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Freshwater copepods in the tributaries of the lower Mekong River Basin in Thailand

KAMONWAN KOOMPOOT[1], SANTI WATIROYRAM[2,♥]

[1]Diversity of Family Zingibeaceae and Vascular Plant of Its Applications Research Unit, Walai Rukhavej Botanical Research Institute, Mahasarakham University. 41 Kham Riang, Kantharawichai 44150, Maha Sarakham, Thailand
[2]Division of Biology, Faculty of Sciences, Nakhon Phanom University. 103 Kham Thao, Mueang Nakhon Phanom 48000, Nakhon Phanom, Thailand. Tel./fax.: +66-42-503776, ♥email: santi.watiroyram@npu.ac.th

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Abstract. *Koompoot K, Watiroyram S. 2025. Freshwater copepods in the tributaries of the lower Mekong River Basin in Thailand. Biodiversitas 26: 1846-1859.* The study of copepod species diversity exclusively in the Mekong River Basin of Thailand has been sporadic, with no relevant publications for over a decade. Additionally, cyclopoid taxonomy remains a serious issue. This study investigated the species composition and distribution of copepods in three river basins of the Mekong River in Thailand: the Mekong, Songkhram, and Mun River Basins. Samples were qualitatively collected using a 60-µm plankton net during the monsoon rainy season by dragging the net from the limnetic zone to the littoral zone. A total of 47 species were identified from 480 samples collected across various waterbodies between 2020 and 2023 in seven provinces within the Mekong River Watershed, including Nong Khai, Bueng Kan, Udon Thani, Sakon Nakhon, Nakhon Phanom, Amnat Charoen, and Ubon Ratchathani. Among 27 calanoid and 20 cyclopoid species, one new cyclopoid species was named and published in prior research, and one new calanoid species is currently being prepared for the nomenclature process. Two cyclopoid copepod species were newly recorded in Thailand: *Mesocyclops woutersi* and *Microcyclops pachyspina*. We confirmed the presence of *Microcyclops karvei* in the country after its previous status had been uncertain. Furthermore, at least three calanoid species previously recorded in the study area: *Mongolodiaptomus uenoi, Neodiaptomus songkhramensis,* and *Phyllodiaptomus christineae* were not observed, suggesting their rarity, potential disappearance, or possible taxonomic misidentification. Similar to cyclopoid copepods, additional sampling and taxonomic study are required for confirmation. The species diversity and species list have been updated, and a brief morphological description along with taxonomic notes are provided for the two newly recorded species and one rare species of cyclopoid copepods.

Keywords: *Mesocyclops woutersi, Microcyclops karvei, Microcyclops pachyspina*, new record, species list

INTRODUCTION

The Mekong River originates on the Tibetan Plateau and is divided into two sections: the Upper Basin and the Lower Basin. The Lower Basin, with a total catchment area of about 571,000 km², is characterized by high biodiversity (Sor et al. 2023). It begins at the border between China and Laos, flows southward through northeastern Thailand, Laos, and Cambodia, reaches the southern tip of Vietnam, and ultimately empties into the Pacific Ocean. A portion of Thailand divides the tributaries of the Lower Mekong River into three basins: the Mekong, Songkhram, and Mun River Basins, all situated in the northeastern region (Mekong River Commission 2024). The traditional term 'Lower Mekong River Basin' in Thailand usually refers to the entire northeastern region, including the Chi River Basin which is one of the 25 major river basins in the country (Polpanich et al. 2022). The Chi River Basin is located in the interior and joins the Mun River in the east before flowing into the Mekong River, the longest river in the country, which extends across 14 provinces: Chaiyaphum, Khon Kaen, Nong Bua Lamphu, Udon Thani, Maha Sarakham, Nakhon Ratchasima, Loei, Phetchabun, Kalasin, Roi Et, Yasothon, Ubon Ratchathani, Sisaket, and Mukdahan (Areerachakul et al. 2022). Since the Chi River Basin is not directly connected to the Mekong River and is therefore less affected by changes in the Mekong, it was not selected as a study area.

