A Mega-Diverse Water Beetle Genus (Coleoptera: Hydraenidae: Hydraena Kugelann) Commonly Overlooked in Southeast Asia and its Potential Use for Environmental Biomonitoring

Hendrik Freitag  
Ateneo de Manila University

Follow this and additional works at: https://archium.ateneo.edu/biology-faculty-pubs

Part of the Biodiversity Commons, Biology Commons, and the Entomology Commons

Recommended Citation
Freitag H (2014) A Mega-Diverse Water Beetle Genus (Coleoptera: Hydraenidae: Hydraena Kugelann) Commonly Overlooked in Southeast Asia and its Potential Use for Environmental Biomonitoring. Entomol Ornithol Herpetol 3: 125. doi:10.4172/2161-0983.1000125

This Article is brought to you for free and open access by the Biology Department at Archium Ateneo. It has been accepted for inclusion in Biology Faculty Publications by an authorized administrator of Archium Ateneo. For more information, please contact oadrcw.ls@ateneo.edu.
A Mega-Diverse Water Beetle Genus (Coleoptera: Hydraenidae: Hydraena Kugelann) Commonly Overlooked in Southeast Asia and its Potential Use for Environmental Biomonitoring

Hendrik Freitag*
Ateneo de Manila University, School of Science & Engineering, Department of Biology, Philippines

Abstract
This study summarizes the current knowledge of the water beetle genus Hydraena Kugelann in Southeast Asia. The surprising species diversity and endemism rates in Hydraenopsis Janssens, the only subgenus present in Southeast Asia, are discussed. Data of five published Hydraena surveys from the Philippines and Singapore are used to evaluate species richness and the occurrence of species assemblages that are subject to the presence and quality of forests. Species richness was found to be generally higher in old grown forests. Some species appeared to be confined to near-natural forests. The denomination of indicator species is impeded by adequate sampling data, so it is suggested to intensify efforts in taxonomic and ecological research on these water beetles. It is concluded that the species richness and the common occurrence of the genus in the region might make Hydraena useful as biomonitoring organisms.

Keywords: Hydraena; Water beetles; Species richness; Endemism; Philippines; Singapore; Southeast Asia; Biomonitoring; Indicator species

Introduction
The Polyphaga family Hydraenidae (Minute Moss Beetles) is one of the most diverse, but least studied groups of predominantly aquatic and semi-aquatic beetles. Its largest genus, Hydraena Kugelann (Long-palped Water Beetles), is circumglobally distributed and comprises about 900 described species. A revised phylogenetic concept [1] recognizes five subgenera, namely Hydraena s.str. (mainly “Laurasian” distribution), Hydraenopsis Janssens (mainly “Gondwanan” distribution), Phothydraena Kuwert (Mediterranean distribution), Spanglerina Perkins (Central American distribution), and Holohydraena Kuwert (Holarctic distribution). The overwhelming part of the genus’ species diversity is confined to the more widely-distributed subgenus Hydraena s.str. and Hydraenopsis.

Jäch and Balke [2] estimated a total number of 500 species of aquatic Hydraenidae occurring in the Oriental Region. Only 120 of them had been named and described until 2007. While the Palaearctic and the Australian regions are quite well studied in regard to their hyraeid fauna, most islands and the continental areas of Southeast Asia have received little attention. Results of recent taxonomic studies of Hydraena in the Philippines by the AQUA Palawan Program [3,4] and surveys on the islands of Luzon [5] and Mindoro [6,7] have revealed a high number of new species, most of them endemic to one or a few islands.

Some Hydraena are used as indicator organisms for water quality, e.g. by DIN 38410-2 [8]. However, as of now, no representative of the subgenus Hydraenopsis is officially recognized as an indicator species, due to insufficient taxonomic and ecological knowledge.

Aquatic macroinvertebrate taxa in general are suitable as monitoring organisms as their occurrence depends on both aquatic and terrestrial environmental conditions. They have developed fast reproduction cycles and efficient re-colonization strategies as they are commonly exposed to small-scale, natural “catastrophic events” such as flash floods or drying-up of their habitat. Therefore, collection in the wild for biomonitoring and other scientific purposes does not generally affect the population’s survival, as long as the habitats are not destroyed or polluted.

This study uses species richness, distributional, and land-cover data of published taxonomic papers to evaluate the potential use of Hydraena species for biomonitoring and as indicator organisms.

