Dtsch. Entomol. Z. 61 (1) 2014, 3–14 | DOI 10.3897/dez.61.7046

PENSOFT. museum für naturkunde

Caddisflies (Trichoptera) from Lombok, Bali and Java (Indonesia), with a discussion of Wallace's Line

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Received 17 June 2013
Accepted 30 December 2013
Published 30 May 2014

Academic editor:
Dominique Zimmermann

Key Words

zoogeography
Sunda Islands
Asia
new records
faunistics

Abstract

Caddisflies (Trichoptera) of Southeast Asia are analyzed with special attention to the Sunda Islands to evaluate the zoogeographic effects of island isolation and potential influence from the neighboring continental faunas. Results of recent Trichoptera collections and synopsis of previously published data for the islands of Java, Bali, and Lombok are presented along with their zoogeographical interpretation on the islands as well as on the adjacent regions. A total of 202 Trichoptera species is known to occur on the three islands; 146 species are known in Java, 73 in Bali and 61 in Lombok. 43 species are common to Java and Bali, 27 to Java and Lombok, 30 to Bali and Lombok, 70 to Java and Sumatra. A significant decrease in species richness has been observed in comparison to the Asian mainland. The caddisfly fauna of the three islands is of Asiatic origin, no Australian influence was noted. The well-known Wallace's line does not act as a faunistic border between Bali and Lombok for Trichoptera.

Introduction

Caddisflies (order Trichoptera) have a complicated distribution in the world, with significant species diversity concentrated in Tropical Asia, especially in the Himalayas (Schmid 1970, 1984; Morse 1997; de Moor and Ivanov 2008). One of the regions of highest faunistic diversity is the area which includes Thailand, Yunnan, northern Myanmar, and northeastern India (Assam, Arunachal Pradesh and surrounding territories). There is a strong decrease of diversity from this region along the Himalayas in a western direction (e.g., Schmid 1970). This high diversity however does not necessarily mean an evolution center of caddisfly groups. It could be a result of local speciation processes in the relatively young mountains. The great tropical diversity of caddisflies is a subject of recent studies (e.g., Mey 2001; Malicky 2010; Malicky et al. 2011), although with the rapid environmental deterioration in the tropics many species may not be discovered and become extinct before they can be described. The faunistics and taxonomy of the tropical faunas has its own scientific value. Furthermore, such a species-rich aquatic group as Trichoptera can clarify some problems of general zoogeography. One of these problems, the formation and structure of the great transition zone between Asia and Australia, has not been intensively analyzed for Trichoptera previously. The study of this problem requires data on the species composition and distribution for numerous islands between the southeastern end of Asia and the western shores of Australia and New Guinea, the Malay Archipelago, previously known as East Indian Archipelago, including the Sunda Islands and the Molucca Islands.

The amazing species richness and endemism of the Malay Archipelago exists in one of the most geologically dynamic regions of our planet. The geological history of the Malay Archipelago is very complex (Hall 2009; Van Welzen et al. 2011). There were complicated movements of land blocks in the Cenozoic, and most islands in the central Malesian region started to emerge from the sea only some 5 million years ago. Direct use of the geological data to delimit areas in Southeast Asia is difficult because of the climate and sea level changes, which occurred during periods of glaciation.

There are two shallow ocean regions in the western (Sunda Shelf) and eastern (Sahul Shelf) parts of the Malay Archipelago. Past glaciations caused a fall of sea level so that certain vast areas, currently covered by shallow seas, have been parts of continents and have opened migration pathways. The area between Sunda and Sahul Shelves is called Wallacea. When the sea level was lower and the Sunda Shelf was an extension of the Asian continent (Sundaland) and, respectively, the Sahul Shelf connected with Australia, the islands of Wallacea continued to be relatively isolated from the continental land masses. Nevertheless, these islands could have acted as steppingstones for the organisms that were able to cross the narrow straits between them.

A famous boundary dividing the Asian and Australian biotas, Wallace's line, is one of the most disputed topics in biogeography since the end of the XIX century (Camerini 1993) and this concept has been in the focus of intensive discussions during recent decades (de Lattin 1967; Simpson 1977; Van Welzen et al. 2011). Even though some other lines have been introduced to describe the changing species composition of the Wallacea region including the Philippines, Sulawesi, the Lesser Sunda Islands, and Moluccas (Fig.1), Wallace's line is usually referred to as the major divider between the Oriental and Australian biotas. All proposed boundaries were based on the faunal data, mostly if not exclusively on the distribution of birds and mammals, and only recently some of them have been analyzed by botanists (Van Welzen et al. 2011). The most crucial point of Wallace's line is situated in a narrow strait between the two islands called Bali and Lombok. They are the westernmost members of the Lesser Sunda Islands archipelago, adjoining to the southeastern boundary of Java, a member of the Greater Sunda Islands.

The knowledge of the caddisflies of the Sunda Islands was poor for a long time. The first representative summary was given by Georg Ulmer (1951, 1955, 1957). In this work, the islands of Sumatra, Java, and Bali were considered, with some minor exceptions. It took nearly half a century that more papers, including several extensive studies, were published, e.g. on Sumatra (Malicky 2007), Java (Malicky 1997, 2002, 2004, 2008, 2009; Malicky and Chantaramongkol 2000, 2006; Wells and Malicky 1997), Bali (Malicky 1995, 1997, 2005, 2006; Malicky and Chantaramongkol 2000, 2006, 2007; Wells 1993) and Lombok (Malicky 2009; Mey 1998, 1999). A survey of the caddisfly fauna of southeastern Asia as a whole was given by Malicky (2010), and the Australasian relationships of Trichoptera faunas were reviewed by Mey (2001).