The Songkhram River and Mun River Basins are the main tributaries connected directly to the Mekong River, providing several habitats in the floodplain of the northeastern region, such as pools, roadside canals, rice fields, ponds, ox-bow, lake, grassland and other wetlands (Shrestha et al. 2018; Prabnakorn et al. 2021). The Songkhram River Basin is the second-largest catchment in the upper part of the northeastern region, covering Udon Thani, Sakon Nakhon, Bueng Kan, and Nakhon Phanom provinces. It was designated as the country's 15th Ramsar Site, an important area for fisheries (Shrestha et al. 2018). In contrast, the Mun River Basin is the largest basin in the lower part of the region, covering Nakhon Ratchasima, Buriram, Surin, Sisaket, and Ubon Ratchathani provinces. It serves as a key area for agriculture, especially for cultivating Jasmine rice (Prabnakorn et al. 2021). These two river basins influence water levels and the extent of floodplains, which provide a variety of microhabitats linked to the species composition and community structure of aquatic organisms, including copepods (Sanoamuang and Watiroyram 2018).

The investigation of copepod diversity in surface waters of Thailand began in the 19th century, with the most reports and ongoing studies focused on Southeast Asia (Alekseev et al. 2013; Sanoamuang and Dabseepai 2021; Boonmak and Sanoamuang 2022; Chaicharoen and Sanoamuang 2022). In Thailand, 88 copepod species have been reported and are primarily based on samples collected in northeastern Thailand (Sanoamuang 1999; Alekseev and Sanoamuang 2006; Saetang et al. 2021, et al. 2024; Sanoamuang and Dabseepai 2021). However, publications on species diversity based on recent field studies have been scarce in the past decade. Most recent publications typically focus on new species rather than their diversity and distribution (Watiroyram and Sanoamuang 2017; Sanoamuang and Watiroyram 2018, 2020, 2021, 2023). Furthermore, taxonomic and distributional information on cyclopoid copepods from epigean habitats remains problematic and uncertain compared to calanoid copepods, particularly regarding unidentified and ambiguous species. Studies on cyclopoid copepods in Thailand have been conducted sporadically and at irregular intervals, primarily due to taxonomic challenges, in contrast to those in subterranean waters (Watiroyram 2021). Accordingly, the tributaries of the Lower Mekong River in three river basins of the northeastern region were selected as the sampling areas: the Mekong River, Songkhram River, and Mun River Basins. The most recent literature was reviewed to update and monitor the copepod community in the present study, along with brief descriptions of some notable cyclopoid copepods.

MATERIALS AND METHODS

Study areas

Copepods were collected from various habitats in the watershed area where the tributaries of the Mekong River flow in Thailand, including ponds, rice fields, roadside canals, lakes, and swamps. Seven provinces were selected as representative sites for the river basins: a) the Mekong River Basin, Nong Khai and Amnat Charoen; b) the Songkhram River Basin, Bueng Kan, Udon Thani, Sakon Nakhon, and Nakhon Phanom; c) the Mun River Basin, Ubon Ratchathani (Figure 1).

Procedures

The samples were taken using a 60-µm plankton net during the rainy season of the monsoon (October 2020-July 2023). At each sampling site, samples were qualitatively collected once per trip by dragging from the limnetic to the littoral zone. The copepods were immediately fixed in 70% ethanol at the sampling site, and the adults were sorted for taxonomic study using a stereomicroscope in the laboratory. Specimens were completely dissected in a drop of a mixture of 70% alcohol and glycerol at a magnification of 10-40x using a stereomicroscope. The dissected specimens were mounted on a slide in glycerol and sealed with nail polish. The examined materials of all representative species were stored in the SW collection at the Division of Biology, Faculty of Science, Nakhon Phanom University, Thailand. All specimens were examined at 1,000x magnification using the Olympus compound microscope (BHS 40) with a drawing tube. The final line drawings were created using Adobe Illustrator.

