

A TAXONOMICAL REVIEW ON *PHERETIMOID* EARTHWORMS (OLIGOCHAETA : MEGASCOLECIDAE) FROM INDONESIAN ARCHIPELAGO

Hari Nugroho

Museum Zoologicum Bogoriense, Research Center for Biology, Indonesian
Institute of Sciences, Jl. Raya Jakarta-Bogor Km 46, Cibinong, Bogor, Indonesia
E-mail: harnoeg@gmail.com

ABSTRAK

Kegiatan penelitian tentang cacing tanah *Pheretimoid* di Indonesia banyak dilakukan pada periode 1860-an sampai dengan tahun 1940-an. Setelah periode tersebut hanya sedikit hasil penelitian yang diterbitkan, dan publikasi terbaru ditulis oleh Easton (1979). Koleksi specimen cacing tanah diperoleh dari hampir semua pulau-pulau utama di kawasan Indonesia, tetapi lokasinya hanya terbatas di tempat-tempat tertentu. Sebanyak 162 jenis cacing tanah *Pheretimoid* tercatat dari kawasan kepulauan Indonesia dan dikelompokkan kedalam Sembilan genus: *Amynthas*, *Archipheretima*, *Metaphire*, *Metapheretima*, *Pheretima*, *Pithemera*, *Planapheretima*, *Pleionogaster* dan *Polypheretima*. Saat ini diketahui hanya terdapat empat specimen tipe yang disimpan di Museum Zoologicum Bogoriense (MZB) dan berada dalam kondisi rusak. Sedangkan dua spesimen tipe yang seharusnya tersimpan di MZB tidak dapat ditemukan. Di dalam tulisan ini, permasalahan-permasalahan taksonomi cacing tanah *Pheretimoid* diungkapkan dan dibahas, sehingga dapat digunakan sebagai bahan penelitian di masa yang akan datang.

Kata Kunci: Review, Taksonomi, *Pheretimoid*, Cacing Tanah, Indonesia.

ABSTRACT

Hari N. 2010. A Taxonomical Review on *Pheretimoid* Earthworms (Oligochaeta: Megascolecidae) From Indonesian Archipelago. Zoo Indonesia 2010. 19(2): 71-86. Most studies on Indonesian *Pheretimoid* earthworms were done from 1860's to 1940's in arbitrary manner. After this period only a small number of publications were available, and the latest one was conducted by Easton (1979). A collections of earthworms were obtained from all of main islands of Indonesian Archipelago, but the collecting site were restricted to certain localities. Total of 162 valid species of *Pheretimoid* worms were recorded and grouped into 9 genera: *Amynthas*, *Archipheretima*, *Metaphire*, *Metapheretima*, *Pheretima*, *Pithemera*, *Planapheretima*, *Pleionogaster* and *Polypheretima*. Only four type specimens deposited at Museum Zoologicum Bogoriense (MZB) in macerated and poorly condition, and the remaining two types cannot be located. Taxonomical problems on *Pheretimoid* worms of Indonesia are discussed consecutively to give guidance

for further studies.

Key words : Review, Taxonomy, Pheretimoid, earthworm, Indonesia.

INTRODUCTION

Earthworms constitute more than 80% of the total invertebrate biomass in most world ecosystem, and perhaps the most important soil organism in terms of their influence on organic matter breakdown, soil structural development and nutrient cycling, especially in productive ecosystem (Bohlen, 2002 ; Veeresh *et al*, 1991).

Besides their important role on ecosystem, some aspects of earthworms activities can be undesirable. These includes their activities as pest on agriculture. Some species of earthworms have been reported as pests of rice, although there are not yet reported in Indonesia. Burrowing activities of certain species of earthworms causes problems for strength of rice field terrace. Despite their negative effects on some aspects, earthworms are considered to be a beneficial factor for soil fertility.

Among the order of Oligochaeta, Pheretimoid worms was a enormous taxon which consist of more than 800 nominal taxa, and now assigned into twelve different genera. Blakemore (2007) stated that today the number of species approaches ca. 930 nominal taxa, but not all synonymies are yet determined. According to Easton (1979) the *Pheretima*-group of genera has a wide distribution, from Japan, China, Burma through south-east Asia, Indo-Australasian Archipelago, Queensland, New Caledonia, New Hebrides, Caroline Islands, to Comoro Islands. Apparently Pheretimoid are the biggest group of

earthworms in Indonesian Archipelago, and belongs to 9 different genera: *Amyntas*, *Archipheretima*, *Metaphire*, *Metapheretima*, *Pithemera*, *Pheretima*, *Planapheretima*, *Pleionogaster* and *Polypheretima*. As a consequence it is believed that this group have played an important role on soil fauna and soil properties interaction in this region. Besides their importance in ecosystem, this group may have a potential benefit for medical material, animal feed (poultry, fish, and cattle), and other purposes. In the other side, researches on taxonomy as a base for further studies are still far from complete.

Most Indonesian earthworms have been collected in random collecting events. As a result, there are no comprehensive data on species and its geographical distribution. Some type specimens are not extant or in a poorly condition creating a possibility of misidentification. Since then, it is necessary to provide a preliminary list and distribution of earthworms in Indonesia, especially for Pheretimoid which is the largest group in Indonesian Archipelago.

SYSTEMATICS AND BIOGEOGRAPHY

Pheretimoids are the largest group of earthworms in the world, currently consisting of more than 900 nominal taxa and assigned into 13 genera. Because it is too large to be handled, Sims and Easton (1972) divided the *Pheretima* into eight genera by phenetic analysis according to the greatest number of shared morphological attributes. Furthermore,

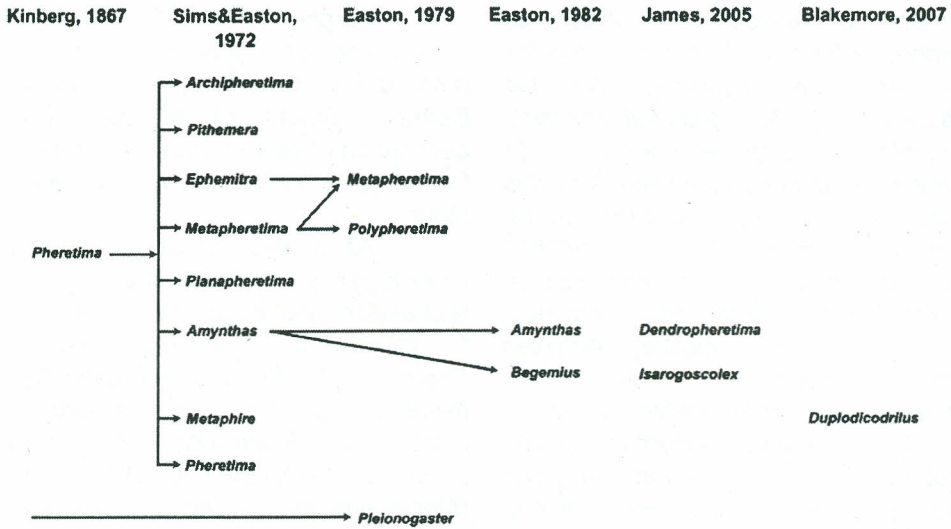


Figure 1. Change of the taxonomic status of the *Pheretima* group [Modified from Shih, et al (1999)].