Nevertheless, the caddisflies of the island of Lombok remained practically unknown, and this is still the state of knowledge of the caddisflies of the islands east of Lombok, including the Moluccas. This was the reason for the members of the Department of Entomology of the State University of St. Petersburg to make collections on the islands of Java, Bali, and Lombok in 2008 and 2009. The species which were new for science have been already described elsewhere (Malicky et al. 2011). This paper presents the complete results of the collections along with some zoogeographic considerations.

Material and methods

Field collection included the well-known methods of light catch by small water-filled UV traps installed close to the water edge, net sweeping during daytime in the riparian vegetation, and hand picking. Only adults were collected; larvae and pupae were left for future investigations. The material is preserved in 70% ethanol and is stored in the collections of the Zoological Institute of the Russian Academy of Sciences in St. Petersburg. Some specimens are in the collection of the first author. Data from the faunistic publications and some material from the Malicky collection have been used for the analysis of zoogeography and species distribution.

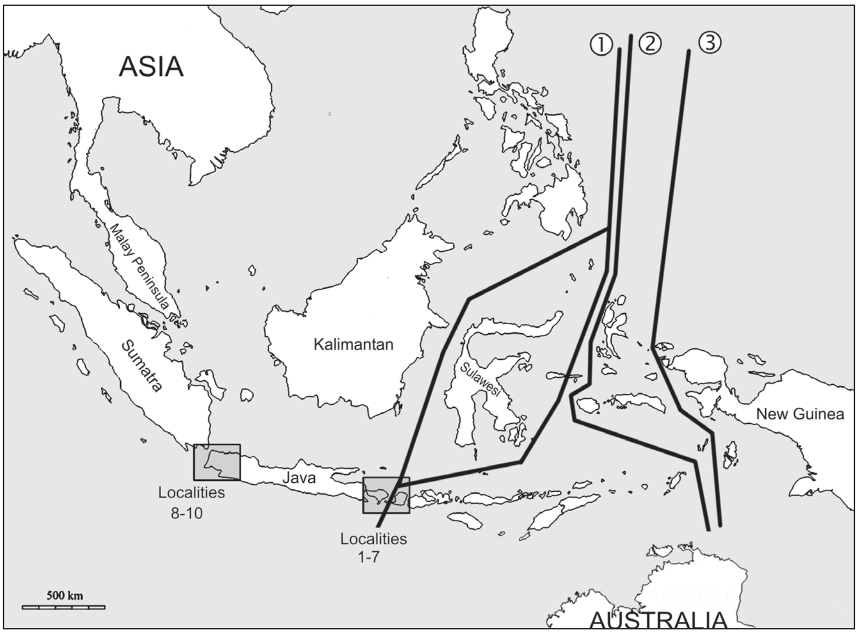


Figure 1. Malay Archipelago, sampling areas (rectangles), and the major biogeography divider lines: **1** – Wallace's lines (divergence around Sulawesi Island is caused by the changing views of Wallace, while the western branch is currently accepted as the canonic one), **2** – Weber's line, **3** – Lydekker's line. Wallacea is delimited by Wallace's and Lydekker's lines.

Sampling localities were as follows:

LOCALITY 1: Lombok, Senaru, Sindanggala waterfall, Tiu Kelep waterfall and irrigation canal, 08°18'09"S, 116°24'30"E (Sindanggala waterfall, 455 m, lowest point), 08°18'29"S, 116°24'27"E (irrigation channel, 508m, highest point), 2–4 March 2008, at light and net sweeping, leg. V.D. Ivanov and S.I. Melnitsky; Lombok, Senaru, 19–26 September 2009, leg. N. Yu. Kluge. There were 5 biotopes situated close to each other: 2 of them were large waterfalls, one was a shallow rapid tropical river with stony bed in a deep canyon, and another one was an irrigation channel with fast running water and stony bottom some 30 m above the river. Several new species of *Tinodes* and *Hydropsyche* were present only near a leakage from the irrigation channel flowing down the mountain slope.

LOCALITY 2: Lombok, Sembalung Lawang, 08°21'37"S, 116°32'17"E, h=1160 m, 5 March 2008, at light, leg. V.D. Ivanov and S.I. Melnitsky. An irrigation channel with warm water in a flat mountain terrace surrounded by fields and shore bushes.

LOCALITY 3: Lombok, vic. Kembangkuning, 7 March 2008, 08°30'40"S, 116°25'23"E, h=835–875 m. Rinjani National Park, Jeruk Manis waterfall, at light and net sweeping, leg. V.D. Ivanov and S.I. Melnitsky. A high waterfall and a short piece (approximately 100 m) of rapid river below it followed by cascading waterfalls downstream.

LOCALITY 4: Lombok, vic. Kembangkuning, 2 km N Kotaraja, 08°33'33"S, 116°25'23"E h=490 m, river and irrigation canal, 8 March 2008, at light and net sweeping, leg. V.D. Ivanov and S.I. Melnitsky. An irrigation complex including a river with rapids and reaches in a deep canyon with an irrigation channel originating at the water divider.

LOCALITY 5: Lombok, Pelangan Barat, near mt. Embit, 08°48'23"S, 115°56'24"E, h=20 m, 11 March 2008, at light, leg. V.D. Ivanov and S.I. Melnitsky. Shallow muddy slowly running and warm river nearby the village Pelangan Barat.

LOCALITY 6: Bali, Gitgit waterfall, 08°11'34"S, 115°08'04"E, h=520 m, 14–15 March 2008, at light and net sweeping, leg. V.D. Ivanov and S.I. Melnitsky. Cascading waterfalls above the sampling place followed by a rapid river with large boulders.

LOCALITY 7: Bali, Munduk, Melanting waterfall, 08°15'27"S, 115°04'12"E, h=700–900 m, 16–17 March 2008, at light and net sweeping, leg. V.D. Ivanov and S.I. Melnitsky. A river and an irrigation channel originating right below a large waterfall in deep canyon.

LOCALITY 8: Java, Bogor, Sadame river, Botanical Garden, 06°35'34"S, 106°48'06"E, h=250 m, 23 February 2008, at light, leg. V.D. Ivanov and S.I. Melnitsky. Large warm muddy river crossing the Bogor Botanical Garden; rapids at the bridge below the garden.