Materials and Methods
Published taxonomic studies of the Hydraena fauna in clearly defined and well-sampled areas of the Philippines and Singapore are analyzed in regard to species richness, regional species distribution and habitat conditions. The original data, sampling methods, and detailed area descriptions are published by Freitag and Jäch [3], Freitag and Zettel [4], Freitag [5], Freitag and Pangantihon [6], and Jäch et al. [9]. All sampling sites are located in lowlands. Various microhabitats (submerged leaf litter, littoral sediments, submerged wood) where Hydraena species usually occur were sampled. Species lists of all sampled microhabitats of each site were combined for this paper. Data of the following regional surveys were used:

PAL1: Philippines, Palawan; Puerto Princesa; Puerto Princesa Subterranean River National Park, Brgy. Cabayugan and Marufinas; 10°15’22’’N 118°49’33’’E and 10°09’05’’N 118°58’45’’E, 8m – 150m asl.

PAL2: Philippines, Palawan; Taytay; Lake Manguao Catchment, Brgy. Bato and Poblacion; inbetween 10°44’02’’N 119°29’47’’E and 10°44’29’’N 119°34’00’’E; 15m–100m asl.

MIN: Philippines, Oriental Mindoro; Socorro and Victoria; Lake Naujan Catchment, Brgys. Leido, Lapug, Malayas, Subaan; inbetween 13°09’26’’N 121°18’29’’E and 13°06’46’’N 121°21’45’’E, 3m – 20m asl.

*Corresponding author: Hendrik Freitag, Ateneo de Manila University, School of Science & Engineering, Department of Biology, Loyola Heights, Quezon City, Philippines, Tel: +63 939 2605040; E-mail: hfreitag@ateneo.edu

Received January 08, 2014; Accepted March 20, 2014; Published March 23, 2014

Citation: Freitag H (2014) A Mega-Diverse Water Beetle Genus (Coleoptera: Hydraenidae: Hydraena Kugelann) Commonly Overlooked in Southeast Asia and its Potential Use for Environmental Biomonitoring. Entomol Ornithol Herpetol 3: 125. doi:10.4172/2161-0983.1000125

Copyright: © 2014 Freitag H. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
LUZ: Philippines, Luzon; National Capital Region; Quezon City; Ateneo de Manila University Campus, Loyola Heights; in between 14°38'30''N 121°04'30''E and 14°38'04''N 121°04'56''E; 37m – 63m asl.

SIN: Singapore, various sites between 1°26'43''N 103°43'27''E and 1°40'25''N 103°50'13''E; 8m-70m asl.

Google earth satellite images were enhanced by the use of Corel Photopaint software tools to obtain high contrast images that allows discrimination of old grown forests, secondary vegetation, and other land-use types. These images were used as an underlay for (Figures 1–3), illustrating the Hydraena species richness at the selected sampling areas.

This preliminary analysis is based solely on a descriptive comparison of the species habitats and species occurrence data. A comprehensive, statistically supported analysis was not carried out due to the varying and inconsistent quality of the habitat variables that are available from the original publications. Some of these studies are purely taxonomic.

Results and Discussion

All species recorded from Southeast Asia up to date belonged to the subgenus Hydraenopsis. Representatives occurred in various freshwater habitats and were quite common, although they might be easily overlooked due to their small size, or by unconscious exclusion of their typical microhabitats from sampling. Hydraena species were usually found to be unevenly distributed within a suitable habitat. They commonly occurred in a clumped distribution pattern. Therefore, in order to obtain an accurate representation of Hydraena diversity in a sampling area, many microhabitat patches should be assessed.

The taxonomic knowledge of the genus varies greatly among countries and islands. The Republic of China (Taiwan: 13 species) and the Republic of Singapore (7 species) appear comparably well-explored in regard to their hyraenid fauna [9,10], while in contrast, lists of described species for Indonesia (12 species predominantly from Sumatra and Java) and Malaysia (3 species) are rudimentary [9,11].

In the Philippines, the knowledge of the Hydraena fauna in some islands has substantially improved during the last decade. Only two species, Hydraena scabra d’Orchymont and H. boettcheri d’Orchymont, were known from the country until 2007. Twelve additional endemic species were recently described (see checklist in [5]), and further species descriptions from the Philippines are in preparation. The distribution of most species was restricted to one or a few islands (Table 1).