Easton (1979) re-examined the specimens and revised species without caecum (*acaecate*) in the *Pheretima* group. The genus *Ephemitra* was combined into *Metapheretima*, *Polypheretima* was divided from *Metapheretima*, and *Pleionogaster* with intestinal gizzards was considered to be a member of *Pheretima* group (Shih et al, 1999).

Easton (1982) examined a new earthworm materials from Cape York Peninsula, Queensland. A new genus, *Begemius*, was proposed to accommodate five new species (*B. gavini*, *jamiesoni jamiesoni*, *j. hornensis*, *lockerbiensis*, *raveni*, and *yorkensis*), also three existing species *cyclops* (Cognetti, 1911), *monoperus* (Cognetti, 1911), and *queenslandicus* (Fletcher, 1887) which were previously accommodated in the genus *Amyntas* Kinberg, 1867. *Begemius* was separated from *Amyntas* based on the position of the origin of the intestinal caeca, which is the main character in the division of genera within the *Pheretima* group.

In Addition, James (2005) erected two new genera expanding the diversity of recognized genera in the *Pheretima*-group. These two new genera consisted of four new species that endemic to Philippines, and may be closest to the Australo-Papuan *Begemius*.

Blakemore (2007) proposed new genus *Duplodicrodrilus* based on *Metaphire schmardae* (Horst, 1883).

Horst (1892) published four new species of Pheretimoid worms from Sumatra, *Perichaeta indica* (= *Pheretima darnleiensis*), *Perichaeta sumatrana* (= *Metaphire javanica*?), *Perichaeta hasseltii* (= *Planapheretima hasseltii*) and *Urochaeta dubia* (= *Ph. dubia*) collected from Alahan Panjang, Silago, Soepajang and Lebong of Sumatra respectively.

Michaelsen (1899) published 18 new species of Pheretimoid worms from Celebes, *Amyntas castaneus* (= *Amyntas castaneus*), *Amyntas culminis* (= *Amyntas culminis*), *Amyntas fissiger* (= *Amyntas fissiger*), *Amyntas jampeanus tigrina* (= *Amyntas jampeana tigrinus*), *Amyntas*

jampeanus fumigata (= *Amyntas jampeana fumigatus*), *Amyntas juloides* (= *Amyntas juloides*), *Amyntas kalaenensis* (= *Amyntas kalaenensis*), *Amyntas lompobatagensis* (= *Amyntas lompobatagensis*), *Amyntas sarasinorum* (= *Amyntas sarasinorum*), *Amyntas semifasciatus* (= *Amyntas semifasciatus*), *Amyntas celebensis* (= *Planapheretima celebensis*), *Amyntas subulatus* (= *Pl. subulata*), *Amyntas stelleri seriata* (= *Polypheretima everetti*), *Amyntas stelleri bonensis* (= *Po. everetti*), *Amyntas stelleri klabatensis* (= *Po. everetti*), *Amyntas stelleri annectens* (= *Po. stelleri*), *Amyntas padasensis lokonensis* (= *Pheretima darnleiensis*), and *Amyntas phakellotheca* (= *Po. phacellotheca*). All type specimens were deposited at the Zoologisches Institut und Zoologisches Museum, Universität Hamburg.

Michaelsen (1924) published three new species of Pheretimoid, *Pheretima baweanensis* (= *Ph. urceolata*), *Ph. dammermani* (= *Amyntas dammermani*), and *Ph. keiana* (= *Am. keianus*). The specimens were collected by H.C. Delsman (Bawean Island) and Dammerman (Krakatau, Kei Island). The specimens were reported to be deposited at Museum Zoologicum Bogoriense (MZB). Unfortunately, only two type specimens were found in collection of MZB.

Michaelsen (1928) reported six species of Pheretimoid collected from Java and Sumba. Two of them collected from Mt. Ijen, East Java were new species. They were *Ph. gastrizusa* (= *Am. gastrizusus*) and *Ph. notizusa* (= *Metaphire notizusa*). The other species reported were *Ph. elongata* (= *Po. elongata*) from Kambara-Sumba, *Ph. posthuma* (= *Me. posthuma*) from Kambara-Sumba, *Ph. capensis* (= *Me. javanica*) from Kananggar-Sumba, and *Ph. Montana* from Mt. Ijen-East Java.

Stephenson (1930) described a new species *Pheretima berhalana* (= *Metaphire berhalana*) from Pulau Berhala, Straits of Malacca. The description of new species were based from a collection by J.C van der Meer Mohr.

As a result of *der Deutschen Limnologischen Sunda-Expedition*, Michaelsen and Boldt (1932) reported 5 species of Pheretimoid worms, *Pheretima (Ph.) thienemanni* (= *Amyntas thienemanni*), *Ph. (Ph.) feuerborni* (= *Metaphire feuerborni*), *Ph. (Ph.) baliensis* (= *Amyntas baliensis*), *Ph. (Metapheretima) musiana* (= *Metaphire musiana*) and *Ph. (Metapheretima) bryoni* (= *Metaphire bryoni*).

Gates (1936) on his studies of earthworms from MZB reported 8 species of Pheretimoid, *Ph. capensis* (= *Me. javanica*), *Ph. dammermani* (= *Am. dammermani*), *Ph. fakfakensis* (= *Po. fakfakensis*), *Ph. falcata* (= *Me. falcata*), *Ph. indica* (= *Am. corticis*), *Ph. omtrekensis* (= *Am. omtrekensis*), *Ph. posthuma* (= *Me. posthuma*), and *Ph. quadragenaria* (= *Me. quadragenaria*).

On a further studies of specimens from MZB, Gates (1940) reported six species of Pheretimoid, *Ph. baweanensis* (= *Ph. urceolata*), *Ph. halmaherae* (= *Am. halmaherae*), *Ph. indica* (= *Am. corticis*), *Ph. javanica* (= *Me. javanica*), *Ph. omtrekensis* (= *Am. omtrekensis*), and *Ph. sangirensis*. On this publication, Gates (1940) re-described a type specimen of *Ph. keiana* Michaelsen, 1924 as *Ph. omtrekensis*.

