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Biodistribution of the Informal Group Basommatophora in the Philippines

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ABSTRACT

Basommatophora is an informal group within the molluscan subclass Pulmonata comprising of air-breathing freshwater snails that are typically characterized by eyespots located at the base of two non-contractile tentacles and two external genital orifices. They also have varied shell structures and habitats, not only within the group but also within families. Families of the Basommatophora are highly ubiquitous and may play a role in the life cycles of various parasites of humans and animals. Basommatophora has a worldwide geographical distribution across freshwater, terrestrial and marine habitats. However, little is known on their distribution in the Philippines. This report focuses on describing the biogeographical distribution of the basommatophorans in the Philippines through data gathered from museum collections, foreign databases accessed online, and identification of species found in various literatures. A qualitative description of the distribution of each Basommatophora family in the Philippines is given by distribution maps, indicating locations where specimens were collected and/or identified. A total of 336 counts of basommatophorans from 22 genera were encountered from available literature, museums and public databases. The majority of the occurrences are from the genera *Siphonaria*. The data and maps generated describe most of the distribution to be in Luzon, with Visayas and Mindanao having close counts with each other. The Philippines has the third most occurrences and genera of basommatophorans of all tropical countries in the world. However, the true diversity of the group could be higher if a more systematic sampling of the archipelago is conducted.

Keywords: Basommatophora, Philippines, biogeographical distribution

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INTRODUCTION

Basommatophora is currently regarded as an informal group of the molluscan subclass Pulmonata, containing about 2500 species that are grouped into the superfamilies Amphiboloidea and Siphonarioidea as well as the clade Hygrophila. There are nine recognized families under this group (Bouchet and Rocroi 2005). However, it was found recently that Basommatophora is polyphyletic, and all its members were moved into a new taxon, Panpulmonata (Jörger and others 2010).

The most distinct observable characteristics of this group are the eyespots, which are normally located at the base of two non-contractile tentacles, and the two external genital orifices. Other features seem to be shared with other pulmonate superorders, though specializations may occur if there are major changes in habitat or body form (Solem 2008).

Basommatophora has a worldwide geographical distribution, with species inhabiting predominantly freshwater but may also thrive in marine and terrestrial habitats (Fretter and Peake 1978). Like other invertebrates, freshwater gastropods present an overall pattern of high diversity in the tropics, with low levels of species richness and endemicity at higher latitudes. Small oceanic islands are noteworthy for generally low levels of freshwater gastropod species richness and endemism (Starmühlner 1979). Most species are capable of self-fertilization, so it is possible to populate a new body of water; however, cross-fertilization is the normal mode of reproduction (Solem 2008). Egg-laying is the norm for the basommatophorans, although two species of *Protancylus* have been observed to brood eggs (Albrecht and Glaubrecht 2006). Generation time is usually short, so enormous numbers of snails can build up very quickly during favorable conditions. As a result, basommatophoran snails show minor variation among populations (Solem 2008).

Families in this suborder inhabit a great variety of freshwater habitats, living in water of less than 12 ft depth. Only rarely have there been live species observed at relatively great depths. These species must depend upon cutaneous respiration or air bubbles for oxygen exchange while species living in shallow waters come to the surface at regular intervals to breathe. In addition, variations in shell structure and form exist (Solem 2008). The forms of the shell vary widely not only within Basommatophora but also within the individual families. Family Siphonariidae has shells that are cap-shaped, with an irregular bulge on the right side and a secondary gill in the mantle cavity. Amphibolidae has high-spired and dextral shells and are also unique in having operculum as adults. Gills are lacking but amphibolids possess an osphradium (olfactory organ) in the mantle cavity. A high-spired dextral shell also commonly characterizes the families Chilinidae and most of Lymnaeidae.

Planorbidae often has a planispiral shell that coils sinistrally, with their spire reduced and all whorls being arranged into a single plane. A sinistral shell is also always present in Physidae. Reduction in the elevation of the spire and the number of whorls also vary. Partial reduction of the whorls has occurred in Latiidae. A vestigial spire is also present in some species of Planorbidae (Fretter and Peake 1978, Pechenik 2005). Because of these and other variations, it is difficult to find structures that are common to all taxa that can define the group (Solem 2008).

Families of Basommatophora are usually highly visible and are ecologically significant both for serving as a food resource for vertebrates and for browsing on the shallow-water encrusting organisms such as algae, fungi, and protozoa. Certain snails of this order are also of medical significance by serving as intermediate hosts for trematode parasites of both humans and domestic animals. Some planorbids transmit schistosomiasis in Africa, the West Indies, and South America while lymnaeids are involved usually in both sheep and cattle liver fluke life cycles (Solem 2008).

Previous data identified five basommatophoran families present in the Philippines, namely Acroloxidae, Lymnaeidae, Physidae, Planorbidae, and Siphonariidae (Pagulayan 1995, Springsteen and Leobrera 1986). Ancylidae, formerly a distinct family within Basommatophora, was placed under Siphonariidae (Bouchet and Rocroi 2005). However, there is no consolidated data on the biogeographical distribution of the group in the Philippines. This study, therefore, aims to survey available literature and journals, museums and online databases in order to address this problem.

MATERIALS AND METHODS

Data for the distribution of basommatophorans in the Philippines were gathered from various databases, using known basommatophoran families in the modern taxonomy scheme provided by Bouchet and Rocroi (2005).

The online network of Global Biodiversity Information Facility (http://data.gbif.org/welcome.htm), which compiled various datasets around the world, was accessed through the internet. A spreadsheet of basommatophoran occurrences was downloaded (http://data.gbif.org/occurrences/downloadSpreadsheet.htm?c[0].s=20&c[0].p=0&c[0].o=1491) and formatted to show the country and location where the species were collected and which database they were obtained from. A listing of basommatophoran occurrences in the Philippines found in relevant literature was also included. Basommatophoran occurrences in the Philippines found in both listings are tabulated in Table 1.