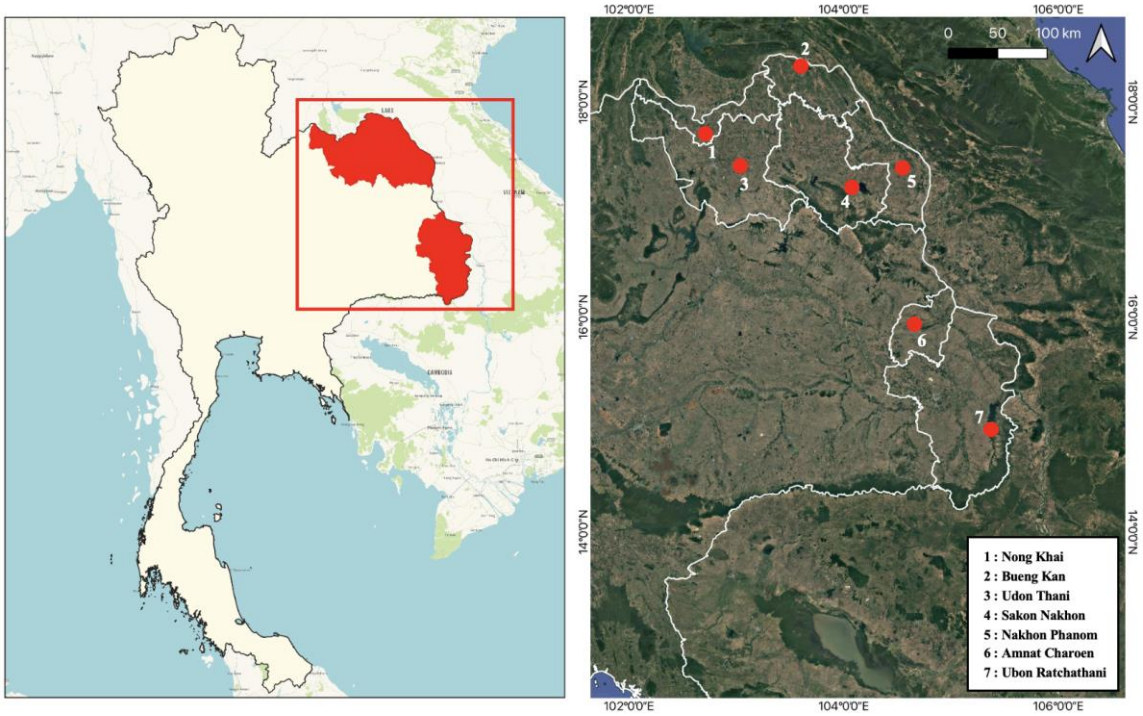

Figure 1. Sampling sites in the Thai tributaries of the lower Mekong River Basin: triangles indicate the locations of provinces along the Mekong's tributaries, while blue circles represent sampling sites (one circle corresponds to one or ore sampling sites)

Specimens for Scanning Electron Microscopy (SEM) were dehydrated through a series of ethanol concentrations (50%, 70%, 80%, 90%, 95%, 100%, and 100% abs.) for 15 min at each concentration. Specimens were dried in a critical point dryer and mounted on stubs. Mounted specimens were coated with gold in a sputter-coater. SEM photographs were carried out using a LEO 1450VP scanning electron microscope.

Data analysis

The species composition and distribution are reviewed and discussed based on the most recent and available publications, including Sanoamuang (1999, 2002), Alekseev and Sanoamuang (2006), Saetang et al. (2021), et al. 2024, Sanoamuang and Dabseepai (2021), Watiroyram (2021), and Saetang and Maiphae (2023). For the taxonomic study, the original species descriptions, relevant re-descriptions, and photographs or figures were used. The following morphological features were used for species identification: the structure and ornamentation of the caudal rami, legs, antennules, antennae, and mouth appendages. The similarity of each feature among species was analyzed. Length was measured using an ocular micrometer, and length ratios were manually calculated.