The number of recorded species differed considerably, from none to seven species per site (Table 2).

Habitats in primary forest usually accommodated more Hydraena species than farmlands, secondary forests and other secondary vegetation. This trend was particularly evident for sites in comparably large patches of old grown forest (Figures 1–3), while sites in altered habitats or those close to altered habitats usually displayed low species richness. However, the available data do not allow clear conclusions regarding whether the age and extent of the forest cover alone, or in combination with other environmental variables, affect the Hydraena species richness. Furthermore, it is not surprising that non-replicated sampling might not be sufficient to detect the majority of species at a certain site. Seasonal aspects are likely to affect species occurrence and species richness.

Some island endemic species (e.g. H. jojoorculloi, H. nielshaggei (Figure 4a), H. sp.D, H. yungae (Figure 4b), H. hendrichi, H. michaelbakeri) seemed to be either rare or confined to certain habitat conditions. Although they belong to different species groups, all of these species, except for H. hendrichi, are characterized by comparably small size and shallowly to moderately deeply impressed elytral and pronotal punctures (Figures 4–5).

Another assemblage of more widely distributed species (H. paulmoritz, H. jacobsoni, H. scabra (Figure 4c), H. palawanensis) appeared to be quite common in various habitats, including disturbed and undisturbed sites. The same applied for H. hosiweri, though it is

| Island | No. of species recorded | No. of island-endemic species | References |
|--------|-------------------------|-----------------------------|------------|
| Palawan | 15 | 12 | [3, 4] |
| Luzon* | 4 | 2 | [5] |
| Mindoro* | 9 | 6 | [6, 7] |
| Singapore | 7 | 3 | [9] |
| Taiwan | 13 | 12 (13) | [10, 14] |

Table 1: Island endemism of Hydraena species in several Southeast Asian islands and Taiwan: total number of species including published records of still undescribed species, number of island endemic species and taxonomic references. * = more undescribed material available at NMW, ADMU and other scientific collections that was not treated in any publication yet and which is not included herein.
probably endemic to Palawan. Among these, *Hydraena paulmoritz*, *H. jacobsoni*, and *H. scabra* belong to the same species group [9] that can be recognized externally by color patterns and the deeply impressed, large elytral and pronotal punctures. In contrast, *H. palawanensis* is a small species, with shallow and inconspicuous punctures that rather resembles the previously mentioned group of rare and island-endemic species.

The respective members of the *Hydraena porcula* group [10] displayed partly contrary characteristics: the large, Palawan-endemic *H. hosiwergi* is common and undemanding, while the Singapore-endemic *H. yangae* is small and so far only recorded from natural forests; the medium-sized *H. hendrichi* is more widely distributed in the Sundrac Region, but might be confined to forested and less disturbed habitats.

All previously known Singaporean *Hydraena* species are considered as “target species” for conservation efforts as they are found to be threatened due to anthropogenic alterations of their specific habitats and their low ecological amplitude [12]. Balke et al. [12] generally regard “water beetles” (in the sense of True Water Beetles [13,14]) as a useful biomonitoring group because the following factors are fulfilled:

1) the group is species-rich; 2) they are present in all types of freshwater and brackish water habitats; 3) several species are confined to particular microhabitats; 4) there is rapidly increasing taxonomic data; 5) the general biological knowledge on most groups is increasing; and 6) some large, colorful, and enigmatic species may attract public interest.

Moreover, some water beetle species might be useful as specific bioindicators for the evaluation of habitat conditions and water quality when particularly No. 3) and further criteria are fulfilled, such as: 7) the species are somewhat common and easily collectable in their typical habitats; 8) they are widely distributed (not regionally endemic); and 9) somewhat easily identifiable. These conditions are usually presupposed for bioindicator species.