LOCALITY 9: Java, Ciapus, Gunung Salak, 06°39'29"S, 106°44'55"E, h=625 m, 24 February 2008, leg. V.D. Ivanov and S.I. Melnitsky. A brook with stony bottom above a small unstable river on the northern slope of Salak volcano.

LOCALITY 10: Java, Cipanas, 30 km SE Bogor, 6°42'43"S, 107°01'12"E, h=1100 m, 25–26 February 2008, 06°42'S, 107°01'E, leg. V.D. Ivanov and S.I. Melnitsky; Java, Cipanas, Cibodas, 6–11 August 2009, leg. N. Yu. Kluge. A small river in a rural environment.

Table 1. List of species known from Java, Bali and Lombok, with new records
Abbreviations: B – Borneo, P – Peninsular Malaysia, S – Sumatra, Wd – wide distribution; m – males, f – females.

Taxa/family, species	Java	Bali	Lombok	other	Found in localities (Loc)
RHYACOPHILIDAE Stephens, 1836					
Rhyacophila anakbatukau MALICKY, 1995		+	+		Loc.1:5m,1f; Loc.7:1m
Rhyacophila curvata MORTON, 1900	+	+	+	S, P	Loc.1:1m; Loc.3: (1f); Loc.6: 1m; Loc.7:1m
Rhyacophila lieftincki ULMER, 1951	+				
GLOSSOSOMATIDAE Wallengren, 1891					
Glossosoma gera MALICKY & CHANTARAMONGKOL, 2009	+				
Glossosoma kerambos MALICKY, 2004	+				
Agapetus abbreviatus ULMER, 1913	+	+	+		Loc.1:21m, 159f; Loc.3:2m, 5f; Loc.4:7m, 19f; Loc.6:17m, 26f; Loc.7:10f; Loc.8:3m; Loc.9:2m, 15f
Agapetus antilochos MALICKY, 1998	+				
Agapetus cataractae ULMER, 1951	+				Loc.10:2m
Agapetus kekrops MALICKY, 2004	+				
HYDROPTILIDAE Stephens, 1836					
Hydroptila baukis MALICKY, 1998	+				
Hydroptila crenata ULMER, 1951	+			S	
Hydroptila elongata ULMER, 1951	+				

Taxa/family, species	Java	Bali	Lombok	other	Found in localities (Loc)
Hydroptila pintal WELLS & HUISMAN, 1992	+			B, P, S	
Hydroptila rahel MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.4:12m
Hydroptila ruben MALICKY, IVANOV & MELNITSKY, 2011		+			Loc.7:1m, (5f)
Hydroptila rumpun WELLS & HUISMAN, 1992			+	P, S	Loc.4:5m
Hydroptila sphinx MALICKY & CHANTARAMONGKOL, 2007		+		S	
Hydroptila tong WELLS & MALICKY, 1997		+		S	
Hydroptila trullata ULMER, 1951	+			P, S	
Microptila innokentiyi MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:3m
Microptila pasak WELLS, 1993		+			
Microptila rinjani MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:1m
Microptila taji WELLS, 1993		+			
Tricholeiochiton fortensis ULMER, 1951	+			P, S	
Oxyethira bogambara SCHMID, 1958		+		B, P, S, Wd	
Oxyethira incana ULMER, 1906	+			P, S	
Ugandatrichia kebumen WELLS & MALICKY, 1997	+				
Orthotrichia curvata ULMER, 1951	+	+	+		Loc.4:1m; Loc.8:16m, (numerous f); Loc.10:4m, (13f)
Orthotrichia indica MARTYNOV, 1935	+			S, P, Wd	
Orthotrichia jethran MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.4:2m
Orthotrichia litoralis ULMER, 1951	+	+		S, P, Wd	
Orthotrichia maeandrica ULMER, 1951	+			P, S	
Orthotrichia ranauana ULMER, 1951	+	+		S	
Saranganotrichia decussata ULMER, 1951	+				
Scelotrichia jari WELLS & HUISMAN, 1993			+	B, P	Loc.1:4m; Loc.4:1m
Scelotrichia milka MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.4:1m, (1f)
Scelotrichia nikolayi MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:1m, (1f); Loc.4:1m
Scelotrichia saranganica ULMER, 1951	+		+	S	Loc.1:17m, (3f); Loc.4:1m; Loc.10:1m, (2f)
Chrysotrichia piring WELLS, 1993		+			
Chrysotrichia sukamade WELLS & MALICKY, 1997	+			S	
Chrysotrichia terpisaduri WELLS, 1993		+			
Chrysotrichia trisula WELLS, 1993	+				
Plethus baliana ULMER, 1951	+	+			
Plethus berbulu WELLS, 1993		+			
Plethus cruciatus ULMER, 1951	+	+	+	S	Loc.1:2m; Loc.6:59m, numerous f
Parastactobia duatali WELLS & MALICKY, 1997	+	+	+		Loc.1:1m
Stactobia bersisik WELLS, 1993	+	+	+		Loc.4:2m Loc.6:1m
Stactobia betiri WELLS & MALICKY, 1997	+				
Stactobia crassa ULMER, 1951	+				
Stactobia germani MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.4:1m
Stactobia keluk WELLS, 1993	+	+			
PHILOPOTAMIDAE Stephens, 1829					
Chimarra anam MALICKY, 2008		+		S	
Chimarra ard MALICKY, 2008	+				
Chimarra arkit MALICKY, 2008	+				
Chimarra batukaua MALICKY, 1995	+	+	+		Loc.1:4m, 41f; Loc.5:1m; Loc.6:15m, 68f; Loc.4:43m, 193f
Chimarra berenike MALICKY, 1998	+				
Chimarra briseis MALICKY, 1998	+		+	S	Loc.1:2m
Chimarra chiangmaiensis MALICKY & CHANTARAMONGKOL, 1989		+		P	
Chimarra concolor ULMER, 1951	+			S	Loc.10:1m, (1f)
Chimarra gunungkawi MALICKY, 1995	+	+			
Chimarra jacobsoni ULMER, 1951	+	+			
Chimarra mahalaleel MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.5:1m