The morphological terminology follows Huys and Boxshall (1991). The abbreviations used in the text are: a: aesthetasc; s: spine; Enp: endopod; Exp: exopod; Exp-n or Enp-n: exopodal segment n or endopodal segment n; P1-P6: legs 1-6; S1-S7: caudal seta I-VII. S1: anterolateral accessory seta (I); S2: anterolateral seta (II); S3: posterolateral seta (III); S4: outer terminal seta (IV); S5: inner terminal seta (V); S6: terminal accessory seta (VI); S7: dorsal seta (VII).

RESULTS AND DISCUSSION

Diversity and distribution

A total of 480 samples were collected from standing waters across three river basins in Thailand: the Mekong River Basin (Nong Khai and Amnat Charoen provinces), the Songkhram River Basin (Bueng Kan, Udon Thani, Sakon Nakhon, and Nakhon Phanom provinces), and the Mun River Basin (Ubon Ratchathani province). For more information on the collection and identification data, see Watiroyram (2024). Calanoida and Cyclopoida were found, comprising 2 families, 14 genera, and 37 species. Among the 27 calanoid species (Table 1), *Heliodiaptomus elegans*, *Mongolodiaptomus botulifer*, *M. malaindosinensis*, *Neodiaptomus yangtsekiangensis*, and *Vietodiaptomus blachei* are the most widely distributed in the three river basins. *Mongolodiaptomus malaindosinensis* was the most frequently found species, occurring in 54.3% of the total samples and followed by *M. botulifer* (26.2%). Six species were uncommon in the study area during the sampling period, comprising less than 1% of the total samples: *Eodiaptomus sanoamuangae*, *Mongolodiaptomus loeiensis*, *M. rarus* (Reddy et al. 1998), *Tropodiaptomus lanaonus*, *T. oryzanus*, and *T. ruttneri*. The results of the present study revealed: (i) The first record of *Phyllodiaptomus thailandicus* in the northeastern region; (ii) five species, *Mongolodiaptomus loeiensis*, *M. mekongnensis*, *M. pectinidactylus*, *Phyllodiaptomus parachristineae*, *Tropodiaptomus megahyaline* were found to have wider distributions than previously reported; (iii) seven species, *Arctodiaptomus* sp., *Dentodiaptomus orientalis*, *Mongolodiaptomus uenoi*, *M. phutakaensis*, *N. songkhramensis*, *P. surinensis*, *P. christineae* were not observed in the present study (for the most recent species list in Thailand see Sanoamuang and Dabseepai (2021)). Besides the 27 calanoid species, one species is likely a new species and is currently under taxonomic study, with the nomenclature process pending (not presented in this study).

Among the 20 cyclopoid species found in the study area (Table 2), the *Mesocyclops* and *Thermocyclops* genera were dominant, particularly *Mesocyclops affinis* (11.8% of the total samples), *M. thermocyclopoides* (19.9%), *Thermocyclops crassus* (11.3%) and *T. decipiens* (18.6%), which were distributed throughout the floodplain of the Lower Mekong River Basin in Thailand. Six species were found at only one site: *Ectocyclops polyspinosus*, *Mesocyclops ferjemurami*, *M. kayi*, *Microcyclops karvei*, *Paracyclops affinis*, and *Thermocyclops vermifer*. Additionally, *Mesocyclops woutersi* and *M. pachyspina* are recorded for the first time in Thailand. Eight species were not found in the present study: *Eucyclops serrulatus*, *Ectocyclops phaleratus*, *E. rubescens*, *Paracyclops fimbriatus*, *Tropocyclops prasinus*, *Mesocyclops splendidus*, *Microcyclops varicans*, and *Thermocyclops taihokuensis*.

Taxonomic notes on three recorded species

Mesocyclops woutersi *(Van de Velde, 1987) (Figures 2-3)*

Material examined. Adult females (n: 4), completely dissected and mounted on a slide, collected from pool by Koompoot K. on 14 January 2023 (Nong Khai province, no. NK70-72, NK99).