While 1), 3), and 7) are true for Southeast Asian *Hydraena*, some other criteria are not fulfilled for most representatives by critical evaluation: their non-ambiguous determination requires dissection of the male genitalia; the rate of island endemism is very high (Table 1) and would require different indicator species for various islands of the same archipelago; the taxonomic and ecological knowledge is still very insufficient for many islands, regions and entire countries in the Oriental Region, as pointed out above.

| Island | Site Code | Vegetation/land use | Hydraena species recorded |
|--------|-----------|---------------------|--------------------------|
| PAL1   | CR1       | Disturbed primary forest | *H. hosiwergi*, *H. kodadai*, *H. nielshaggei*, *H. pseudopalawanensis*, *H. zetteli* |
| PAL1   | CR2       | Secondary forest | *H. nielshaggei* |
| PAL1   | CR3       | Paddy fields/farmland | *H. palawanensis*, *H. pseudopalawanensis* |
| PAL1   | CR4       | Disturbed Primary forest* | *H. zetteli* |
| PAL1   | LS4       | Primary forest | *H. claudia*, *H. palawanensis*, *H. pseudopalawanensis*, *H. zetteli* |
| PAL1   | NC3       | Secondary forest | *H. hosiwergi*, *H. palawanensis*, *H. pseudopalawanensis* |
| PAL1   | PR1       | Secondary vegetation | *H. jojoorculloi*, *H. kodadai*, *H. sp.2* |
| PAL1   | 18        | Secondary forest | *H. castanescens* |
| PAL1   | 19        | Secondary forest | *H. kodadai* |
| PAL2   | 11        | Disturbed primary forest/secondary vegetation | *H. claudia*, *H. castanescens*, *H. hosiwergi*, *H. jojoorculloi*, *H. kodadai*, *H. palawanensis*, *H. scabra* |
| PAL2   | 13        | Disturbed primary forest | *H. claudia*, *H. hosiwergi*, *H. jojoorculloi*, *H. kodadai*, *H. manguao*, *H. scabra* |
| PAL2   | 63        | Disturbed primary forest | *H. claudia*, *H. jojoorculloi*, *H. kodadai*, *H. palawanensis*, *H. sp.2*, *H. sp.E* |
| PAL2   | 64        | Secondary forest/reforestation | *H. claudia*, *H. hosiwergi*, *H. manguao*, *H. palawanensis*, *H. scabra* |
| PAL2   | 65        | Secondary vegetation/farmland | *H. hosiwergi*, *H. palawanensis*, *H. scabra* |
| PAL2   | 66        | Secondary vegetation/paddy fields | *H. manguao* |
various habitats: waters in disturbed areas with secondary vegetation probably not suitable as indicators for disturbance since they occur in *Hydraena scabra*, in the taxonomically explored islands might be a first step towards the needed from many countries in the region. Regional ecological surveys allow us to denominate some species as bioindicators. Ecological studies megacity. Furthermore, it must be assumed that the public appreciation of such small and non-spectacular taxa might be rather low, and there might be little public acceptance for *Hydraena* species as an argument for conservation endeavors. Nevertheless, at least one recently discovered species, namely *Hydraena ateneo*, received international media attention due to its unusual type locality in the middle of a *Hydraena* ateneo, *H. palawanensis* for conservation endeavors. Nevertheless, at least one recently discovered species, namely *Hydraena ateneo*, received international media attention due to its unusual type locality in the middle of a megacity. Our recent knowledge on Southeast Asian *Hydraena* does not yet allow us to denominate some species as bioindicators. Ecological studies on the micro- and macro-habitat requirements of various species are needed from many countries in the region. Regional ecological surveys in the taxonomically explored islands might be a first step towards the identification of indicator species that are common enough, but also confined to certain environmental conditions.

Widely distributed species (in particular the closely related group of species including *Hydraena scabra, H. paulmoritz, H. jacobsoni*) are probably not suitable as indicators for disturbance since they occur in various habitats: waters in disturbed areas with secondary vegetation and in primary forests. On the other hand, endemic species that are more or less confined to pristine forest may be too rare, and they are not always detectable in such habitats.

For several reasons, it would be a great advantage to establish measures beyond the intricate species identification level to make use of *Hydraena* species for biomonitoring by non-specialists. Unfortunately, the use of externally identifiable species groups, body size classes, or similar measures do not appear to be suitable tools as of now. The most promising approach might be the use of the species richness in an area based on replicated sampling during different seasons and should take similar measures do not appear to be suitable tools as of now. The most promising approach might be the use of the species richness in an area based on replicated sampling during different seasons and should take different measures into account varying microhabitats and the patchy micro-distribution of *Hydraena* species.