Taxa/family, species	Java	Bali	Lombok	other	Found in localities (Loc)
Chimarra sythoffi ULMER, 1951	+				
Chimarra thienemanni ULMER, 1951	+	+		P, S	
Chimarra xumappa MALICKY, IVANOV & MELNITSKY, 2011		+			Loc.7:1m, 2f
Chimarra yskal MALICKY, 1989		+			
Gunungiella aguha MELNITSKY & IVANOV, 2010			+		Loc.1:7m, 1f; Loc.3:1m
Gunungiella britomartis MALICKY, 1998	+				
Gunungiella kalliope MALICKY, 2004	+				
Gunungiella reducta ULMER, 1913	+				
Pseudoneureclipsis ramosa ULMER, 1913	+	+	+	P, S, Wd	Loc.1:3m, 6f; Loc.3:2f; Loc.4:3f; Loc.7:5m, 3f
POLYCENTROPODIDAE Ulmer, 1903					
Polyplectropus gedehensis ULMER, 1951		+			
Polyplectropus jahzeel MALICKY & MEY, 2011		+			
Polyplectropus javanicus ULMER, 1905	+			S	
Polyplectropus kristyantoi MALICKY, 1998	+				
Nyctiophylax baydeom MALICKY, IVANOV & MELNITSKY, 2011	+				Loc.9:1m
ECNOMIDAE Ulmer, 1903					
Ecnomus anakagung MALICKY, 1995	+	+			Loc.10:1m
Ecnomus jethet MALICKY, IVANOV & MELNITSKY, 2011			+		
Ecnomus obtusus ULMER, 1910	+			S	
Ecnomus quordaio MALICKY, 1993	+			S, P	Loc.8:2m, (1f)
Ecnomus robustior ULMER, 1951	+			P, S	
Ecnomus serratus ULMER, 1930	+	+		S	
Ecnomus tjurupensis ULMER, 1951	+			S	
Pseudoneureclipsis ramosa ULMER, 1913	+	+	+	P, S, Wd	Loc.1:3m, 6f; Loc.3:2f; Loc.4:3f; Loc.7:5m, 3f
PSYCHOMYIIDAE Walker, 1852					
Paduniella kalamos MALICKY, 2004	+	+	+	S	Loc.1:27m, (23f); Loc.2:1m; Loc.3:9m, (1f); Loc.4:15m; Loc.7:9m, (4f); Loc.9:1m, (10f)
Paduniella koehleri MALICKY, 1995	+	+	+		Loc.5:3m; Loc.8:1m, (5f)
Paduniella semarangensis ULMER, 1913	+	+		S, P	
Paduniella trichobogiella MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.4:3m
Psychomyia anaksusuan MALICKY, 1995		+			
Psychomyia capillata ULMER, 1910	+			P, S	
Psychomyia feuerborni ULMER, 1951	+	+	+	S	Loc.1:1m; Loc.4:4m; Loc.6:16m, 16f
Psychomyia kalais MALICKY, 2004	+				Loc.9:7m; Loc.10:5m, (3f)
Psychomyia monto MALICKY & CHANTARAMONGKOL, 1993	+			P	
Psychomyia thienemanni ULMER, 1951	+			P, S	
Tinodes dedan MALICKY, 2009	+				
Tinodes flavopunctatus ULMER, 1910	+	+			Loc.7:6m; Loc.8:2m, (5f); Loc.9:3m, (9f); Loc.10:1m
Tinodes ihalauwi MALICKY, 1998	+				
Tinodes katreus MALICKY, 2004	+				
Tinodes kawiensis MALICKY, 1995		+	+		Loc.1:16m; Loc.3:1m; Loc.6:1m
Tinodes kepheus MALICKY, 2004	+				
Tinodes luhurensis MALICKY, 1995		+	+		Loc.1:47m, (9f); Loc.4:20m, (46f)
Tinodes mataram MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:52m; Loc.2:1m
Tinodes methusael MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:1m; Loc.4:2m
Tinodes moab MALICKY, IVANOV & MELNITSKY, 2011	+				Loc.10:1m
Tinodes noah MALICKY, IVANOV & MELNITSKY, 2011	+				Loc.10:1m
Tinodes prihatmoi MALICKY, 1998	+				
Tinodes pujungan MALICKY, 1995		+			Loc.7:5m, (3f)
Tinodes saul MALICKY, IVANOV & MELNITSKY, 2011	+				Loc.8:5m; Loc.10:3m
Tinodes simeon MALICKY, IVANOV & MELNITSKY, 2011	+				Loc.9:5m, (7f)
Tinodes tegenungan MALICKY, 1995		+			
Tinodes timotii MALICKY, 1998	+				
Tinodes zibeon MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:1m
Trawaspsyche weilgunii MALICKY, 2004	+				