Female. Body length 1,281 (1,210-1,367) µm excluding caudal setae. Ratio of prosome/urosome length: 1.95 (1.60-2.22); cephalothorax length/width: 0.91 (0.89-0.97); cephalothorax width/genital double-somite width: 2.56 (2.50-2.60). Pediger 5 (Figure 2.B) without hairs laterally and dorsally. Genital double-somite (Figure 2.B) 1.13 (1.10-1.15) times as long as wide, with cuticular pits and six pores posterior to P6 (Figure 2.C). Seminal receptacle with relatively short lateral arms, transverse ducts forming a V-shape next to copulatory pore, and strongly curved copulatory duct. Anal somite (Figure 2.D) with tiny spinules arranged in a random pattern laterally and ventrally, a pair of pores at the inner posterior margin, and a row of spinules along the posterior margin dorsally and ventrally (Figures 2.D, G).

Caudal ramus (Figure 2.B) parallel, about 2.77 (2.50-3.27) times as long as wide, with tiny spinules covering the entire ramus and no hairs or spinules along the inner margin. S2 and S3 lack spinules at their insertions. Relative length of caudal setae: S6/S3: 2.90 (2.70-3.00); S5/S3: 5.71 (5.40-5.87); S4/S3: 4.25 (4.20-4.38); S7/S3: 0.95 (0.94-1.00); S5 longest, about 1.38 (1.00-1.50) times as long as urosome.

Table 1. The calanoid copepod species discovered in the Thai tributaries of the lower Mekong River Basin in the present study

Species and distribution	The river basins in Thailand							Global distribution
	Songkhram				Mun	Mekong		
	BK	UD	SK	NP	UB	NK	AN	
Order Calanoida								
Family Diaptomidae								
Allodiaptomus raoi			●		●			China[1], India[1], Cambodia[1,2], Vietnam[1,3]
Dentodiaptomus javanus		●		●				China[1], Indonesia[1], Cambodia[1,2], Vietnam[1,3]
Eodiaptomus draconisignivomi	●		●	●	●	●	●	Laos[1], Cambodia[1,2], Vietnam[1,3]
E. phuphanensis	●	●	●	●	●	●		Laos[1], Cambodia[1,2]
E. phuvongi			●		●		●	Laos[1], Cambodia[1,2]
E. sanoamuangae				●				China[1], Cambodia[1,2]
Heliodiaptomus elegans	●	●	●	●	●	●	●	China[1], Bangladesh[1], Myanmar[1], Cambodia[1,2], Vietnam[1,3]
H. phuthaiorum	●	●		●		●		Cambodia[2]
Mongolodiaptomus botulifer	●	●	●	●	●	●	●	Laos[1], Cambodia[1,2], Vietnam[1,3], Malaysia[1], Singapore[1]
M. calcarus	●	●		●	●	●		China[1], Laos[1], Cambodia[2], Vietnam[1,3], Malaysia[1], Singapore[1], Indonesia[1]
M. dumonti		●	●	●	●			Cambodia[2]
M. loeiensis[*]						●		Endemic to Thailand[1]
M. malaindosinensis	●	●	●	●	●	●	●	Cambodia[1], Malaysia[1], Singapore[1], Vietnam[3]
M. mekongnensis		●	●		●			Laos[1], Cambodia[1], Vietnam[3]
M. pectinidactylus			●	●	●			China[1], Vietnam[1,3]
M. rarus			●					Endemic to Thailand[1]
Neodiaptomus laii			●	●	●			Laos[1], Cambodia[2], Malaysia[1], Singapore[1]
N. yangtsekiangensis	●	●	●	●	●	●	●	China[1], Laos[1], Cambodia[1,2], Vietnam[1,3]
Phyllodiaptomus parachristineae				●	●			Cambodia[4]
P. praedictus		●	●	●		●		Laos[1], Cambodia[1,2], Indonesia[1]
P. thailandicus[**]	●		●	●		●		Endemic to Thailand[1]
Tropodiaptomus lanaonus					●			Philippines[1]
T. megahyaline	●					●		Endemic to Thailand[1]
T. oryzanus						●		China[1], Korea[1], Japan[1], Taiwan[1], Cambodia[2],Vietnam[1,3]
T. ruttneri					●			China[1], Japan[1], Taiwan[1], Malaysia[1]
T. vicinus		●		●	●	●		India[1], Cambodia[1,2], Vietnam[1,3], Malaysia[1], Indonesia[1], Philippines[1]
Vietodiaptomus blachei	●	●	●	●	●	●	●	Laos[1], Cambodia[1,2], Indonesia[1], Malaysia[1], Singapore[1], Vietnam[3]