Continuing his studies on earthworms from MZB, Gates (1948) reported 11 species of Pheretimoid, and five of them were described as new species, *Ph. baliemensis* (= *Me. baliemensis*), *Ph. bernhardi* (= *Ph. (Parapheretima) bernhardi*), *Ph. habbemana*, *Ph. rufa* (= *Ph. (Parapheretima) rufa*), and *Ph.*

rufomaculata (= *Planapheretima rufomaculata*). The other 6 species were *Ph. alkmaarica* (= *Ph. (Parapheretima) alkmaarica*), *Ph. beaufortii* (= *Ph. (Parapheretima) beaufortii beaufortii*), *Ph. longa* (= *Me. longa*), *Ph. musica* (= *Me. musica*), *Ph. panarana* (= *Po. gatesi*), and *Pheretima* sp. Most of the specimens were collected by Dr. L.J. Toxopeus from West Irian in The Third Archibold Expedition during 1938-1939, while the other were collected from Sindanglaya-West Java (Ouwens), Central Java-Res. Kediri-Mt. Willis (C.A. Backer), and Enggano Island (J.K. de Jong). From catalogue of annelida of MZB, none of the specimens was found.

Baguion in 1978 (*unpublished data*) reported his survey in Mt. Gede Pangrango, West Java mentioning that the Pheretimoid worms collected in this area were *Metapheretima fakfakensis fakfakensis*-group (= *Polypheretima fakfakensis*), *Amyntas minimus*, *Metaphire longa*, *Metaphire caducichaeta*, *Metaphire javanica*, *Metaphire javanica*-group sp. 1 (= *Metaphire javanica*), *Metaphire javanica*-group sp. 2 (= *Metaphire javanica*), *Metaphire capensis* (= *Metaphire javanica*), *Pheretima (Pheretima) sluiteri* sp. 1 (= *Pheretima (Ph.) sluiteri*), *Pheretima (Pheretima) sluiteri* sp. 2 (= *Pheretima (Ph.) sluiteri*).

A revision of the 'acaecate' earthworms of the *Pheretima* group was published by Easton (1979). Continuing a study of *Pheretima* auct. by Sims&Easton (1972), Easton divided the *Pheretima* group into *caecate* and *acaecate* genera. Four genera *Archipheretima*, *Metapheretima*, *Planapheretima*, *Pleionogaster*, and *Polypheretima* were assigned to *acaecate* genera because of the absence of intestinal caeca. The remaining four were assigned to *caecate* genera whose accommodated

a species with intestinal caeca. Moreover *Metapheretima* re-defined to accommodated *Ephemitra* and some of its species assigned to *Polypheretima*, previously a synonym. Three species, *Polypheretima sempolensis*, *Po. lesonea*, and *Planapheretima sera* were described as new species from Indonesia, and then two species, *Po. gatesi* and *Po. grata* were reported as new records. *Po. gatesi* reported as a new record based on specimen of *Ph. panarana* identified by Gates (1948). '*Pheretima flabellifera* Cognetti, 1911 were known from individual with damaged intestine, and listed as species *incertae sedis*.

Easton (1979) stated that the Pheretimoid group domain extended throughout the forested lands of Asia and Australasia, but it was curiously restricted in some area. Climatic, Ecological condition, and paleogeography of Asia were considered as a limiting factors for the distribution of Pheretimoid worms. As most of Megascolecidea were indigenous on land masses which once formed part of Gondwanaland, it seems likely that they evolved in this region and that their precursors existed in Gondwanaland prior to the Mezozoic break up of this ancient continent. In this model, the origin of *Pheretima* group would lie in New Guinea and Northern Australia since these were the only major Gondwanaland derived area inhibited by indigenous species.

As mentioned by Easton (1979), the distribution of *Pheretima* group of genera were curiously restricted in some areas, as it occurred in the 'acaecate' genera. *Archipheretima* was restricted to Borneo and Philippines, while *Polypheretima* and *Planapheretima* were the most widespread, from Indo-Australasian Archipelago to the Mainland of Asia. *Metapheretima* was restricted to New Guinea, and

their closely allied *Pleionogaster* was restricted to Philippines and possibly Moluccas, although James (2004) denied this opinion. Three genera, *Polypheretima*, *Planapheretima*, and *Metapheretima* probably represent a radiation of precursor from the Papuan area. Some infra-generic groups were also restricted to the Mainland of Asia, while the other were indigenous to Indo-Australasian archipelago.

In Indonesian archipelago, the distribution ranges of species or species-groups seemed to have no correlation with Wallace's or Weber lines, because of their occurrence on both sides of Wallace's line (Easton, 1979). A geographical distribution and evolution patterns of Pheretimoid were interesting in the case of geological history of Indonesian Archipelago. Since the Indonesian archipelago was formed from Eurasian/Laurasian part and Gondwanaland part, sometimes an island were composite and formed by two or more different plates. It was interesting to know the radiation of the precursor from their origin.

The distinction and distribution's extension of *Pheretimoid* in Indonesian archipelago and its vicinity, i.e. Philippines Islands are uncertainly known. As James (2004 & 2005) described several new species and two new genera from Philippines, its seemed that the Pheretimoid of Philippines tended to be distinct. In the other hand, we were lacking of sufficient data from the area nearby, such as north-eastern Borneo, Northern part of Sulawesi and Moluccas.

DISCUSSION

A. Diversity and Distribution of *Pheretimoid* Earthworms

Total of 162 species of Pheretimoid worms were recorded

from Indonesian archipelago, and grouped into nine genera: *Amyntas*, *Archipheretima*, *Metaphire*, *Metapheretima*, *Pheretima*, *Pithemera*, *Planapheretima*, *Pleionogaster* and *Polypheretima* (See Appendix 1). Apparently *Amyntas* and *Metaphire* are the largest of Pheretimoid-group of genera which consisting of 65 and 38 species respectively, followed by *Pheretima* (25 species), *Polypheretima* (21), *Planapheretima* (5), *Metapheretima* (3), *Pithemera* (2), *Archipheretima* (2) and then *Pleionogaster* consisting of only single species. Most of the earthworms were published during 1860's to 1940's. After this period, there were only a few publications on Indonesian Pheretimoid earthworms, and the latest publication was conducted by Easton (1979). From 1980's to present there were no research and publication about Indonesian earthworm's taxonomy.

Most types of new species published from Indonesian archipelago were deposited in several museums in European countries (Amsterdam, Berlin, British Museum, Frankfurt, Hamburg, Leiden, Paris, and Stockholm Museum). Only four type specimens were deposited in Museum Zoologicum Bogoriense (MZB), with macerated and poorly condition. 23 type specimens were lost or cannot be located from where it supposed to be deposited.

Collections of Indonesian earthworms were obtained from all of main islands of Indonesian archipelago, but the collecting localities were restricted to certain area.