Based on this preliminary assessment, it is suggested (1) to increase

| PAL2 67 | Secondary forest | H. kodadai, H. palawanensis |
| PAL2 68 | Secondary forest | H. hosiwergi, H. manguao, H. palawanensis, H. sp.2, H. sp.E |
| PAL2 71 | Secondary forest | H. claudia, H. hosiwergi, H. palawanensis |
| PAL2 72 | Secondary forest | H. claudia, H. hosiwergi, H. manguao, H. palawanensis |
| PAL2 73 | Secondary vegetation/ secondary forest | H. hosiwergi, H. jojoocoroloi |
| PAL2 74 | Secondary forest/ reforestation | H. hosiwergi, H. kodadai |
| PAL2 78 | Secondary vegetation | H. sp.D |
| PAL2 100 | Degraded forest secondary forest | H. hosiwergi, H. kodadai |
| PAL2 101 | Secondary forest | H. claudia, H. hosiwergi |
| PAL2 119 | Disturbed primary forest | H. claudia, H. hosiwergi, H. kodadai, H. manguao, H. palawanensis |
| PAL2 120 | Disturbed primary forest | H. hosiwergi, H. kodadai |
| PAL2 121 | Disturbed primary forest | H. claudia, H. castanescens, H. hosiwergi, H. palawanensis |
| PAL2 122 | Disturbed primary forest | H. claudia, H. castanescens, H. hosiwergi, H. kodadai |
| PAL2 145** | Disturbed primary forest | H. hosiwergi |
| PAL2 177** | Disturbed primary forest | H. claudia, H. hosiwergi |
| MIN 1** | Secondary vegetation | NONE |
| MIN 2** | Farmland & secondary vegetation | H. palawanensis, H. scabra, H. sp.A, H. sp.B |
| MIN 3** | Farmland & secondary vegetation | H. scabra, H. sp.A, H. sp.B, H. sp.C |
| LUZ ADM1 | Secondary vegetation/ polluted | NONE |
| LUZ ADM2 | Secondary vegetation/ unpolluted | H. ateneo, H. palawanensis, H. scabra |
| LUZ ADM3 | Secondary vegetation/ unpolluted | H. ateneo, H. palawanensis, H. scabra |
| LUZ ADM4 | Secondary vegetation/ eutrophic | NONE |
| LUZ ADM5 | Secondary vegetation/ eutrophic | NONE |
| SIN BB | Secondary vegetation/ secondary forest | H. paulmoritz |
| SIN BG | Secondary vegetation/ park | H. jacobsoni |
| SIN BT | Primary Forest | H. formula, H. hendrichi, H. jacobsoni, H. paulmoritz |
| SIN KR | Secondary vegetation/ secondary forest | H. paulmoritz |
| SIN LP | Secondary forest | H. jacobsoni, H. paulmoritz |
| SIN MR | Secondary forest/ disturbed primary forest | H. michaelbaikei, H. singaporensis |
| SIN NS | Primary forest | H. formula, H. jacobsoni, H. paulmoritz, H. singaporensis |
| SIN RR | Secondary forest/ disturbed primary forest | H. formula, H. yangae |
| SIN RS | Secondary vegetation | H. jacobsoni, H. paulmoritz |
| SIN SB | Secondary (?) swamp/ mangrove forest | H. paulmoritz |
| SIN UP | Secondary forest | H. singaporensis |

Table 2: List of sampling sites of *Hydraena* surveys (see Material and Methods) with land-use and forest classification and list of recorded species.

* This river section is situated in disturbed primary forest, but very close to upstream farmlands; ** single, non-replicated sampling; label codes as in the original publication except for: BB=Bukit Batok Nature Park; BG=Botanical Gardens; BT=Bukit Timah Nature Reserve; KR=Kranji Reservoir; LP=Lower Peirce Reservoir; MR=MacRitchie Reservoir; NC3 =Nagdayan Creek; NS=Nee Soon Swamp Forest; RR=Stream near Rifle Range Road (east Bukit Timah); RS=River Sembawang/Senoko (habitat destroyed); SB=Sungai Buloh Wetland Reserve; UP=Upper Peirce Forest.
efforts in the taxonomic study of the genus, especially in previously unexplored islands and areas; (2) to study micro- and macro-habitat requirements and preferences of hydraenids; (3) to investigate the occurrence patterns of Hydraena species in time and space subject to water parameters, substrate quality, hydraulic conditions, land-use and surrounding vegetation.

A better knowledge of the hydraenid fauna of Borneo, as well as Malaysia and Indonesia in general, would particularly contribute to a better understanding of the ecological adaptations and distribution patterns of several species groups of the subgenus Hydraenopsis in Southeast Asia.