Note: AN: Amnat Charoen; BK: Bueng Kan; NK: Nong Khai; NP: Nakhon Phanom; SK: Sakon Nakhon; UB: Ubon Ratchathani; UD: Udon Thani; ●: Presence of the species; *: First found outside the type locality; **: First found in the northeast region. Selected references: 1: Sanoamuang and Dabseepai (2021); 2: Chaicharoen and Sanoamuang (2022); 3: Boonmak and Sanoamuang (2022); 4: Sanoamuang and Watiroyram (2023)

Antennule 17-segmented, with cuticular pits on segment 1, 4, 7, 9, 10, 13, 15-16. Segment 17 (Figure 3.A) with one notch on hyaline membrane. Segments 1, 4-5, 7-13, and sometimes 14 (one out of four) ornamented with ventral spinules. Labrum (Figure 3.I) with 9 teeth on distal margin between lateral angles, ornamented with grouped hairs on ventral surface. Mandible, maxillule, maxilla and maxilliped (Figures 3.D-H) similar to what is known for *M. woutersi* and other morphologically close species (Hołyńska 2000).

Antenna with 2 medial setae on basis. Basis in frontal view (Figure 3.C) with longitudinal row of 28 spinules along outer margin, without row of spinules near insertion of exopodal seta. In caudal view, with 6 spinular groups in outer and inner margins (Figure 3.B): outer margin with row of 4 long spinules proximally, oblique row of 12 spinules in proximal half, and longitudinal row of 20 spinules more distally; Inner margin with a field of tiny spinules located near proximal margin, in middle third, and near insertion of medial setae. Exp with single seta. Enp-1-3 with 1, 7, and 7 setae respectively; with cuticular pits.

P1-P4 with 3-segmented Exp and Enp; intercoxal sclerites smooth; basis with setules on inner margin. P4 intercoxal sclerite (Figure 2.F) with small triangular outgrowths but other legs with rounded outgrowths on free distal margin. P1 basis without inner spine. P4 Exp-3 and Enp-3 (Figure 2.E) with tiny spinules on caudal surface. P4 Enp-3 3.14 times as long as wide; inner apical spine 1.08 times as long as outer apical spine, 0.8 times as long as segment bearing it.

Remarks. The caudal ramus is covered with small spinules on both the dorsal and ventral surfaces in the Thai specimens, while this feature was not described in specimens from Papua New Guinea (Van de Velde 1987), the Philippines (Paz et al. 2016), and Vietnam (Tran et al. 2020). This microcharacter is an example of a trait that is more likely to be overlooked than truly absent.

Table 2. The cyclopoid copepod species discovered in the Thai tributaries of the lower Mekong River Basin in the present study