Geographical distribution of Pheretimoid worms in Indonesian archipelago varied among their genera, as seen on figure 2:

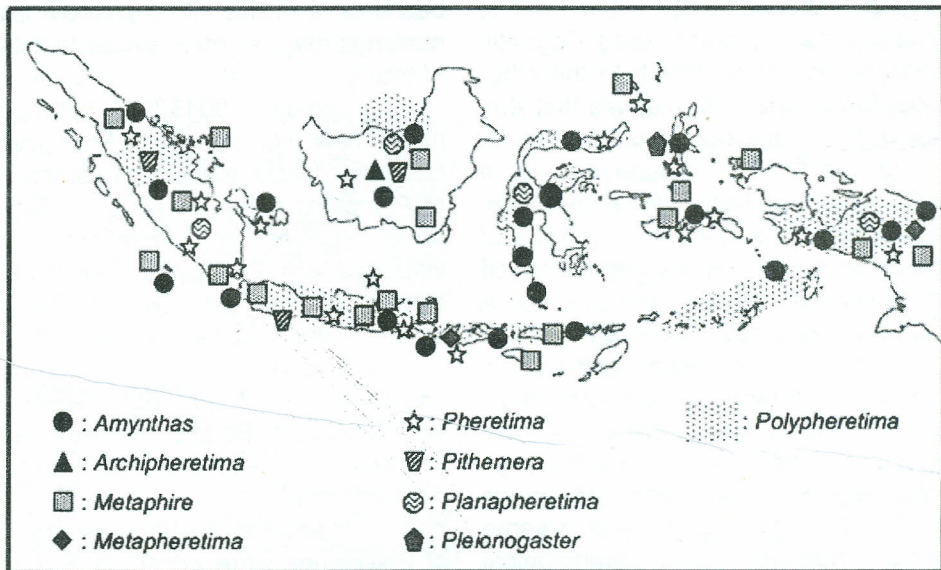


Figure 2. Distribution of the Pheretima group of genera in Indonesian Archipelago [Based on literatures, MZB specimens, and a list from R.J.B Blakemore 2006 (pers. com.)].

Some genera of Pheretimoid had wide distribution along Indonesian archipelago (from Sumatra to Papua). *Amynthus* Kinberg, 1867 occurred in all over Indonesian Archipelago with the greatest number of species was found in Sumatra (22 species) and Sulawesi (20 species). *Metaphire* Sims and Easton, 1972 has been reported from Sumatra, Java, Nusa Tenggara/ Lesser Sunda Islands, Moluccas and Papua with most of them were found in western part of Indonesia: Sumatra (18 species), Java (13), Kalimantan (10) and Lesser Sunda Islands (8 species).

Some genera were restricted to certain islands of Indonesian archipelago, like *Archipheretima*, *Metapheretima* and *Pleionogaster*. *Archipheretima* Michaelsen, 1928 were known from Borneo and Philippines, with only two species occurred in Kalimantan (Borneo-Indonesia), *Archipheretima zonata* (Michaelsen, 1922) and *Ar. picta* (Michaelsen,

1892). *Metapheretima* Michaelsen, 1928 was only recorded from Papua and Lombok island with 3 species, *Metapheretima jocchana* (Cognetti, 1911), *M. myriochaeta* (Cognetti, 1911) and *M. sembaluensis* (Ude, 1932).

Refer to the distribution map above, it seems that the distribution pattern of *Pheretima* group of genera were not completely detailed yet (for detailed geographical distribution of some genera, see fig. 2 on appendix). It could be possible to some genera *Amynthus*, *Metaphire*, *Pheretima*, and *Planapheretima* were widely distributed along the main islands of Indonesian archipelago. And there were a possibility that a lot of new species in all over areas in Indonesian Archipelago were waiting for being discovered.

B. Taxonomical Problems

Gates (1940: 417) re-described a type specimen of *Ph.*

keiana Michaelsen, 1924 (= *Am. keianus*) as *Ph. omtrekensis* Cognetti, 1911 (= *Am. omtrekensis*). In the other side, Blakemore (2005) stated that *Am. keianus* was a synonym of *Ph. Keiana*. It signified that *Ph. Keiana* was still a valid name, not just a synonym of *Am. omtrekensis*. Examination on types of these two species were urgently needed to clarify the status of the species. A material examined by Gates was on much macerated condition, and most of the internal organs had been removed.

Two large species from Sumatera and Java, *Metaphire longa* (Michaelsen, 1892) and *Metaphire musica* (Horst, 1883) shared a same great number of morphological and internal characters, with a little differences on : intestinal caeca, setal formulae (vii, xvii, xviii, xix), extension of clitellum, length and width of body, seminal chamber of spermathecal diverticulum, and typhlosole. According to Gates (1948), *M. longa* was known from Sumatera and West Java, while *M. musica* was restricted to Central Java. The record of distribution of *M. musica* may appear some confusions. As mentioned by Gates (1948), material examined came from Central Java, res. Kediri, Mt. Wilis. Actually, Kediri-Mt. Wilis lay on the eastern part of Java and now belongs to East Java province. Further study on *longa-musica* complex may be interesting for taxonomist due to their closest taxonomical characters and the limitation on distribution between them.

Easton (1979) stated that a member of *Polypheretima bifaria*-group, *Po. brevis* Rosa, 1898 were reported only from Christmas Island. The affinities of *Po. brevis* with the Papuan representatives of the *bifaria* species-group might indicate that it was indigenous in the New Guinea area. None of the three syntypes possessed genital markings, but when more material

becomes available, it is possible that markings may be found similar to those of *bifaria*.

James (2004&206) described many new species from Philippines, raising the questions about the distinctions of *Pheretima* group. In the other hand, some species of *Pheretima* from Indonesia and Philippines were related closely, so the extensive distribution among some species are interesting. A comprehensive survey on earthworms and collections of specimen, especially from Indonesia (Borneo, Sulawesi, and Moluccas) are recommended to obtain more information.

In addition, the paleogeography of Philippines were uncertain and still in question (Whitmore, 1981). A favor paleogeographic model stated that Philippines were the composite, the western part was a fragment rifted away from Asia mainland and the eastern part was an intra-oceanic arc. The Philippines was separated from Asia in Late Mesozoic and collided with eastern part during Oligocene at 23-35 million years ago. As a results, it provided a migration route of animals from Asia mainland and Intra-oceanic arc to northern Borneo and Sulawesi (Whitmore, 1981).

Species incertae sedis

Two species from Indonesian archipelago were still on uncertain position, in which genus their taxonomic position existed. Either Easton (1972) and Blakemore (2007) listed these two species below as *species incertae sedis*, as their position were still uncertain.

***Pheretima? Atheca* Rosa, 1896**

Easton (1972) cited this species as original description, *Perichaeta atheca* Rosa, 1896, while Blakemore (2007) in his checklist of Pheretimoids cited as *Pheretima? Atheca*. Based

on the characters of the type, Easton (1972) stated that this species belongs to *Metaphire* or *Pheretima*.

Pheretima? flabellifera (Cognetti, 1911) Originally this species was described by Cognetti as *Pheretima*, but the damage of the intestine prevents a further examination on presence or absence of caeca which was the important character for *Pheretima s. strict*.

C. Future Research

This paper gives a brief overview of Pheretimoid worms' studies in Indonesian Archipelago. Concerning its condition, a thorough and appropriate survey on Pheretimoid worms of Indonesia is needed to obtain more comprehensive information and solve the problems on it.