Table 1. Basommatophoran genera and species found occurring in the Philippines. No distribution data are indicated for species marked with (*) because of no specificity in location. Sources for each specimen are the following:

USNM (NMNH Invertebrate Zoology Collections), MCZ (Museum of Comparative Zoology, Harvard University), UCM (CUMNH Mollusc Collection), ANSP (MALACOLOGY), NBCNL (Naturalis Biodiversity Center (NL) – Mollusca), ZMB/Moll (SysTax – Zoological Collections), MNCN (Museo Nacional de Ciencias Naturales, Colección de Malacología), FLMNH (Invertebratezoology), NBCNL (Naturalis Biodiversity Center (NL) – Mollusca), TOYA (Mollusca Specimens of Toyama Science Museum), NMR (Natural History Museum Rotterdam (NL) – Mollusca Collection), NMP (National Museum of the Philippines), Springsteen and Leobrera's Shells of the Philippines (SP), Pagulayan's Studies on the biodiversity of the molluscan fauna of Lake Taal, Batangas (P), Boragay's A survey of gastropods at the University of the Philippines Diliman Campus (B), and Bequaert and Clench's Philippine Lymnaeidae and Planorbidae (PLP).

Individual (Species)	Location (Count)	Dataset
	Family Acroloxidae	
Acroloxus sp.	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (1)	USNM
	Family Lymnaeidae	
Amphipeplea sp.	Marinduque (1)	MCZ
Amphipeplea cumingiana	Camarines Sur (1), * (1)	UCM
Amphipeplea luzonica	Zamboanga (1)	UCM
Amphipeplea quadrasi	Donsul, Sorsogon (1); Ermita, Manila (1); Manila, Manila (1)	ANSP
Bullastra cumingiana	Solano (1)	NBCNL
Bullastra velutinoides	* (1)	ZMB/Moll
Lymnaea sp.	Abra de Ilog, QCC, Mindoro (1); Cebu (1); Laguna de Bay, Luzon (1); Mabilangan, Mt. Data, Mt. Province, Luzon (1); Panay Island, Jaro River (1); Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (6)	USNM
	Sulu Islands (1)	ANSP
Lymnaea blaisei	* (1)	UCM
Lymnaea cumingiana	Bayninan, Banaue, Ifugao (1); Sinebaran Creek, Matnog, Sorsogon (1)	NMP
Lymnaea monticola	* (1)	MNCN
Lymnaea pereger	Trinidad Mountain, Benguet (1)	ANSP
Lymnaea rubiginosa	Cebu (1)	NMP
Lymnaea swinhoei	Manila (1); Trinidad Valley (1)	MCZ
	Trinidad Valley (1)	NMP
Myxas sp.	Calamianes (1)	MNCN
Myxas cumingiana (=*Myxas cumingianus* and *M. cumungi*)	* (1)	FLMNH
	* (3)	LMD
	Catanduanes (1)	MNCN
	* (1); Bukid River, Tacloban, Palo, Leyte (1); Candaba Swamps, Candaba, Pampanga (1); Dagami, Guinarona, Leyte (1); Macalajar (1);	NMP

Table 1. Basommatophoran genera and species found occurring in the Philippines. No distribution data are indicated for species marked with (*) because of no specificity in location (cont'n.).

Individual (Species)	Location (Count)	Dataset
	Negros Occidental (1)	MCZ
	Musuan, Bukidnon, Mindanao (1)	B
	* (1)	NBCNL
Myxas imperialis	Batangas, Lipa (1); Cebu (1); Nagcarlang, Palayan, Laguna (1); San Juan River, Calamba, Laguna (1); Manila (1)	MCZ
Myxas luzonica	* (1)	MNCN
Myxas quadrasi	* (4)	FLMNH
	Porac (1)	MNCN
Radix sp.	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (1)	USNM
Radix auricularia (=*Lymnaea auricularia*)	Batang Creek, San Victor, Tacloban, Leyte (1); Bukid River, Tacloban, Palo, Leyte (1); Quilot River, Palo, Leyte (1); Tacloban, Leyte (1); Tributary of Bukid River, Tacloban, Leyte (2); Tributary of Quilot River, Guingawan, Tacloban, Leyte (2); Lake Taal (1);	NMP
	Daral-og River, Tacloban, Leyte (1)	PLP
Radix philippinensis (=*Lymnaea philippnensis* and *Lymnaea philippinica*)	Bohol, Vilar Id., Barrio Toog (1); Calbiga, Samar (1); Cebu (1); Binan, Laguna (1); Mahaihai, Laguna (1); Albuero, Leyte (2); Caridad, Leyte (1); Ormoc, Leyte (1); Palo, Leyte (2); Tarragona, Leyte (1); Manila (2)	MCZ
	Cagbatan Island, Coron, Palawan (1); Carmen-Sagbayan-Bacani Road (1)	NMP
	Cebu (1); Mangaldan (1)	PLP
	Cebu (1); Guihulngan (1); Manila (1)	MNCN
	Bilar, Bohol Island (1)	UCM
	Maynit, Laguna (1); Manila (1)	ANSP
	* (4)	FLMNH
Radix quadrasi (=*Lymnaea quadrasi* and *Bulinus quadrasi*)	* (1)	FLMNH
	UP Diliman (1)	NMP
	Agus River, Manila (1)	UCM
	Mindanao, Macajalar (1)	MCZ
Radix swinhoei	Macajalar (1)	MCZ
Stagnicola wyomingensis	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (1)	USNM
	Family Physidae	
Limnophysa sp.	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (3)	ANSP
	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (2)	MCZ
	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (3)	MNCN
	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (1)	ZMB/Moll

Table 1. Basommatophoran genera and species found occurring in the Philippines. No distribution data are indicated for species marked with (*) because of no specificity in location (cont'n.).