Taxa/family, species	Java	Bali	Lombok	other	Found in localities (Loc)
XIPHOCENTRONIDAE Ross, 1949					
Melanotrichia samaconius MALICKY & CHANTARAMONGKOL, 1992	+	+		P	Loc.6:11m
HYDROPSYCHIDAE Curtis, 1835					
Diplectrona aspersa ULMER, 1905	+				
Diplectrona aurovittata ULMER, 1906	+	+	+	P, S	Loc.1:5m, 2f
Diplectrona extrema BANKS, 1920	+			K, S	
Diplectrona jacobsoni ULMER, 1909	+			S	
Diplectrona lavinia MALICKY, 2002	+			B	
Diplectrona pseudofasciata ULMER, 1909	+			B, S, P, Wd	
Diplectrona salakensis ULMER ,1951	+				
Diplectrona ungaranica ULMER, 1951	+			S	
Oestropsyche vitrina HAGEN, 1859	+	+		B, S, P, Wd	
Polymorphanisus nigricornis WALKER, 1852	+			P, S, Wd	
Polymorphanisus ocularis ULMER, 1906	+			B, P, S, Wd	
Polymorphanisus scutellatus BANKS, 1939	+			B, S,	
Macrostemum fastosum WALKER, 1852	+	+		P, S, Wd	Loc.7:2f
Macrostemum fenestratum ALBARDA, 1887	+			B, P, S	
Amphipsyche meridiana ULMER, 1909	+			P, S, Wd	
Amphipsyche petiolata ULMER, 1930	+			B, P, S	
Hydromanicus dilatus BETTEN, 1909	+				
Hydromanicus flavoguttatus ALBARDA, 1881	+			S	
Hydromanicus irroratus BRAUER, 1865	+				
Hydromanicus ornatus ULMER, 1951	+				
Hydromanicus unicolor ULMER, 1951	+				
Potamyia aureipennis ULMER, 1930	+			S	Loc.8:16m
Potamyia dentifera ULMER, 1930	+				
Potamyia flavata BANKS, 1934	+	+	+	P, S	Loc.4:(5f); Loc.5:1m, 22f
Cheumatopsyche brevis ULMER, 1930	+				
Cheumatopsyche concava ULMER, 1930	+	+		S	Loc.6:(2f); Loc.7:8m, (40f)
Cheumatopsyche contexta ULMER, 1951	+			B, S	
Cheumatopsyche dodan MALICKY & MEY, 2009			+		Loc.1:1m
Cheumatopsyche globosa ULMER, 1910	+	+		B, S, P	
Cheumatopsyche kebumena MALICKY, 1997	+				
Cheumatopsyche kraepelini ULMER, 1905	+	+			
Cheumatopsyche lucida ULMER, 1907	+	+	+	B, P, S, Wd	Loc.4:1m, (6f); Loc.5:7m, (25f); Loc.8:23m, (28f)
Cheumatopsyche misma MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:2f
Cheumatopsyche sindanggala MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:8m, (227f); Loc.4:3m, (6f)
Hydropsyche annulata ULMER, 1905	+	+			Loc.6:1m; Loc.8:26m, (numerous f); Loc.9:1m, (12f); Loc.10:2m, (4f)
Hydropsyche bryanti BANKS, 1939	+			S	
Hydropsyche didyma MEY, 1999			+		Loc.1:8m, (20f); Loc.3:3m, (4f)
Hydropsyche doctersi ULMER, 1951	+			P	
Hydropsyche irroratella ULMER, 1951	+			B?	
Hydropsyche javanica ULMER, 1905	+				
Hydropsyche kottos MALICKY, 2004	+				
Hydropsyche mesech MALICKY, IVANOV & MELNITSKY, 2011		+			Loc.7:4m, (4f)
Hydropsyche renschi MEY, 1999		+	+	S	Loc.1:1m; Loc.4:3m, (3f); Loc.6:1m
Hydropsyche saranganica ULMER, 1951	+	+	+	S, Wd	Loc.1:1m; Loc.4:2m; Loc.6:4m, (11f)
Hydropsyche sasakorum MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:6m, (3f); Loc.3:4m, (5f); Loc.4:1m
Hydropsyche sinear MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.3:1m

Taxa/family, species	Java	Bali	Lombok	other	Found in localities (Loc)
Hydropsyche staphylostirpis MEY, 1998			+		
LEPIDOSTOMATIDAE Ulmer, 1903					
Lepidostoma brevior ULMER, 1913	+	+		S	Loc.7:1m
Lepidostoma conjunctum BANKS, 1934	+			B, S	
Lepidostoma diehli WEAVER, 1989		+	+	S	Loc.1:8m, 3f
Lepidostoma jacobsoni ULMER, 1910	+			S	
Lepidostoma kephalos MALICKY, 2004	+				
Lepidostoma lombokensis MALICKY, IVANOV & MELNITSKY, 2011			+		Loc.1:1m, (1f)
Lepidostoma picea ULMER, 1913	+	+		S	Loc.7:2m, 2f
BRACHYCENTRIDAE Ulmer, 1903					
Micrasema ripat MALICKY, IVANOV & MELNITSKY, 2011	+				Loc.10:1m
GOERIDAE Ulmer, 1903					
Goera conclusa ULMER, 1905	+	+	+		Loc.1:3m, 1f
Goera pugnio ULMER, 1951	+	+		S?	Loc.6:1m
Goera ranauana ULMER, 1951	?			S	
Gastrocentrides sumatranus ULMER, 1930	+	+	+	S, P, Wd	Loc.4:1f; Loc.7:2m, 3f
HELICOPSYCHIDAE Ulmer, 1906					
Helicopsyche lata ULMER, 1951	+			S, P	
LEPTOCERIDAE Leach, 1815					
Adicella byblis MALICKY, 1998	+		+	S	Loc.1:14m, 9f; Loc.4:2m
Adicella evadne SCHMID, 1994		+	+	S, P, Wd	Loc.4:4m; Loc.7:1m
Adicella kanake MALICKY & CHANTARAMONGKOL, 2002			+	S, P	Loc.1:3m, (5f)
Adicella pulcherrima ULMER, 1906	+			S	
Adicella oviformis ULMER, 1951	+	+			
Leptocerus ciconiae MALICKY, 1993		+		S, P	
Setodes karnyi ULMER, 1930		+	+	S	Loc.1:1m
Setodes klakahanus ULMER, 1951	+	+	+		Loc.4:1m; Loc.5:1m
Setodes larentia MALICKY & CHANTARAMONGKOL, 2006	+		+	S	Loc.4:2m, (4f); Loc.7:1m, (5f)
Setodes nauplios MALICKY & CHANTARAMONGKOL, 2006	+				
Setodes uncinatus ULMER, 1913	+			S	
Trichosetodes handschini ULMER, 1951	+				Loc.8:11m, (6f); Loc.9:2m, (5f)
Oecetis karnyi MALICKY, 2009	+				
Oecetis kyparissos MALICKY, 2005		+	+		Loc.4:2m, 9f; Loc.5:1m
Oecetis pelops MALICKY, 2006		+	+		Loc.3(1f); Loc.7:(16f)
Oecetis singularis ULMER, 1930	+			S	
Oecetis spatula CHEN & MORSE, 1991	+			Wd	
Oecetis tripunctata FABRICIUS, 1793	+	+	+	B, P, S, Wd	Loc.4:1m, 6f
Tagalopsyche brunnea ULMER, 1905	+		+	B, S, P	Loc.4:1m
Triaenodes pelias MALICKY, 2005	+			S	
Parasetodes respersella RAMBUR, 1842		+		B, P, S, Wd	
Triplectides indica WALKER, 1852	+		+	S, P, Wd	Loc.4:5f
CALAMOCERATIDAE Ulmer, 1905					
Anisocentropus flavomarginatus ULMER, 1906	+			B, S	
Anisocentropus handschini ULMER, 1951	+				
Anisocentropus ulmeri MALICKY, 1998	+				
Ganonema fuscipenne ALBARDA, 1881	+	+	+	P, S	Loc.1:1f; Loc.4:1f; Loc.6:3m
ODONTOCERIDAE Wallengren, 1891					
Marilia javana ULMER, 1951	+				
Marilia sumatrana ULMER, 1951	+			S	
Total: 202 species	146	73	61		Collected by V.Ivanov, S.Melnitsky, N. Kluge: 84 species