Clearly, there are a needs for detailed systematic and biological studies on Pheretimoids from various localities in Indonesia, for a better understanding about evolvement of the group of genera, their ecological importance in various habitats, and their interaction with various soil habitats.

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REFERENCES

Anonim. Lists of Type Specimens of Earthworms. www.Nmb.bs.ch/Naturmuseum Basel.
Baguinon, NT. 1978. *Taxonomic and Ecological Survey of Earthworms*

- at Mt. Gede-Pangrango Complex, West Java, Indonesia. BIOTROP-SEAMEO Regional Center for Tropical Biology. Bogor, Indonesia. (*Unpublished report*).
- Blakemore RJ. 2004. Checklist of New Guinea Earthworms (Oligochaeta : Clitellata). <http://bio-eco.eis.ynu.ac.jp/eng/database/earthworm/NewGuinea.pdf>. (accessed on February 18, 2010).
- Blakemore RJ. 2006. List of Indonesian earthworm species (original), compiled by R.J.B. with some help from Hari Nugroho. <http://bio-eco.eis.ynu.ac.jp/eng/database/earthworm/Indonesia.xls>. (accessed on February 18, 2010).
- Blakemore RJ. 2007. Updated Checklists of Pheretimoids (Oligochaeta: Megascolecidae: *Pheretima auct.*) taxa. <http://www.annelida.net/earthworm/Pheretimoids.pdf> (accessed on February 18, 2010).
- Bohlen, P. J. 2002. Earthworms. In *Encyclopedia of soil science*, R. Lal (ed.), p. 370-373. Marcel Dekker, Inc., NY.
- Easton EG. 1976. Taxonomy and Distribution of the *Metapheretima elongata* Species-Complex of Indo-Australasian Earthworms (Megascolecidae : Oligochaeta). *Bulletin of the British Museum* 30 : 31-52.
- Easton EG. 1979. A Revision of the 'Acaecate' Earthworms of the *Pheretima* Group (Megascolecidae : Oligochaeta): *Archipheretima*, *Metapheretima*, *Planapheretima*, *Pleionogaster*, and *Polypheretima*. *Bulletin of the British Museum* 35 : 1-126.

- Easton EG. 1982. Australian Pheretimoid Earthworms (Megascolecidae : Oligochaeta): A Synopsis with the Description of a New Genus and Five New Species. *Australian Journal of Zoology* 30 : 711-735.
- Gates GE. 1936. On Some Earthworms from the Buitenzorg Museum. *Treubia* 15: 379-393.
- Gates GE. 1940. On Some Earthworms from the Buitenzorg Museum II. *Treubia* 17: 409-420.
- Gates GE. 1948. On Some Earthworms from the Buitenzorg Museum III : Results of the Third Archbold Expedition 1938-1939. *Treubia* 19(2): 139-166.
- Horst R. 1883. New Species of the Genus *Megascolex* Templeton (*Perichaeta* Schmarida) in the Collections of the Leyden Museum. *Notes from the Leyden Museum* vol. 5: 182-196.
- Horst R. 1892. Vermes in Midden-Sumatra. Reizen en onderzoekingen der Sumatra-expeditie, uitgerust door het Aardrijkskundig genootschap, 1877-1879, beschreven door de leden der expeditie, onder toezicht van Prof. P.J. Veth. Vol. 4(1.2): 1-13.
- James SW. 2004. New Species of *Amyntas*, *Pheretima* and *Pleionogaster* (Clitellata : Megascolecidae) of the Mt. Kitanglad Range, Mindanao Island, Philippines. *The Raffles Bulletin of Zoology* 52 (2) : 289-313.
- James SW. 2005. New Genera and Species of Pheretimoid Earthworms (Clitellata : Megascolecidae) from Southern Luzon, Philippines. *Systematics and Biodiversity* 2 (3) : 271-279.
- James, SW. The earthworm genus *Pleionogaster*. (Clitella: Megascolecidae) in southern Luzon, Philippines. *Organisms Diversity & Evolution* 6: 1-20.
- Michaelsen W. 1924. Oligochaten Von Nederlandisch-Indien. *Treubia* Vol. 5 : 379-401.
- Michaelsen W. 1928. Oligochaten Von Java, Sumba und Anderen Hollandischen Sunda-Inseln. *Treubia* 10: 291-297.
- Michaelsen W and W. Boldt. 1932. Oligochaeta der Deutschen Limnologischen Sunda-Expedition. *Archiv für Hydrobiologie* 11: 587-622.
- Shih HT, HW Chang, and JH Chen. 1999. A Review of the Earthworms (Annelida : Oligochaeta) from Taiwan. *Zoological Studies* 38(4) : 435-442.
- Sims, RW and EG Easton. 1972. A numerical revision of the earthworm genus *Pheretima* auct. (Megascolecidae : Oligochaeta) with the recognition of new genera and an appendix on the earthworms collected by the Royal Society North Borneo Expedition. *Biological Journal of the Linnean Society* 4(3): 169-268.
- Stephenson J. 1930. On Some Oligochaeta from Berhala Island in the Straits of Malacca. *Miscellanea Zoologica Sumatrana* 48 : 1-5
- Veeresh GK, D Rajagopal, and CA Viraktamath. 1991. *Advances in Management and Conservation of Soil Fauna*. Mohan Primlani, New Delhi.
- Whitmore TG. 1981. *Wallace's Line and Plate Tectonics*. Oxford University Press. New York.

APPENDIX

Appendix 1.