Individual (Species)	Location (Count)	Dataset
Physa sp.	* (1)	ANSP
	* (2); Panay Island	USNM
	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (1)	PLP
	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (2)	ZMB/Moll
Physa heterostropha	Tapul Group, Lapac Island, Vicinity of Siasi, Sulu Archipelago (1)	ZMB/Moll
Physa hungerfordiana	Aparri, Cagayan (2); Claveria, Cagayan (1); Malabon, Manila (2); Porac (1)	USNM
	Claveria, Cagayan (1); Morong (1)	LMD
	Manila (1)	MCZ
	Manila (1)	MNCN
Physa philippina	* (3)	USNM
	Bosoboso near Manila (1)	ANSP
Physa semperi	* (1)	USNM
	Family Planorbidae	
Amerianna quadrasi	Lake Mainit (1)	MNCN
Amerianna sulcifera	* (1)	FLMNH
Anisus convexiusculus	Ilocos Sur, Rio del Pueblo de Sinay (1); San Juan del Monte (1); Surigao (1)	MCZ
Anisus corinna	Leyte, Baybay (2)	MCZ
Anisus quadrasi	Leyte, Palo (1); Mindoro (1); San Juan River, Manila (1)	MCZ
Bulinus sp.	Sulu Archipelagi, Tapul Group, Lapac Island, Vicinity of Siasi (1)	USNM
Bulinus boholensis	Bohol, Baclayon (3)	MCZ
Bulinus bullulus	Mindoro (1)	MCZ
Bulinus camelopardalis	* (1)	MCZ
Bulinus hungerfordianus	* (1);	FCMNH
(*B. hungerfordiana*)	Dagami, Digabonegan, Leyte (1); Palo, Leyte (2); Tarragona, Leyte (1); Tolosa, Leyte (1); Manila (1); Irrigation Canal, Bo. Dita, Cabuyao, Laguna (2); Laguna Bay, Laguna (1); Alabang River, Manila (1); Muntinglupa River, Manila (1); Virac, Catanduanes (1)	MCZ
Bulinus luzonicus	* (1)	MCZ
Bulinus mindoroensis	Mindoro (1)	MCZ
Bulinus ustulatus	Mindoro (1)	MCZ
Cyclophinus canaliferous	Mindoro (1)	MCZ
Gyraulus chinensis	* (2)	SMF
	Lake Taal (1)	P
	UP Diliman (1)	B
Gyraulus compressus	* (1)	FLMNH
Gyraulus convexiusculus	* (2)	FLMNH
	Aparri, Cagayan (1); Boac (1); Pasig River, Manila (1); Visita Palanas, Lacy (1)	MNCN

Table 1. Basommatophoran genera and species found occurring in the Philippines. No distribution data are indicated for species marked with (*) because of no specificity in location (cont'n.).

Individual (Species)	Location (Count)	Dataset
Gyraulus prashadi	Zambales Prov., San Antonio (2)	MCZ
Gyraulus quadrasi	* (1)	FLMNH
Hippeutis umbilicalis mearnsii	Palo, Leyte (1)	MCZ
Indoplanorbis exustus	UP Diliman (1)	B
Pettancylus manillensis	Lake Taal (1)	P
Physastra hungerfordiana	* (5)	FLMNH
	Lake Taal (1)	P
	UP Diliman (1)	B
Physastra quadrasi	Lake Mainit (1)	PLP
Planorbis sp.	* (1); Surigao (1); Bohol (1)	MCZ
	* (1)	MNCN
	Sulu Archipelagi, Tapul Group, Lapac Island, Vicinity of Siasi (3)	USNM
Planorbis compressus	* (1)	UCM
	Alrededores, Manila (1); Baclayon, Bohol (1); Isabela, Luzon (1); Lacy, Siquijor (1); Paco, Manila (1)	MCZ
	Ermita, Manila (1); Isabela, Luzon (1); Loey, Siquijor (1); Manila (1); Marinduque (1)	ANSP
Planorbis corneus	* (1); Zamboanga (1)	MNCN
Planorbis lugubris	Batangas, Lipa (1)	MCZ
Planorbis mindanensis	Cotobato, Rio Grande Valley, Lake Baluan (1)	MCZ
	Cotobato, Rio Grande Valley, Lake Baluan (1)	USNM
Planorbis philippinarum	* (1)	MNCN
Planorbis planorbis	* (1)	FLMNH
Planorbis quadrasi	Inopacan (1)	MNCN
	Montalban (1)	MCZ
Planorbis umbilicalis	Cagayan, Buguey (1)	MNCN
Segmentina umbilicalis	Cagayan, Buguey (1); San Antonio, Zambales (1)	MCZ
	Family Siphonariidae	
Siphonaria sp.	Mambajao, Camiguin Island (1)	NMP
	Ambulony Island (1)	CAS
	Maubu Beach, Jojo Island, Sulu Archipelago (1)	ANSP
	Muso, Siasi Island, Sulu Archipelago (1)	
	Turnina Island (2)	YPM
	Cabra Island, Mindoro (1); Cuyo, Palawan (2); Bacuit, Palawan (1)	MCZ
Siphonaria acuta	Palawan, Bacuit (1)	MCZ
	* (1)	FLMNH
Siphonaria atra	Balite Beach, Puerto Galera, Mindoro (1); Bohol (1); Buenavista, Marinduque (1); Cabcaban, Bataan (1), Cagayan de Sulu (1); Ibabang Pulo, Pagbilao, Grande Island, Pagbilao, Quezon (1); Manlumod, Mogpog, Marinduque (1); Puntod, Gaspar Island, Tres Reyes Islands, Marinduque (1); Tawi-tawi Island, Sulu (1)	NMP

Table 1. Basommatophoran genera and species found occurring in the Philippines. No distribution data are indicated for species marked with (*) because of no specificity in location (cont'n.).