Results and discussion

Table 1 gives the complete list of specimens with data on the sample localities and the distribution outside the studied region. The maps (Figs 2–4) show the position of the localities. In Table 2 a survey is given on genera and families of all Trichoptera identified to species level known from the three islands in comparison to the better studied neighboring regions. Many specimens, mainly females, could not be identified to species. Two species require additional remarks. The types of the microcaddisflies *Plethus acutus* Ulmer and *P. cruciatus* Ulmer have been studied by one of us (H. Malicky) in the Hamburg museum. The type material shows no difference between these species hence we omit one of them (*P. acutus*) in our counts as probable junior synonym. The genus *Marilia* (Odontoceridae) is insufficiently studied in the region. Two species are known from Java (Table 1), but have not been collected on Lombok and Bali. The taxonomy of this genus suffers from the absence of good characters for identification. We do not include this family and genus in Table 2 because the count of species in Asian mainland (Thailand and Malaysia) and Sumatra would not provide good results until this genus has been revised. All data on total species counts are considered here as preliminary. Any further collection is expected to provide more species new for science as well as new regional records.

Table 2. Synopsis of the number of species in Thailand, Sumatra, Java, Bali, and Lombok (except Odontoceridae: see text)

Taxa/family, genus	Thailand	Sumatra	Java	Bali	Lombok
RHYACOPHILIDAE					
Rhyacophila	37	7	3	2	2
GLOSSOSOMATIDAE					
Glossosoma	3	2	2	0	0
Agapetus	14	5	4	1	1
HYDROPTILIDAE					
Hydroptila	33	14	5	3	2
Microptila	2	0	0	2	2
Tricholeiochiton	1	1	1	0	0
Oxyethira	4	4	1	1	0
Ugandatrichia	5	1	1	0	0
Orthotrichia	32	11	5	3	2
Saranganotrichia	2	0	1	0	0
Scelotrichia	5	3	1	0	4
Chrysotrichia	13	5	2	2	0
Plethus	9	1	2	3	1
Parastactobia	2	1	1	1	1
Stactobia	7	0	4	2	2
PHILOPOTAMIDAE					
Chimarra	60	21	10	8	3
Gunungiella	9	3	3	0	1
STENOPSYCHIDAE					
Stenopsyche	8	1	0	0	0
POLYCENTROPODIDAE					
Polyplectropus	13	14	2	2	0
Nyctiophylax	20	6	1	0	0
ECNOMIDAE					
Ecnomus	51	16	6	2	1
Pseudoneureclipsis	41	5	1	1	1
PSYCHOMYIIDAE					
Paduniella	13	2	3	3	3
Psychomyia	24	10	5	2	1
Tinodes	19	5	11	5	5
Trawaspsyche	0	0	1	0	0
XIPHOCENTRONIDAE					
Melanotrichia	4	1	1	1	0
HYDROPSYCHIDAE					
Diplectrona	8	10	8	1	1
Oestropsyche	1	1	1	1	0
Polymorphanisus	5	5	3	0	0
Macrostemum	12	8	2	1	0
Amphipsyche	2	3	2	0	0

Taxa/family, genus	Thailand	Sumatra	Java	Bali	Lombok
Hydromanicus	13	5	5	0	0
Potamyia	13	3	3	1	1
Cheumatopsyche	29	11	7	4	4
Hydropsyche	30	13	7	4	6
LEPIDOSTOMATIDAE					
Lepidostoma	41	15	5	3	2
BRACHYCENTRIDAE					
Micrasema	6	0	1	0	0
GOERIDAE					
Goera	16	6	2	2	1
HELICOPSYCHIDAE					
Helicopsyche	14	3	1	0	0
LEPTOCERIDAE					
Adicella	20	12	3	2	3
Leptocerus	42	8	0	1	0
Setodes	63	17	4	2	3
Trichosetodes	7	3	1	0	0
Oecetis	50	39	4	3	3
Tagalopsyche	3	3	1	0	1
Triaenodes	11	5	1	0	0
Parasetodes	1	1	0	1	0
Triplectides	1	1	1	0	1
CALAMOCERATIDAE					
Anisocentropus	10	5	3	0	0
Ganonema	4	1	1	1	1