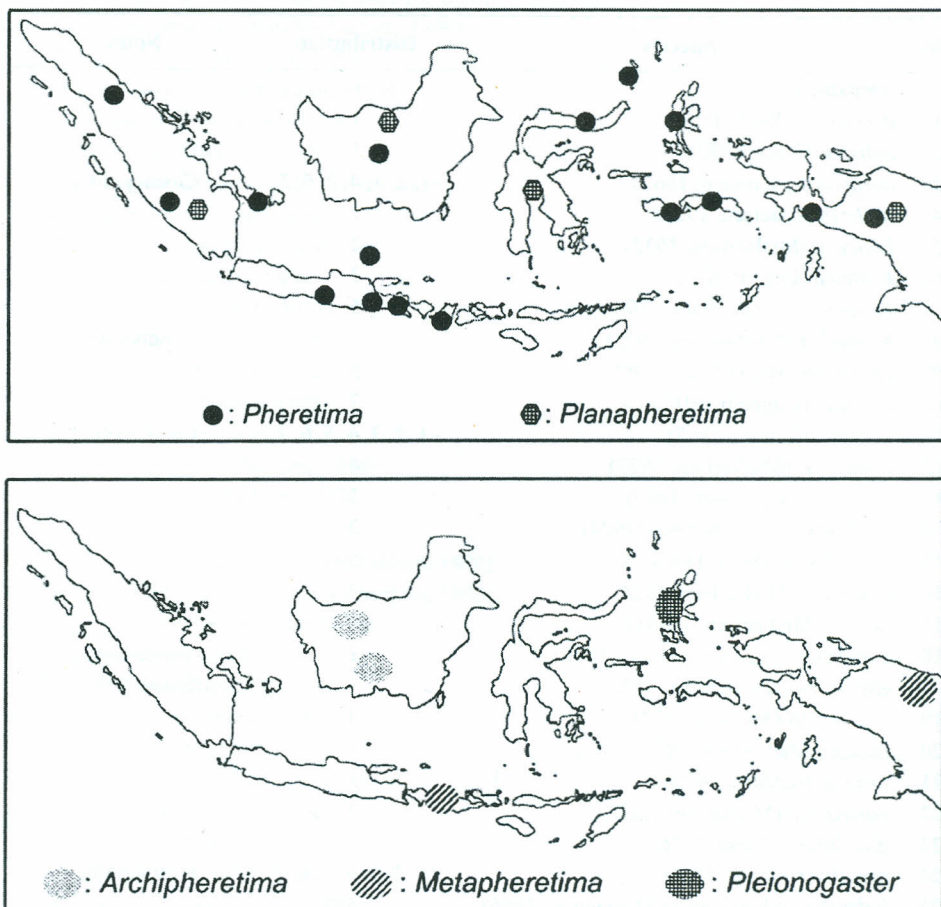


Figure 3. Geographical distribution of some genera of Pheretimoid worms along the Indonesian Archipelago.

Appendix 1. List and geographical distribution of Pheretimoid earthworms from Indonesian Archipelago [From compilation by R.J Blakemore with help from H. Nugroho (pers. Comm.), 2006].

No.	Species	Distribution	Notes
<i>Amyntas</i>			
1.	<i>acrophilus</i> (Rosa, 1896)	1	
2.	<i>aelianus</i> (Rosa, 1892)	1	
3.	<i>aeruginosus</i> Kinberg, 1867	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
4.	<i>agilis</i> (Michaelsen, 1923)	1	
5.	<i>baliensis</i> (Michaelsen, 1932)	2	
6.	<i>benhami</i> (Ude, 1932)	3	
7.	<i>bonthainensis</i> (Benham, 1896)	5	
8.	<i>buitendijki</i> (Michaelsen, 1922)		Indonesia
9.	<i>castaneus</i> (Michaelsen, 1899)	5	
10.	<i>colossus</i> (Cognetti, 1911)	7	
11.	<i>corticis</i> (Kinberg, 1867)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
12.	<i>copulatrix</i> (Michaelsen, 1922)	4	
13.	<i>culminis</i> (Michaelsen, 1899)	5	
14.	<i>dammermani</i> (Michaelsen, 1924)	2	
15.	<i>digitatus</i> (Benham, 1896)	5	
16.	<i>doormani</i> (Michaelsen, 1924)	7	
17.	<i>dorous</i> (Michaelsen, 1934)	5	
18.	<i>enganensis enganensis</i> (Rosa, 1892)	1	Sunda Island.
	<i>enganensis tetrus</i> (Rosa, 1892)	1	Sunda Island.
19.	<i>festivus</i> (Michaelsen, 1922)	4	
20.	<i>fissiger</i> (Michaelsen, 1899)	5	
21.	<i>forbesi</i> (Beddard, 1890)	3	
22.	<i>gastrizusus</i> (Michaelsen, 1928)	2	
23.	<i>glandulosus</i> (Rosa, 1896)	1	
24.	<i>gracilis</i> (Kinberg, 1867)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
25.	<i>halmaherae batjanensis</i> (Michaelsen, 1896)	6	
	<i>halmaherae caecilus</i> (Michaelsen, 1896)	6	
	<i>halmaherae galelensis</i> (Michaelsen, 1896)	6	
	<i>halmaherae gamsungi</i> (Michaelsen, 1896)	6	
	<i>halmaherae halmaherae</i> (Michaelsen, 1896)	6	
	<i>halmaherae imparicystis</i> (Michaelsen, 1896)	6	
	<i>halmaherae kauensis</i> (Michaelsen, 1896)	6	
26.	<i>heurni</i> (Michaelsen, 1924)	7	
27.	<i>hexathecus</i> (Benham, 1897)	5	
28.	<i>jacobsoni</i> (Michaelsen, 1922)		Indonesia

¹Sumatra, ²Java&Bali, ³Lesser Sunda Islands, ⁴Kalimantan, ⁵Sulawesi, ⁶Moluccas, ⁷Papua.

No.	Species	Distribution	Notes
29.	<i>jampeanus fumigatus</i> (Michaelsen, 1899)	5	
	<i>jampeanus jampeanus</i> (Michaelsen, 1896)	5	
	<i>jampeanus tigrinus</i> (Michaelsen, 1899)	5	
30.	<i>juloides</i> (Michaelsen, 1899)	5	
31.	<i>kalaenensis</i> (Michaelsen, 1899)	5	
32.	<i>keianus</i> (Michaelsen 1924)	6	
33.	<i>lalangi</i> (Michaelsen, 1923)	1	
34.	<i>lompotatangensis</i> (Michaelsen, 1899)	5	
35.	<i>maximus</i> (Cognetti, 1915)	7	
36.	<i>minahassae</i> (Michaelsen, 1896)	5	
37.	<i>minimus</i> (Horst, 1893)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
38.	<i>misellus</i> (Cognetti, 1913)	7	
39.	<i>miserus</i> (Cognetti, 1913)	7	
40.	<i>mjobergi</i> (Michaelsen, 1923)	1	
41.	<i>modiglianii</i> (Rosa, 1889)	1	
42.	<i>nanus</i> (Rosa, 1896)	1	
43.	<i>noebianus</i> (Michaelsen, 1934)	3	
44.	<i>ocellatus</i> Michaelsen, 1899	1	
45.	<i>omtrekensis</i> (Cognetti, 1911)	6, 7	
46.	<i>pataniensis labuhensis</i> (Michaelsen, 1896)	6	
	<i>pataniensis pataniensis</i> (Michaelsen, 1896)	6	
47.	<i>petahanus</i> (Michaelsen, 1934)	4	
48.	<i>principalis</i> (Michaelsen, 1932)	2	
49.	<i>proporus</i> (Rosa, 1896)	1	
50.	<i>purpureus</i> (Benham, 1897)	5	
51.	<i>rodericensis</i> (Grube, 1879)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
52.	<i>sarasinorum</i> (Michaelsen, 1899)	5	
53.	<i>semifasciatus</i> (Michaelsen, 1899)	5	
54.	<i>silvestris</i> (Michaelsen, 1923)	1	
55.	<i>sinabunganus</i> (Michaelsen, 1923)	1	
56.	<i>supuensis</i> (Michaelsen, 1896)	6	
57.	<i>thienemanni</i> (Michaelsen, 1932)	1	
58.	<i>tobaensis</i> Michaelsen, 1899	1	
59.	<i>udei</i> (Rosa, 1896)	1	
60.	<i>versteegi</i> (Michaelsen, 1938)?	7	
61.	<i>vialis</i> (Michaelsen, 1924)	7	
62.	<i>vordermani</i> (Horst, 1890)	1	
63.	<i>wetzeli</i> (Ude, 1932)	3	
64.	<i>winkleri</i> (Michaelsen, 1928: 29)	4	
65.	<i>zebrus</i> (Benham, 1896)	5	

¹Sumatra, ²Java&Bali, ³Lesser Sunda Islands, ⁴Kalimantan, ⁵Sulawesi, ⁶Moluccas, ⁷Papua.