Individual (Species)	Location (Count)	Dataset
	Butas, Mariveles Point, Bataan (1); Cabra Island, Mindoro (1); Candelaria, Zambales (1); Bacuit, Palawan (1); Cuyo, Palawan (1)	MCZ
	Little Santa Cruz, Mindoro (1); * (1)	UCM
	* (3)	FLMNH
Siphonaria cornuta	Balabac, Mangsee del Sur (1); Palawan (1)	MCZ
Siphonaria corrugata	Semirara Island (1)	NMP
Siphonaria diemenensis	Candelaria, Zambales, Luzon (1)	MCZ
Siphonaria japonica	* (2)	FLMNH
Siphonaria javanica	Barangay Tawog, Bulusan, Sorsogon (1); Batangas Bay, Batangas (1); Bulalasas Bay, Or. Mindoro (1); Cata-an River, San Joaquin, Iloilo (1); Malitpalit Islet, Pandan, Catanduanes (1); Morongborongan Island, Sorsogon (1); Muelle Bay, Puerto Galera, Or. Mindoro (1); Pandan, Catanduanes (1); Sinugbuan, San Joaquin, Iloilo (1); Sulangan, Guiuan, Eastern Samar (1); Tabugoe, Pandan, Catanduanes (1)	NMP
	Zamboanga (1)	MCZ
Siphonaria kurrachiensis	Palawan, Bacuit (1)	MCZ
Siphonaria laciniosa	Batangas Bay, Batangas (1); Punta Canomay, Calveria, Burias Island, Masbate (1); Subic, Calimtaan Island, Sorsogon (1)	NMP
	Butas, Mariveles Pt., Bataan, Luzon (1); Cabra Island, Mindoro (1); Calapan (2); Candelaria, Zambales, Luzon (2); Dapitan Bay (1); Lubang Island, Mindoro (1); Mindoro (1); Santa Margarita, W. Samar (1)	MCZ
	* (3)	FLMNH
	* (3)	TOYA
Siphonaria normalis	Balite Beach, Puerto Galera, Mindoro (1); Bobon (1); Bolauos, Narvacan, Ilocos Sur (1); Cabuyo, Torrijos, Marinduque (2); Dapdap, Tagum, Sta. Cruz, Marinduque (2); Honda Bay, Palawan (1); Imelda Park, Ilocos Sur (1); Lusong-Bagac, Bataan (1); Manlumod, Mogpog, Marinduque (1); Melchor Island, Tres Reyes Island, Gasan, Marinduque (1); Parpatong, Bangui, Ilocos Norte (1); Sulvec, Narvacan, Ilocos Sur (1); Suyo, Bangui, Ilocos Norte (1)	NMP
	* (2)	FLMNH
Siphonaria sipho	* (1)	UCM
	Palawan (2)	MCZ
	* (1)	LMD
Siphonaria siquijorensis	Siquijor (1)	ANSP
	Baler, Quezon (1); Lubang Island, Mindoro (1)	NMP
	* (1)	NBCNL
	* (1)	NMR

Table 1. Basommatophoran genera and species found occurring in the Philippines. No distribution data are indicated for species marked with (*) because of no specificity in location (cont'n.).

Individual (Species)	Location (Count)	Dataset
Siphonaria sirius	Angas Point, Otavi, Bulan, Sorsogon (1); Balbagon Island, Carles, Iloilo (1); Barangay Tawog, Bulusan, Sorsogon (1); Canlubi, Pandan, Catanduanes (1); Cata-an River, San Joaquin, Iloilo (1); Dayhagan, Suchan, Panay Island (1); Catanduanes (1); Macalanhog Island, Gigmoto, Catanduanes (1); Malitpalit Islet, Pandan, Catanduanes (1); Morongborongan Island, Sorsogon (1); Punta Nasio, Taloto-an, Pan de Azucar Island, Concepcion, Iloilo (1); Sinugbuan, San Joaquin, Iloilo (1); Sorsogon (1); Subic, Calimtaan Island, Sorsogon (1)	NMP
	* (1)	UCM

The number of basommatophoran families and genera occurring in tropical countries in the world were also obtained from the online listing and are tabulated in Table 2. Endemicity was also checked by comparing the occurrences between other countries. The website DiscoverLife (http://www.discoverlife.org/) was also used to check for further consistencies. Endemicity was also confirmed if there were no clear sources refuting it for certain species. Endemic species are tabulated in Table 3.

The National Museum of the Philippines in Manila was visited to document and list down the specimens in their collection with the help of Ms. Vivian Ang. The documentation of the specimens are found in Appendix 1.

All data were tabulated using a spreadsheet computer program (Microsoft Excel 2007). Locations where each species was found were marked using Adobe Photoshop CS5 on an outline map of the Philippines, from Free US and World Maps.com (http://www.freeusandworldmaps.com).

RESULTS AND DISCUSSION

A total of 336 recorded occurrences, 21 genera, and 75 species from the listings indicated above were found to occur in the Philippines. These records reveal basommatophorans from five families out of nine total based on Bouchet and Rocroi's (2005) classification scheme: Acroloxidae (1 occurrence, 1 genus, 1 species), Lymnaeidae (99 occurrences, 6 genera, 20 species), Physidae (32 occurrences, 2 genera, 6 species), Planorbidae (95 occurrences, 11 genera, 35 species), and Siphonariidae (111 occurrences, 1 genus, 13 species). This is mostly consistent

Table 2. A list of tropical countries defined as being in the region between the Tropic of Cancer (23° 26' 16" N) and Tropic of Capricorn (23° 26' 16" S) found in the world. Listed also are the number of basommatophoran occurrences and genera that are found occurring in each country. (Accessed through GBIF Data Portal, data.gbif.org, 2014-01-29)