Acknowledgement

This paper is a preliminary study linked to a survey and evaluation of rural landscape biodiversity in Mindoro funded by PHERNet, a program of the Philippine Commission of Higher Education (CHED). The presentation of the paper during the 2nd GCE conference in Kuching, Malaysia, was also kindly co-financed by this CHED-funded program. Thanks are due to Dr. Manfred A. Jäch (Natural History Museum Vienna, Austria) for the permission to publish a microscopic photograph of Hydraena yangae (Figure 5) of the Image Collection of the World Water Beetle Collection & Research Centre. I would also like to thank Dr. Anneke Padolina (Ateneo de Manila University, Philippines) for proof reading and linguistic improvement of the manuscript.

References

1. Trizzino M, Jäch MA, Audisio P, Alonso R, Ribera I (2013) A molecular phylogeny of the cosmopolitan hyperdiverse genus Hydraena Kugelann (Coleoptera, Hydraenidae). System Entomol 38: 192–208.
2. Jäch MA, Balke M (2008) Global diversity of water beetles (Coleoptera) in freshwater. Hydrobiologia 595: 419-442.
3. Freitag H, Jäch M (2007) Revision of the Palawan and Busuanga species of Hydraena (Coleoptera: Hydraenidae) with descriptions of eleven new species and redescription of H. (Hydraenopsis) scabra d’Orchymont 1925. Zootaxa 1431: 1-44.
4. Freitag H, Zettel H (2014) Aquatic Coleoptera of the Lake Manguao Catchment, Palawan, the Philippines. Philipp Scient 50 (2013): in press.
5. Freitag H (2013) Hydraena (Hydraenopsis) ateneo, new species (Coleoptera: Hydraenidae) and other aquatic Polyphaga from a small habitat patch in a highly urbanized landscape of Metro Manila, Philippines. Zokeys 329: 9-21.
6. Freitag H, Pangantihon CV (2010) Aquatic Coleoptera and Heteroptera of the Lake Naujan National Park, Mindoro Oriental, the Philippines. Philipp Scient 47: 126-173.
7. Vidal AR, Go KC (2013) A Taxonomic Survey on Hydraena (Hydraenopsis) Species of Baroc River Catchment in Barangay San Vicente, Roxas, Oriental Mindoro, Philippines. B.Sc. Thesis, Department of Biology, Ateneo de Manila University, Quezon City, Philippines.
8. Deutsche Norm (2004) German standard methods for the examination of water, waste water and sludge - Biological-ecological analysis of water (group M) – Part 1: Determination of the saprobic index in running waters (M 1). Beuth, Berlin, 80.
9. Jäch MA, Díaz JA, Skale A (2013) The Hydraenidae (Coleoptera) of the Republic of Singapore. Raffles Bull Zool 61(1): 53-71.
10. Jäch MA, Díaz JA (1998) Hydraenidae: I. The Taiwanese species of the genus Hydraena Kugelann (Coleoptera). In Jäch MA, Ji L (Eds) Water Beetles of China, Vol. II. Zoologisch-Botanische Gesellschaft in Österreich and Wiener Coleopterologenverein, Wien: 147-171.
11. Hansen M (1998) Hydraenidae. In: Hansen, M. (ed.), World Catalogue of Insects 1. Apollo Books, Stenstrup 168.
12. Balke M, Hendrich L, Yang CM (1999) Water beetles (Insecta: Coleoptera) in the Nature Reserves of Singapore- Proceedings of the Nature Reserves Survey Seminar. Gardens’ Bulletin Singapore 49 (2) (1997): 321-331.
13. Jäch MA (1998) Annotated check list of aquatic and riparian/littoral beetle families of the world (Coleoptera). In Jäch MA, Ji L (Eds) Water Beetles of China, Vol. II. Zoologisch-Botanische Gesellschaft in Österreich and Wiener Coleopterologenverein, Wien: 25-42.
14. Jäch MA, Díaz JA (2003) Hydraenidae: IV. Additional notes on Hydraena Kugelann from the Ryukyu Archipelago (Nansei-shoto), Japan (Coleoptera). In Jäch MA, Ji L (Eds) Water Beetles of China, Vol. III. Zoologisch-Botanische Gesellschaft in Österreich and Wiener Coleopterologenverein, Wien 3: 379-382.