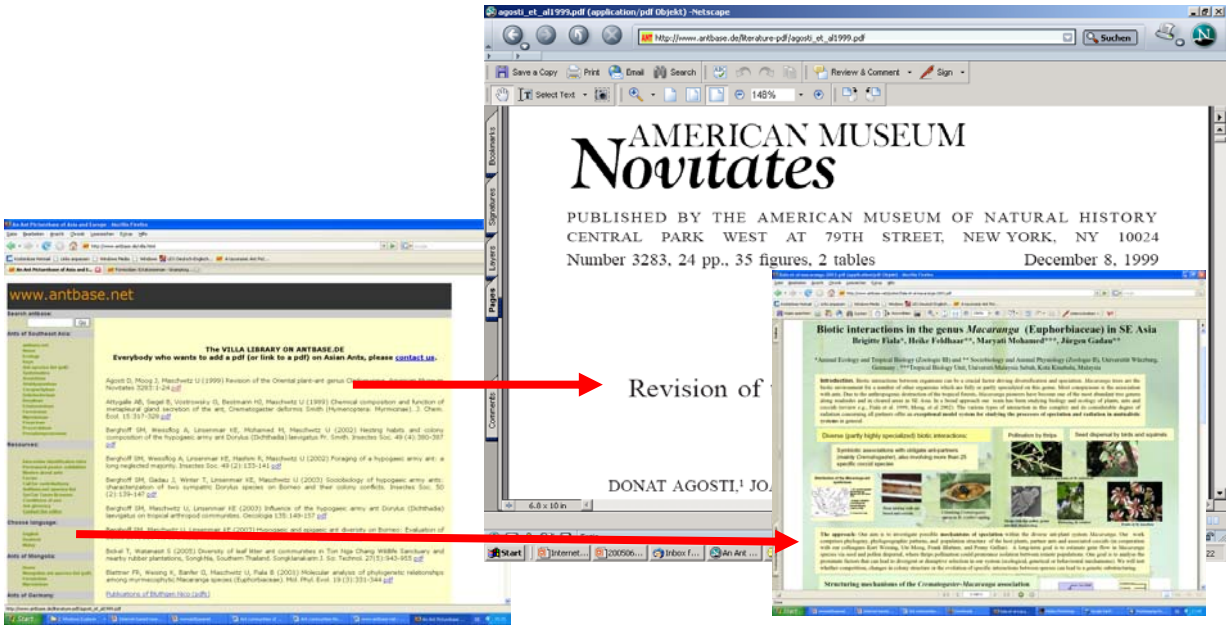

Fig. 5 The "Villa library of Asian Ant Research" provides links to pdfs of original articles. A permanent poster exhibition shows posters by different authors from long-ago conferences.

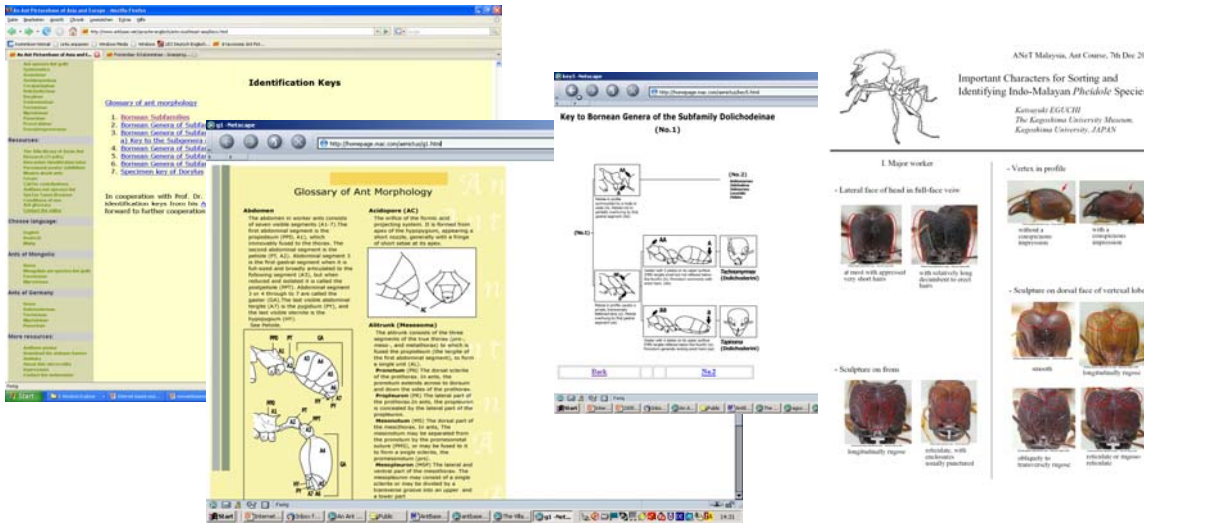

Fig. 6 The keys to subfamilies and genera of Bornean ants are provided by Yoshiaki Hashimoto, University of Hyogo, Japan and are continually updated.

The dataset will be available by the start of 2008 in the SysTax datasystem and comprise more than 2900 type specimens of ants from all over the world that will be available via www.antbase.net.

Following this, the original focus of www.antbase.net, which currently provides data on more than 400 ant species, including about 1200 photographs of Southeast-Asian ants, a complete photographical record of the ant fauna of Mongolia and a set of field photos of many German ant species taken by Bernhard Seifert, will be much expanded. The next steps will include the provision of photographs of the ant fauna of Iran (collaboration with Omid Paknia, University of Ulm), Kyrgyzstan (Kirgiziya) (by Roland Schultz, Zoological Institute & Museum, University of Greifswald), and the "Ants of Central Europe" (in cooperation with Berhard Seifert, Museum of Natural History in Görlitz)[3]. In addition we will provide homepages for all ant researchers cooperating in ANeT and also a database on ant collections in various Asian museums of natural history.

While much more information could have been included in this overview on the activities of www.antbase.net, the only way to truly access the possibilities of this new medium is to visit the myrmecological networking platform in the Internet.

[3] A more detailed outline of the working program of www.antbase.net is given in Pfeiffer, M. 2006. The transformation of a website on ants into a myrmecological networking platform: www.antbase.de changes into www.antbase.net. ANeT newsletter 9(11-14) which is available at http://homepage.mac.com/dorylus/Resources/No.9.pdf

Fig. 8 A set of automontage photographs from www.antbase.net. These pictures have an ultimate depth of field. Shown are the views from the front, above, and the side plus the specimen label. The "antbase number" is an additional label that is attached to the specimen after photographing.