Tropical Country	Number of Occurrences	Number of Genera
Mexico	623	31
Congo	339	19
Philippines	336	21
Cuba	238	20
Indonesia	190	13
Brazil	188	23
India	172	17
Panama	171	17
Jamaica	122	17
Costa Rica	113	16
Uganda	112	11
Guatemala	107	20
Peru	102	17
Venezuela	97	19
Honduras	94	1
Cape Verde	83	5
Thailand	74	13
Haiti	66	13
Kenya	58	12
Nicaragua	54	12
Bolivia	45	7
Sudan	42	8
Dominican Republic	41	11
Oman	40	5
Bermuda	37	7
Ecuador	36	9
Madagascar	35	9
Colombia	35	12
Puerto Rico	35	15
Cayman Islands	33	5
Fiji	33	5
Vietnam	27	6
Liberia	26	5
El Salvador	25	8
New Caledonia	24	7
Sri Lanka	21	6
Suriname	21	7
Senegal	20	4

Table 2. A list of tropical countries defined as being in the region between the Tropic of Cancer (23° 26' 16" N) and Tropic of Capricorn (23° 26' 16" S) found in the world (cont'n.). **Listed also are the number of basommatophoran occurrences and genera that are found occurring in each country. (Accessed through GBIF Data Portal, data.gbif.org, 2014-01-29)**

Tropical Country	Number of Occurrences	Number of Genera
Papua New Guinea	20	7
Malaysia	16	3
Yemen	16	6
Netherlands Antilles	16	8
Tanzania	15	7
Seychelles	14	2
Cameroon	13	5
Trinidad and Tobago	13	10
Angola	12	3
Singapore	12	8
Sierra Leone	11	4
Malawi	10	3
Vanuatu	10	3
Barbados	10	6
Antigua and Barbuda	9	6
Zambia	8	4
Zimbabwe	6	5
Cocos Islands	5	1
Laos	5	3
Belize	5	5
American Samoa	4	1
Nigeria	4	4
Equatorial Guinea	3	1
Hong Kong	3	1
Ghana	3	2
Namibia	3	2
Gabon	2	1
Gambia	2	1
Dominica	2	2
French Guiana	2	2
Mozambique	2	2
Botswana	1	1
Montserrat	1	1
Niger	1	1

with the distribution found in other countries, as can be gleaned from the GBIF spreadsheet, wherein Lymnaeidae, Planorbidae and Siphonariidae were also the most commonly occurring families. Figure 1 presents the families found in the Philippines and their relative numbers to each other. Figure 2 shows the relative numbers of the genera that can be found in the Philippines to each other.

Table 3. A list of endemic basommatophoran genera and species found in the Philippines

Genus	Location
	Family Lymnaeidae
Amphipeplea cumingiana	Camarines Sur
Amphipeplea luzonica	Zamboanga
Amphipeplea quadrasi	Donsul, Sorsogon; Ermita, Manila; Manila, Manila
Bullastra cumingiana	Solano
Bullastra velutinoides	*
Myxas cumingiana	Catanduanes; Bukid River, Tacloban, Palo, Leyte; Candaba Swamps, Candaba, Pampanga; Dagami, Guinarona, Leyte; Macalajar, Negros Occidental; Musuan, Bukidnon, Mindanao
Myxas imperialis	Batangas, Lipa; Cebu; Nagcarlan, Palayan, Laguna; San Juan River, Calamba, Laguna; Manila
Myxas luzonica	*
Myxas quadrasi	*
Radix philippinensis	Bohol, Vilar Id., Barrio Toog; Calbiga, Samar; Cebu; Biñan, Laguna; Mahaihai, Laguna; Albuero, Leyte; Caridad, Leyte; Ormoc, Leyte; Palo, Leyte; Tarragona, Leyte; Manila; Cagbatan Island, Coron, Palawan; Carmen-Sagbayan-Bacani Road, Cebu); Mangaldan, Cebu; Guihulngan, Bilar, Bohol Island; Maynit, Laguna; Manila
Radix quadrasi	UP Diliman; Agus River, Manila; Mindanao, Macajalar
	Family Physidae
Physa hungerfordiana	Aparri, Cagayan; Claveria, Cagayan; Malabon, Manila; Porac; Morong, Manila
Physa philippina	Bosoboso near Manila
Physa semperi	*
	Family Planorbidae
Anisus corinna	Leyte, Baybay
Anisus quadrasi	Leyte, Palo; Mindoro; San Juan River, Manila
Amerianna quadrasi	Lake Mainit
Amerianna sulcifera	*
Bulinus boholensis	Bohol, Baclayon
Bulinus bullulus	Mindoro

Table 3. A list of endemic basommatophoran genera and species found in the Philippines (cont'n.).

Genus	Location
Bulinus camelopardalis	*
Bulinus hungerfordianus	Dagami, Digabonegan, Leyte; Palo, Leyte; Tarragona, Leyte; Tolosa, Leyte; Manila; Irrigation Canal, Bo. Dita, Cabuyao, Laguna; Laguna Bay, Laguna; Alabang River, Manila; Muntinglupa River, Manila; Virac, Catanduanes
Bulinus luzonicus	*
Bulinus mindoroensis	Mindoro
Cyclophinus canaliferous	Mindoro
Gyraulus prashadi	*
Physastra hungerfordiana	Lake Taal; UP Diliman
Planorbis mindanensis	Cotobato, Rio Grande Valley, Lake Baluan
Planorbi sphilippinarum	*
Planorbis quadrasi	Inopacan; Montalban
Segmentina umbilicalis	Cagayan, Buguey; San Antonio, Zambales
	Family Siphonariidae
Siphonaria cornuta	Balabac, Mangsee del Sur; Palawan

Siphonaria (family Siphonariidae) has the most occurrences in the Philippines, accounting for 33% of the total. The genus has a widespread distribution, with increasing diversity towards the tropics (Vermeij 1973). Hodgson (1999) speculated that the success of the siphonariids in general could be due partly to their resistance to increased temperature and desiccation through physiological, morphological or behavioral adaptations. Furthermore, siphonariids are generalist grazers, feeding on a wide range of microalgae, filamentous algae, foliaceous algae, and macrophytous corticated algae (Underwood and Jemakoff 1981, Jara and Moreno 1984, Santelices and Correa 1985, Godoy and Moreno 1989, Hodgson 1999), as well as lichens (Borland 1950) and cyanobacteria (Chan 2003). *Siphonaria* can also influence the settlement, growth and survival of algae, as well as barnacle recruitment and survival (Jara and Moreno 1984, Hodgson 1999) because of their occurrence in large numbers. Some species change their vertical distribution according to seasons. It is widely assumed that the vertical distribution of siphonariids is affected by both biotic – e.g., interspecific competition for space (Black 1979, Hodgson 1999) – and wave action (Allanson 1958, Voss 1959, Hodgson 1999). However, more research is needed as little is known about the ecology of tropical species (Hodgson 1999).