The caddisfly faunas of the three islands correspond quite well. It is evident from the Tables 1 and 2 that, according to our present knowledge, the fauna of caddisflies known for the larger and more diverse Java Island is more comparable to faunas of small islands of the Lesser Sunda Archipelago in numbers of species: the total number of species found on Java (146) exceeds the fauna of Bali 2 times (73) and has 2.4 times more species than small Lombok Island (61). The number and proportion of species on Java is probably much greater than this, but the small number is probably caused by a relatively poor exploration of Java compared to the two islands. The species shared by these faunas are counted as 43 species found on both Java and Bali, and 27 found on both Java and Lombok. The similar counts give 30 species occurring on both Bali and Lombok, and 70 on Java and Sumatra. The total number of caddisfly species known on the three islands is 202. However, one could expect that some of these species will also be found later on the adjoining islands in more intensive collection. Hence, the calculation of the similarity of the faunas is left for the future when more data will be available on the fauna of eastern Java and on the species emerging in dry season (May to September) on Lombok.

Surprises are also possible when species described from far distant regions will be found. For example, *Adicella kanake* Malicky & Chantaramongkol and *Hydroptila rumpun* Wells & Huisman found on Lombok were known previously from Sumatra, Peninsular Malaysia and Thailand, but were never collected on Java and Bali. The microcaddisfly *Scelotrichia jari* Wells & Huisman from Lombok lives on Borneo (or Kalimantan Island on some maps) and Peninsular Malaysia but was not found on Java and Bali. Similarly, *Paduniella dendrobia* Malicky & Chantaramongkol was described from high altitude of Doi Inthanon in northern Thailand and *Phoupanpsyche caroli* Malicky was described from the mountains of Laos, but both were later found in the higher elevations of Mount Kinabalu on Borneo, several thousands of kilometers away. There are some instances of species like *Hydropsyche renschi* Mey and *Lepidostoma diehl* (Weaver) found on both Lombok and Bali but not on Java Island.

Endemics of generic or even more-inclusive categories may scarcely exist on these islands. The genus *Trawaspsyche* with the single species *T. weilgunii* Malicky, which is an extremely derived form in relationship with *Tinodes,* is known only from Java. Similar cases are *Temburongpsyche* on Borneo and *Padangpsyche* and *Edidiehlia* on Sumatra. Neither an evolution center nor numerous centers can be recognized on the three islands. A relatively high number of *Tinodes* species may mean a rather active and recent regional speciation process.

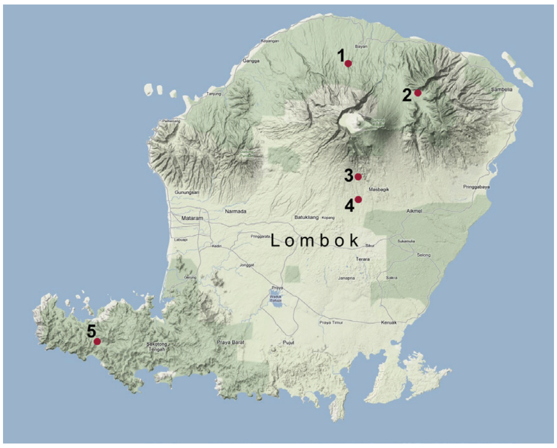
Continuous impoverishment of the Asiatic mainland faunas in the direction of the Lesser Sunda Islands is obvious (Table 2). In Thailand, over 1000 species are presently known (Chantaramongkol et al. 2010); in Sumatra, an island of about the same size, there are about 350 species. In Java we know 146, in Bali 73, and in Lombok 61 species (Malicky 2010 and this paper). Besides the decrease of the total number of species towards the southeast, one can see a notable decrease in the number of genera or families, e.g., Macronematinae, and Odontoceridae. The example of Macronematinae is especially remarkable because these strong flyers are present in New Guinea and Australia.

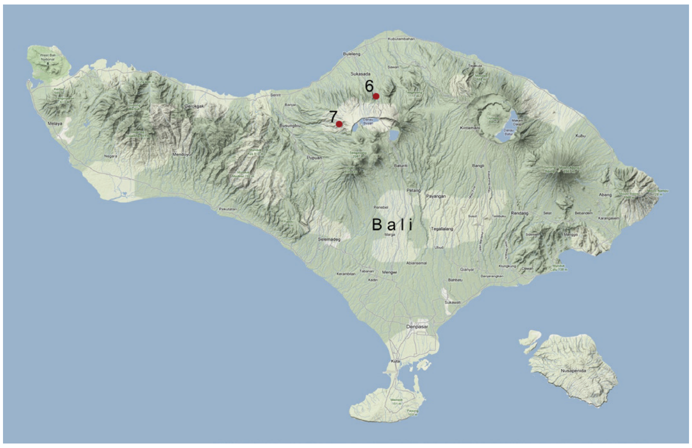
Collecting intensity plays a major role in the knowledge of a fauna. Of Thailand and (northern) Sumatra it is well known, of Western Java and Bali it is relatively well known, too. For Lombok, the results of the first visit are being presented here. Our experience shows that the first intensive collections in an unknown area may yield about 75% unknown species, followed by the second visit results constituting about 20%, while later the percentage of the new species decreases dramatically. We conclude that each of Bali and Lombok may have less than 100 species in total. Such a dramatic decrease of the species numbers from the continent to the islands is not a result of poor collections. Instead it is caused by the island impoverishment and remote position from the continent. The number of caddisfly species in an area of similar size in Thailand is three times larger than in Sumatra. Supposed extreme faunal richness of rainforests does not apply to the aquatic insects, like caddisflies, of this region. To compare with extratropical Central and Southern Europe: about 300 (Austria, Switzerland, Germany, European Russia) to 400 species (Italy, Turkey) are known from these countries.