No.	Species	Distribution	Notes
<i>Archipheretima</i>			
66.	<i>picta</i> (Michaelsen, 1892)	4	
67.	<i>zonata</i> (Michaelsen, 1922)	4	
<i>Metaphire</i>			
68.	<i>baliemensis</i> (Gates, 1948)	7	
69.	<i>berhalana</i> (Stephenson, 1930)	1	
70.	<i>bindjeyensis</i> (Michaelsen, 1899)	1	
71.	<i>bryoni</i> (Michaelsen, 1932)	2	
72.	<i>burchardi burchardi</i> (Michaelsen, 1899)	1	
73.	<i>caducichaeta</i> (Benham, 1895)	2	
74.	<i>cai</i> (Michaelsen, 1916)	2	
75.	<i>californica</i> (Kinberg, 1867)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
76.	<i>densipapillata</i> (Michaelsen, 1896)	6	
77.	<i>ditheca</i> (Michaelsen, 1928)	4	
78.	<i>falcata</i> (Horst, 1883)	1, 3	
79.	<i>fasciata</i> (Rosa, 1892)	1	
80.	<i>ferdinandi</i> (Michaelsen, 1891)	5, 6	
81.	<i>ferion</i> (Cognetti, 1913)	7	
82.	<i>feuerborni</i> (Michaelsen, 1932)	1	
83.	<i>floresiana</i> (Michaelsen, 1934)	3	
84.	<i>gjellerupi</i> (Cognetti, 1914)	7	
85.	<i>houletti</i> (Perrier, 1872)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
86.	<i>impudens</i> (Michaelsen, 1899)	4	
87.	<i>insignis</i> (Michaelsen, 1921)		Indonesia
88.	<i>javanica</i> (Kinberg, 1867)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
89.	<i>kockensis</i> (Michaelsen, 1930)	1	
90.	<i>longa</i> (Michaelsen, 1892)	1, 2	
91.	<i>musiana</i> (Michaelsen, 1932)	1	
92.	<i>musica</i> (Horst, 1883)	2, 3	
93.	<i>notizusa</i> (Michaelsen, 1928)	2	
94.	<i>pajana</i> (Michaelsen, 1928)	4	
95.	<i>peguana</i> (Rosa, 1890)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
96.	<i>posthuma</i> (Vaillant, 1869)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan.
97.	<i>quadragenaria</i> (Perrier, 1872)	1	
98.	<i>quadripapillata</i> (Michaelsen, 1899)	1	
99.	<i>saonekana</i> (Cognetti, 1913)	7	
100.	<i>singalangi</i> (Michaelsen, 1930)	1	
101.	<i>sintangi</i> (Michaelsen, 1922)	4	
102.	<i>tjandiana</i> (Michaelsen, 1932)	2, 4	
103.	<i>variabilis</i> (Horst, 1893)	1	
104.	<i>weberi</i> (Cognetti, 1913)	6	
105.	<i>willeyi</i> (Benham, 1895)	2	

¹Sumatra, ²Java&Bali, ³Lesser Sunda Islands, ⁴Kalimantan, ⁵Sulawesi, ⁶Moluccas, ⁷Papua.

No.	Species	Distribution	Notes
<i>Metapheretima</i>			
106.	<i>jocchana</i> (Cognetti, 1911)	7	
107.	<i>myriochaeta</i> (Cognetti, 1911)	7	
108.	<i>sembalunensis</i> (Ude, 1932)	3	
<i>Pheretima</i>			
Subgenus <i>Pheretima</i>			
109.	<i>ambonensis</i> Cognetti, 1913	6	
110.	<i>ceramensis</i> Cognetti, 1922	6	
111.	<i>darnleiensis</i> (Fletcher, 1886)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
112.	<i>dubia</i> (Horst, 1893)	1	
113.	<i>habbimana</i> Gates, 1948	7	
114.	<i>korinchiana</i> Cognetti, 1922	1	
115.	<i>leopoldi</i> Michaelsen, 1930	1	
116.	<i>montana</i> Kinberg, 1867	2	
117.	<i>philippina</i> (Rosa, 1891)	1	
118.	<i>poiana</i> Michaelsen, 1913	4	
119.	<i>pura</i> (Rosa, 1898)	3	
120.	<i>racemosa</i> (Rosa, 1891)	1, 2, 4	
121.	<i>sangirensis chica</i> (Michaelsen, 1896)	5, 6	
	<i>sangirensis crassicystis</i> (Michaelsen, 1896)	5, 6	
	<i>sangirensis sangirensis</i> (Michaelsen, 1891)	5, 6	
122.	<i>sluiteri</i> (Horst, 1890)	1	
123.	<i>tosariana</i> Cognetti, 1913	2	
124.	<i>urceolata</i> (Horst, 1893)	1, 2	
Subgenus <i>Parapheretima</i>			
125.	<i>aberrans</i> Cognetti, 1911	7	
126.	<i>alkmaarica</i> Cognetti, 1913	7	
127.	<i>barbara barbara</i> Cognetti, 1913	7	
	<i>barbara barbigua</i> Blakemore, 2004	7	
128.	<i>beaufortii apotrema</i> Cognetti, 1913	7	
	<i>beaufortii beaufortii</i> Cognetti, 1911	7	
129.	<i>bernhardi</i> (Gates, 1948)	7	
130.	<i>hellwigiana</i> Cognetti, 1913	7	
131.	<i>pluviosa</i> Cognetti, 1913	7	
132.	<i>rufa</i> Gates, 1948	7	
133.	<i>utakwana</i> Cognetti, 1915	7	
<i>Pithemera</i>			
134.	<i>bicincta</i> (Perrier, 1875)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
135.	<i>?liangi</i> (Michaelsen, 1922)	4	

¹Sumatra, ²Java&Bali, ³Lesser Sunda Islands, ⁴Kalimantan, ⁵Sulawesi, ⁶Moluccas, ⁷Papua.