Many basommatophoran snails have a widespread and cosmopolitan distribution due to their biology. For instance, the North American ancylid *Ferrissia fragilis* has

been spreading in Europe probably due to its many biological attributes such as its ability to aestivate and survive in stagnant waters, its small size, and even its hermaphroditic life cycle (Walther and others 2006). This may also be the case for the siphonariids. Furthermore, the wide distribution of certain invertebrates between unconnected habitat patches could depend on passive dispersal mechanisms (Bilton and others 2001). For snails like siphonariids, passive dispersal could be done through being carried on the feet or feathers of birds from one body of water to another. Perhaps serving as evidence is basommatophoran snails appearing in the geological record at the Jurassic-Cretaceous boundary 145.5 million years ago, shortly after the origin of birds (Solem 2008). Other forms of dispersal are rafting on aquatic vegetation, marine/brackish larval dispersal phase, stream capture and even by air (e.g., cyclonic storms) (Purchon 1977). However, there is no clear material linking this to be the reason for the multitude of occurrences of *Siphonaria* globally or in the Philippines.

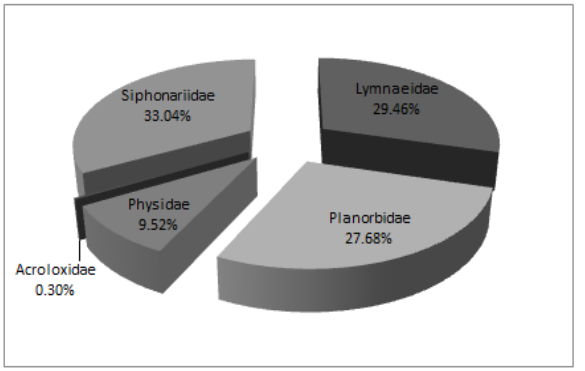

Figure 1. The basommatophoran families found in the Philippines.

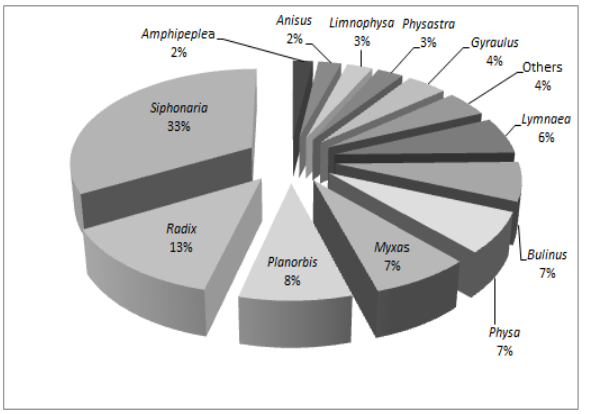

Figure 2. The frequencies of basommatophoran genera in the Philippines.

Figure 3 presents the distribution maps of the basommatophoran families found in the Philippines. The maps indicate where the shells were collected or found. It should be noted that some specimens encountered did not have their localities properly identified and were therefore excluded. There were 138 individuals (52.07%) from Luzon, accounting for majority of the specimens. Meanwhile, 68 individuals (25.66%) were found in the Visayas and 59 individuals (22.26%), in Mindanao. The data thus demonstrate that the basommatophoran species are distributed all throughout the Philippine archipelago. The distribution is noted to be heterogeneous, with clustering in the Luzon region but still dispersed almost evenly among the island groups. It is noted that the patchy distribution could be due to the limited and sporadic sampling of the basommatophorans in the Philippines.

Amongst the tropical countries in the world, the Philippines, with 336 occurrences and 21 genera, ranks third in basommatophoran occurrences, behind Mexico and Congo. Mexico has 623 occurrences and 31 genera while Congo has 339 genera and 19 genera. The Philippines accounts for 8% of the worldwide basommatophoran occurrences out of the 72 countries listed in the GBIF spreadsheet. The Philippines also has 32 endemic species (Table 3); that is, 42.67% of basommatophoran endemic species can be found in the Philippines. Of these, majority are from Planorbidae (46.67%) and Lymnaeidae (26.67%). With this much proportion of the basommatophoran occurrences and endemic species, a more systematic sampling is needed to assess the full biodiversity of the Basommatophora in the Philippines and account for its evolution.

One of the endemic species from Lymnaedae is *Radix quadrasi*. Remigio and Blair (1997) suggested that it may be conspecific with *R. rubiginosa* from Malaysia on the basis of nearly identical mitochondrial 16S rRNA gene sequences and that they are subspecies of the Eurasian *R. auricularia*, which is also present in the Philippines. However, Correa and others (2010) evaluated 50 lymnaeid taxa using the nuclear ITS-1 and ITS-2 sequences in addition to the 16S rRNA gene, and they found that, though both *R. quadrasi* and *R. rubiginosa* clustered together, they gave very distinct sequences to be considered the same species. Furthermore, both taxa clustered separately from *R. auricularia*, clearly indicating that they are distinct from *R. auricularia*.