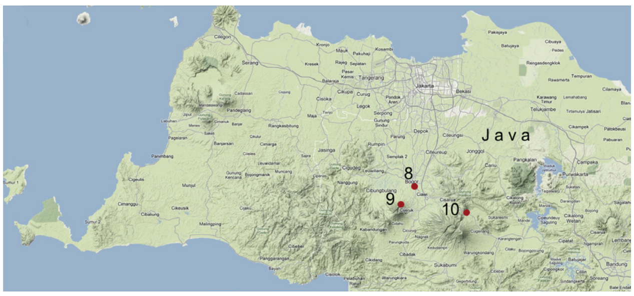
The well-known Wallace's line which runs between Borneo and Bali on one side and Sulawesi and Lombok on the other side (Fig. 1) separates the Asiatic fauna from a mixed area. The latter is bounded from the East by the Lydekker line which runs between the Moluccas on one side and Australia and New Guinea on the other side. This means that Lombok belongs, according to this hypothesis, to the mixed area. According to the floras of this region, Lombok and surrounding islands are also separated (Van Welzen et al. 2011).

It is obvious that there is not an absolute border and the division is rather based on the deep sea waters between Bali and Lombok which remained deep even during the Pleistocene glaciations when the sea level was much lower (de Lattin 1967; Bănărescu 1995). Our data clearly show that there is no faunal gap between Bali and Lombok, as the faunas of these two islands are more or less the same (Tables 1, 2). Some families of Trichoptera have specific distribution patterns including both Asia and Australia (Mey 2001), and the northern part of Australia is faunistically similar to Asia (de Moor and Ivanov 2008). Some families of Asian origin migrated to Australia in the past and the Sunda Islands were probably the bridge for this migration.

Which Trichoptera species or groups may be considered to be the elements of Asiatic or Australian origin? Many families and genera have wide areas in the region, overlapping the borders of the continents (*Chimarra*, *Hydropsyche*, *Cheumatopsyche*, *Oecetis*). Some groups are important members of the Asiatic fauna, though they may be represented by very few species in Australia or New Guinea (*Agapetus*, *Tinodes*). On the other hand, very few groups typical for the Australian fauna are present in Asia, and the species numbers are low in each of these instances. The Australian Trichoptera have been studied for a long time with comprehensive data summarized by Neboiss (1986). Hydrobiosidae, a family rich in genera and species in Australia, is represented in Asia only by the genus *Apsilochorema* of which one species goes as far west as Iran, and relatively few species live on the mainland and on Sumatra and Borneo; none of them were found







Figures 2–4. Recent collection sites cited as localities 1–10 in the text for Lombok (**Figure 2**) Bali (**Figure 3**), and Western Java (**Figure 4**) Islands.

from Java to Lombok. The distribution of Hydrobiosidae emphasizes the separation of the Australian faunas from those of New Guinea and the Malay Archipelago. The Hydrobiosidae of New Guinea are represented by only 2 genera, *Apsilochorema* and related *Tanorus*, with 10 and 12 species, respectively. This family has numerous genera and species in Australia (62 sp.) and New Zealand (104 sp.), widespread in their non-tropical areas, and only 4 species of *Apsilochorema* are known from tropical north-east mountain ranges. The family Hydrobiosidae is known from the Mesozoic Taimyr ambers and the fossil beds of Transbaikalia and Mongolia (Botosaneanu and Wichard 1983; Ivanov and Sukatsheva 2002). Thus the presence of this family mostly on the south continents is a result of secondary proliferation of relics extinct in other regions (Eskov 1984). Similarly, the subfamily Triplectidinae is represented in the Eocene ambers of Europe (Ulmer 1912; Melnitsky and Ivanov 2010) by a few species related to the extant South Asian members of this subfamily. They are secondarily speciated in Australia though in Asia they are represented by only a few species of *Triplectides* and *Symphitoneuria* on the islands of Sumba, Sulawesi and Borneo, including one widespread species, found as far west as Pakistan and occurring also on Java, Bali and Lombok. Both groups, Hydrobiosidae and *Triplectides*, are incorrectly supposed to be of Gondwanian origin by Bănărescu (1990); this hypothesis is based on the recent (Holocene) faunistic data on their distribution and neglects the contradicting fossil data. Indeed the Baltic and Rovno Amber (Paleogene) and Taimyr Amber (Cretaceous) faunas were formed in times when no direct connection to Gondwana existed; the long lost links of Europe to the southern continents had been reestablished only in Oligocene after the times of amber deposition (Blakey 2008). Hence the fossil evidence from these ambers disproves the southern origin of the taxa in question. Thus it is self-evident that the caddisfly fauna of the western Sunda Islands including Lombok is predominantly of Asiatic origin, and influences from the Australian fauna were not found.

It is of highest zoogeographical interest to collect representative samples from the other Sunda Islands east of Lombok, and from the Moluccas. One may wonder that no such material is available in museums despite the intensive collecting activity of many other entomologists. The results of the faunal studies in Wallacea are also of high conservation importance. They can be used to steer both current and future efforts that try to preserve endemic flora and fauna of this uniquely diverse part of the biosphere.

Conclusions

The caddisfly fauna of the islands of Java, Bali and Lombok is largely homogenous, and there is no gap or border between Bali and Lombok which would be expected from the hypothesis of Wallace's line. A continuous impoverishment of the caddisfly fauna from the Asiatic continent over the chain of islands is striking. This gradual impoverishment is observed in species number as well as in the numbers of genera or families. The Trichoptera fauna of the three islands is entirely Asiatic. There is no influence from the Australian fauna. The caddisflies of the Sunda Islands east of Lombok as well as those of the Moluccas are unknown, and their study is much required.

Acknowledgments

This research was supported by grants from the Russian Foundation for Basic Research, grants 11-04-00076 and the Federal Support Program for Leading Scientific Schools NSH-3332.2010.4. The authors are grateful to two reviewers for their valuable comments.

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