No.	Species	Distribution	Notes
<i>Planapheretima</i>			
136.	<i>celebensis</i> (Michaelsen, 1899)	5	
137.	<i>hasselti</i> (Horst, 1883)	1	
138.	<i>nieuwenhuisi</i> (Michaelsen, 1922)	4	
139.	<i>rufomaculata</i> (Gates, 1948)	7	
140.	<i>subulata</i> (Michaelsen, 1899)	5	
<i>Pleionogaster</i>			
141.	<i>horsti</i> (Beddard, 1886)	6	
<i>Polypheretima</i>			
142.	<i>annulata</i> (Horst, 1883)	6, 7	
143.	<i>badia</i> (Ude, 1932)	3	
144.	<i>bifaria</i> (Michaelsen, 1924)	6, 7	
145.	<i>brevis</i> (Rosa, 1898)	7	
146.	<i>elberti</i> (Ude, 1932)	3	
147.	<i>elongata</i> (Perrier, 1872)	1, 2, 3, 4, 5, 6, 7	Cosmopolitan
148.	<i>everetti</i> (Beddard & Fedarb, 1895)	3, 5	
149.	<i>fakfakensis</i> (Cognetti, 1908)	7	
150.	<i>gatesi</i> Easton, 1979	7	
151.	<i>grata</i> (Cognetti, 1914)	7	
152.	<i>kellneri</i> (Ude, 1932)	3	
153.	<i>lesonea</i> Easton, 1979	1	
154.	<i>mertoni</i> (Michaelsen, 1910)	6	
155.	<i>moelleri</i> (Michaelsen, 1921)	2	
156.	<i>panarana</i> (Michaelsen, 1938)	7	
157.	<i>phacellotheca</i> (Michaelsen, 1899)	5, 6	
158.	<i>renschii</i> (Ude, 1932)	3	
159.	<i>sempolensis</i> Easton 1979	2	
160.	<i>sibogae</i> (Michaelsen, 1922)	3	
161.	<i>stelleri</i> (Michaelsen, 1891)	5	
162.	<i>swelaensis</i> (Ude, 1932)	3	

¹Sumatra, ²Java&Bali, ³Lesser Sunda Islands, ⁴Kalimantan, ⁵Sulawesi, ⁶Moluccas, ⁷Papua.

PETUNJUK PENULISAN

Zoo Indonesia merupakan jurnal ilmiah di bidang zoologi yang diterbitkan oleh organisasi profesi Masyarakat Zoologi Indonesia (MZI) sejak tahun 1983. Terbit setiap tahun satu volume dengan dua nomor (Juni & Nopember). Bentuk naskah terbagi atas naskah utama, berupa hasil penelitian yang utuh dan belum diterbitkan; naskah penunjang, berupa catatan pendek dari hasil penelitian yang dirasakan perlu cepat untuk diinformasikan; dan review, suatu kajian ilmiah yang menyeluruh, lengkap dan cukup mendalam tentang suatu topik berdasarkan rangkuman hasil penelitian beberapa peneliti. Bidang pembahasan dalam Zoo Indonesia meliputi fauna, pada semua aspek keilmuan seperti Biosistimatik, Fisiologi, Ekologi, Molekuler, Pemanfaatan, Pengelolaan, Budidaya dll. Tata cara penulisan adalah:

1. Naskah ditulis dalam bahasa Indonesia atau Inggris. Diketik pada format kertas A-4 dengan jarak spasi 1.5, Arial, font 10. Ukuran margin atas & bawah 2.54 cm, kanan & kiri 3.00 cm.
2. Sistematik penulisan :
 - a. **Judul**, singkat dan jelas, penyertaan anak judul sebaiknya dihindari. Diketik dengan huruf besar, dihitamkan, terkecuali pada nama Latin, dengan huruf miring.
 - b. **Nama dan alamat penulis** beserta alamat elektronik, ditulis lengkap tanpa ada singkatan, ditempatkan di bawah judul.
 - c. **Abstrak**, merupakan intisari naskah, ditulis tidak lebih dari 200 kata dan dituangkan dalam satu paragraf. Dibawah abstrak dicantumkan kata kunci maksimal lima kata. Berbahasa Indonesia dan Inggris.
 - d. **Pendahuluan**, ditulis singkat mengenai latar belakang penelitian, permasalahan, hal-hal yang telah diketahui, pendekatan yang dikembangkan dalam memecahkan masalah dan pencapaian tujuan penelitian.
 - e. **Materi & Metode**, menerangkan secara jelas tata cara penelitian, waktu dan tempat penelitian, metode yang digunakan, analisa statistik, sehingga mampu diulang kembali oleh pihak lain atau mengkaji ulang runtutan tata cara penelitian. Data mengenai nomor aksesori spesimen, asal-usul spesimen, lokasi atau hal lain yang dirasa perlu untuk penelusuran kembali, ditempatkan sebagai Lampiran, setelah Daftar Pustaka.
 - f. **Hasil & Pembahasan**, menyajikan hasil penelitian yang diperoleh, sekaligus mengupas dan membahas hasil penelitian, membandingkannya dengan hasil temuan peneliti lain dan penjabaran implikasi dari penelitian yang diperoleh. Penyertaan ilustrasi dalam bentuk Tabel, Gambar atau Sketsa hendaknya berwarna hitam putih. Khusus foto dapat hitam putih atau berwarna, format JPEG. Sitiran untuk menghubungkan nama penulis dan tahun terbitan tidak menggunakan tanda koma. Bila ada beberapa tahun penulisan yang berbeda untuk satu penulis yang sama digunakan tanda penghubung koma, serta tanda gabung bentuk titik koma pada kumpulan sitiran yang mengelompok tetapi berbeda penulis (Hasyim 2005, 2006; Gunawan 2004). Nama penulis yang lebih dari dua orang ditulis *et al.* (jurnal terbitan asing) atau dkk. (jurnal terbitan lokal). Kata penghubung diantara dua penulis menggunakan tanda &.
 - g. **Kesimpulan**, merupakan rangkuman dari keseluruhan hasil penulisan.
 - h. **Daftar Pustaka**, menyajikan semua pustaka yang dipergunakan dalam naskah.

- Flannery, T. 1990. Mammals of New Guinea. Robert Brown & Associates. New York.
- Nelson, M.E & L.D Mech. 1987. Demes with a Northeastern Minesota Deer Population. In: B.D Chepko-Sade & Z Tanghapin (edits.) Mammalian Dispersal Pattern-The Effect of Social Structure on Population Genetics. University of Chicago Press. 230-243.
- Youngson, R.W. 1970. Rearing red deer calves. *Journal of Wildlife Management* 34:467-470.

3. **Ucapan Terima Kasih**, sebagai penghargaan atas pihak-pihak yang dirasa layak diberikan.
4. Naskah lengkap dapat dikirim melalui alamat elektronik atau pos. Bila melalui pos dikirim dua rangkap, satu diantaranya tanpa nama dan alamat penulis, disertai disket/compact disk.

Redaksi Zoo Indonesia
d/a Bidang Zoologi, Puslit Biologi LIPI
Gd. Widyasatwaloka
Jl. Raya Bogor-Jakarta KM. 46
Cibinong 16911
zooindonesia@gmail.com (www.biologi.lipi.go.id)

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