SUMMARY

Survey of Basommatophora in the Philippines based on literature and existing collections demonstrates high diversity in comparison to other tropical countries, with 21 known genera and at least 32 endemic species. These values, however,

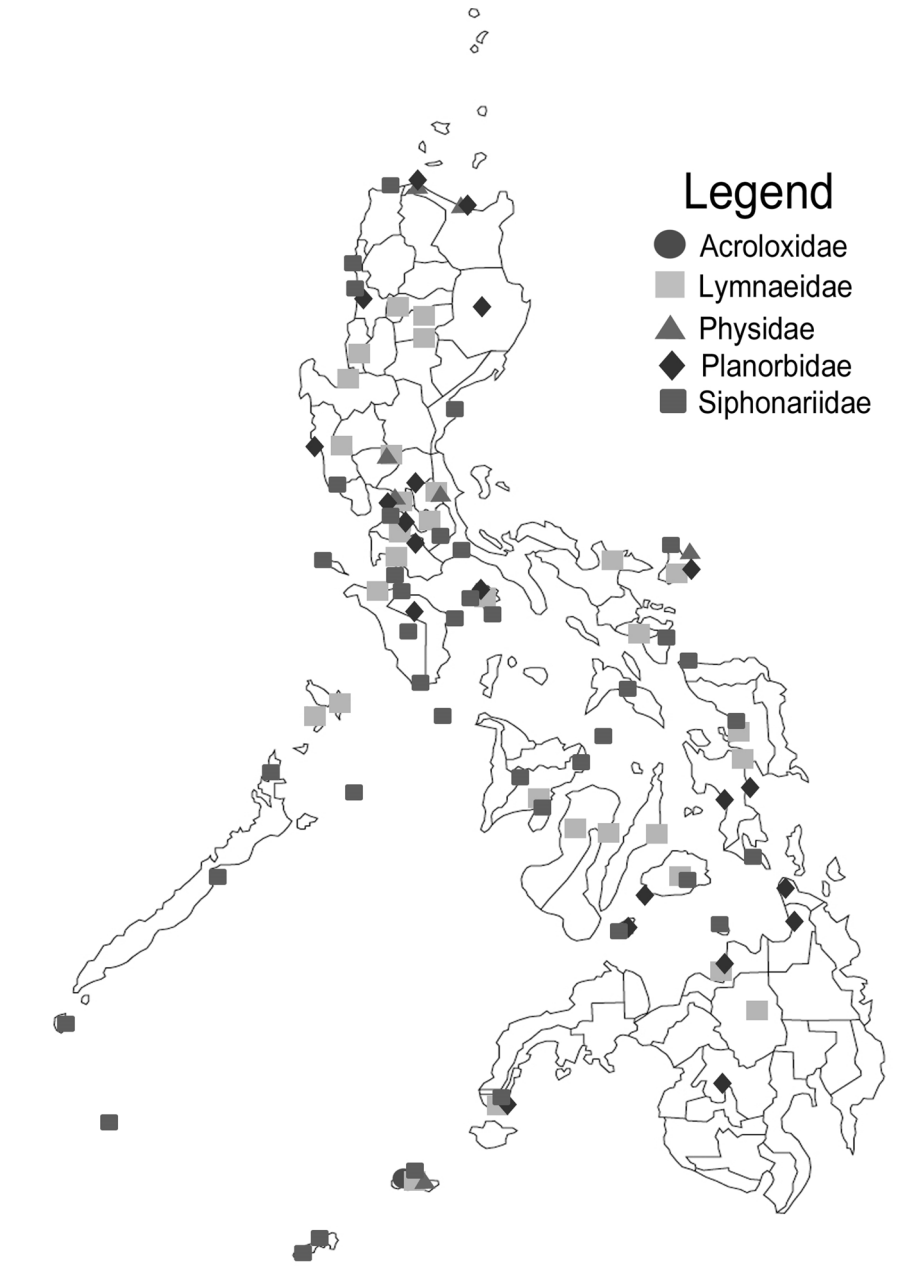

Figure 3. The distribution map of basommatophorans in the Philippines.

could be a gross underestimate of the true diversity of the group as sampling is sporadic. This warrants further systematic sampling to address this issue.

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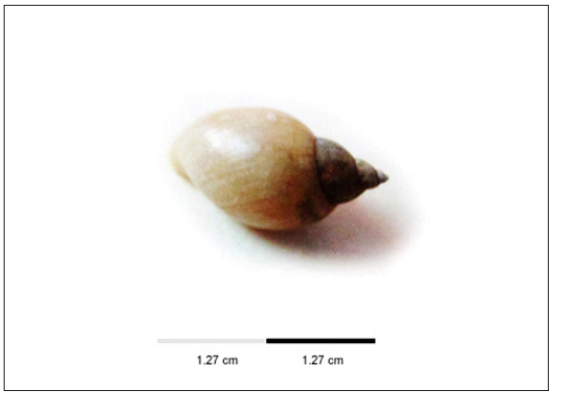
APPENDIX

Documentation of the basommatophoran specimens
found in the National Museum of the Philippines.
Scale is in inches (1 inch = 2.54 cm).

1. *Radix auricularia*

2. *Radix philippinensis*



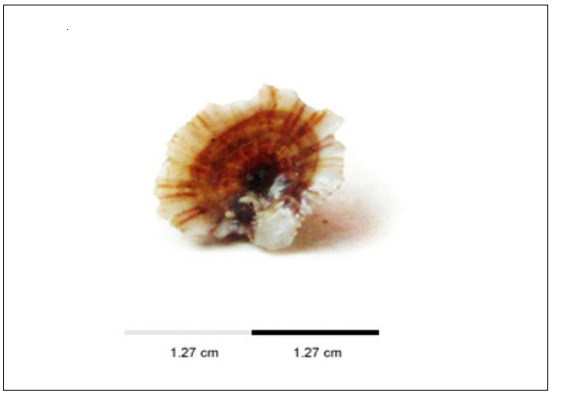
3. *Lymnaea rubiginosa*

4. *Lymnaea* sp.

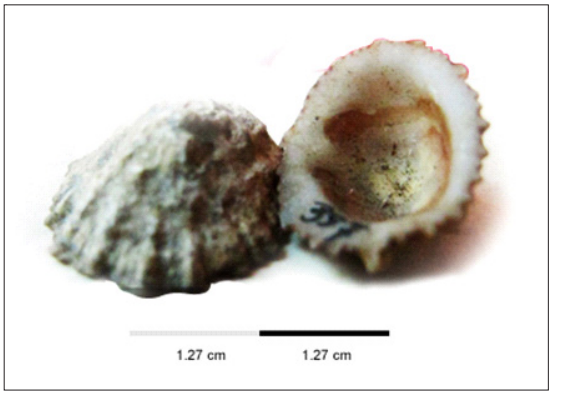
5. *Myxas cumingiana*

6. *Indoplanorbis exustus*

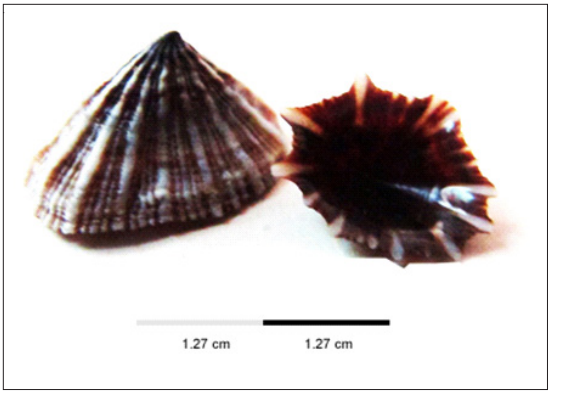
7. *Physastra hungerfordiana*



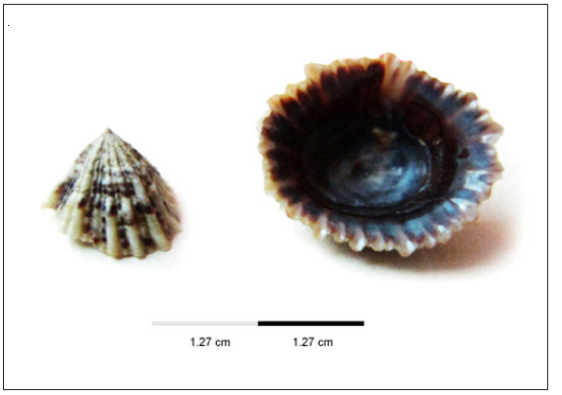
8. *Siphonaria atra*



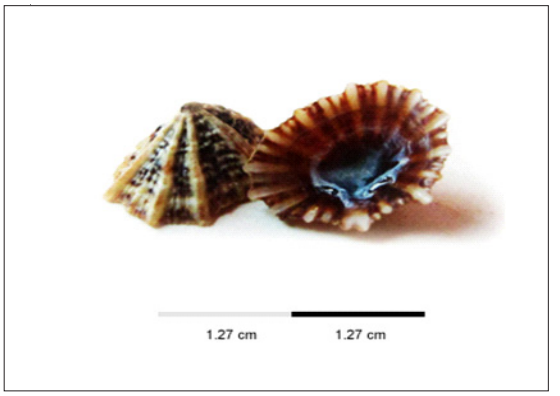
9. *Siphonaria corrugata*



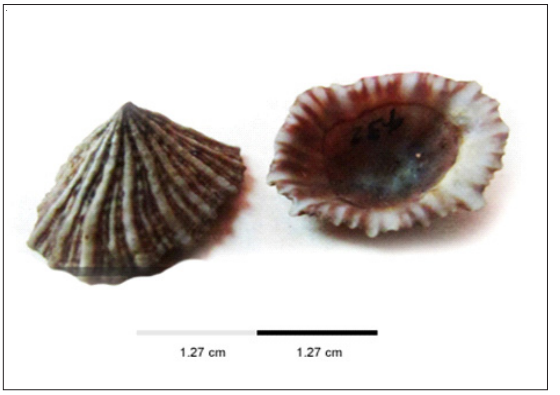
10. *Siphonaria javanica*



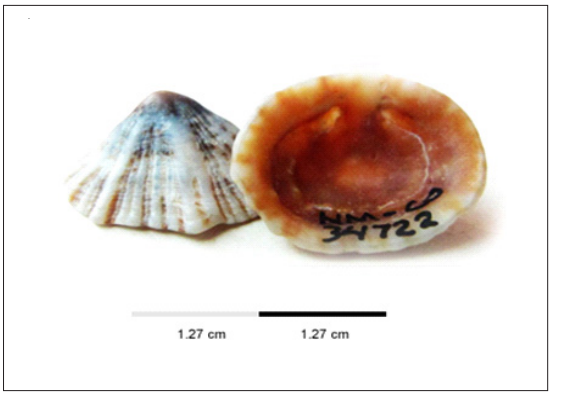
11. *Siphonaria laciniosa*



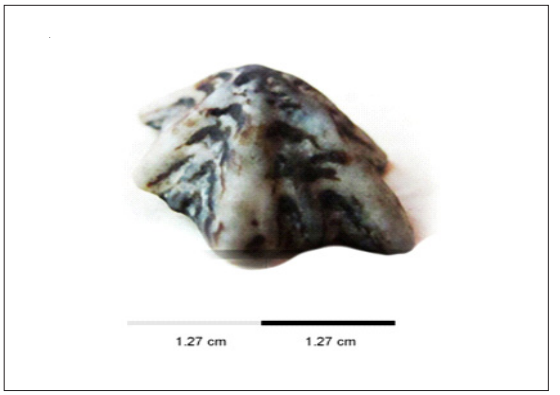
12. *Siphonaria normalis*



13. *Siphonaria siquijorensis*



14. *Siphonaria sirius*



15. *Siphonaria* sp.

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