Species and distribution	The river basins in Thailand							Global distribution
	Songkhram				Mun	Mekong		
	BK	UD	SK	NP	UB	NK	AN	
Order Cyclopoida								
Family Cyclopidae								
Cryptocyclops bicolor	●					●		Almost cosmopolitan, except in Australia[1]; uncommon and introduced in North America[2]
Ectocyclops polyspinosus	●				●			America: Canada[1]; Asia: China[1,3], Malaysia[3], Singapore[3], Taiwan[1,3], Vietnam[3]
Mesocyclops affinis	●	●	●	●	●	●	●	Asia: Indonesia[1], Malaysia[1], Papua New Guinea[1,4], Vietnam[1,5]
M. aspericornis	●	●	●		●	●		Africa[1]; America[1] (introduced[6,7]); Asia[1]
M. ferjemurami					●	●		Asia: India[1,8], Sri Lanka[1,8], Vietnam[1,8]
M. kayi						●		Asia: Myanmar[9], Thailand[10]
M. ogunnus					●	●		Africa[1]; America: introduced in Brazil[1] and Cayman Islands[1]; Asia[1] (incl. Malaysia[11], Philippines[12])
M. thermocylopoides	●	●	●	●	●	●	●	Native to Southeast and East Asia[1,13]; America: Costa Rica[1], Puerto Rico[1], Honduras[1] and Mexico[1] (introduced[14])
*M. woutersi**					●	●		Asia: Cambodia[12], Japan[1,12], Laos[12], Papua New Guinea[1,12], Philippines[15], South China[1,12], South Korea[1,12], Taiwan[12], Vanuatu[12], Vietnam[1,12]; Australia: Queensland[1,12]
Microcyclops karvei						●		Africa?[1,16]; Asia: Cambodia[1,16], India[1], Iran[1,16], Malaysia[11], Tajikistan[1], Uzbekistan[1,16], Sri Lanka[16]
*M. pachyspina**	●	●	●		●	●		Africa: Cameroun[17], Chad[17], Ivory Coast[17], Mauritius[17], Senegal[17], Uganda[17]; Asia: China[17], India[1,17], Iran[17], Iraq[17], Kazakhstan[17], U.A.E.[17], Japan[17], Malaysia[17], Myanmar[17], Oman[17], Pakistan[17], Turkmenistan[17], Uzbekistan[17], Yemen[1,17]
M. rubellus	●			●	●	●		Africa: Burkina Faso[1], Cameroun[1], Ivory Coast[1], Senegal[1], Sudan[1], Tanganyika[1], Tunisia[1]; America†: Barduda[1], Bonaire[1], Canada[1], Cuba[1], Guatemala[1], Honduras[1], Mexico[1], Panama[1], Puerto Rico[1], USA[1]; Asia: China[1], India[1], Indonesia[1,18], Israel[1], Japan[1], Korea[19], Malaysia[11], Sri Lanka[1]; Europe[1]
Paracyclops affinis					●	●		Africa[1], Asia[1], and Europe[1]
Thermocyclops crassus	●	●	●	●		●	●	Africa[1]; America[1]: Canada[20], Mexico[21], and USA[21](introduced); Asia[1]; Australia[1]
T. decipiens	●	●	●	●	●	●		Africa[1]; Australia[1]; central and south America[1,21]; tropical Asia[1]
T. maheensis					●	●		Asia: India[1], Cambodia[21]
T. oryzae	●	●	●					Endemic to Thailand[22]
T. rylovi		●			●	●		Africa: Benin[1], Congo[1], Ethiopia[1], Eganda[1]; Asia: Afghanistan[1], Cambodia[21], India[1], Iran[1], Kazakhstan[1], Malaysia[1], Pakistan[1], Tajikistan[1], Uzbekistan[1]; Australia: Queensland[23]; Europe: Caucasus[1], Dagestan[1]
T. vermifer						●		Asia: Afghanistan[1], Azerbaidjan[1], Cambodia[21], China[1], India[1], Iran[1], Kazakhstan[1], Malaysia[11], Pakistan[1], Tajikistan[1], Turkmenistan[1], Uzbekistan[1]
T. wolterecki		●	●	●	●	●		Asia: Cambodia[21], Papua New Guinea[1], Philippines[1]

Note: AN: Amnat Charoen; BK: Bueng Kan; NK: Nong Khai; NP: Nakhon Phanom; SK: Sakon Nakhon; UB: Ubon Ratchathani; UD: Udon Thani; ●: Presence of the species; *: New records for Thailand; †: It needs reconsideration and is probably not distributed in America (Gutiérrez-Aguirre and Cervantes-Martínez 2016). Selected references: 1: Dussart and Defaye (2006); 2: Reid (1998); 3: Alekseev and Chaban (2021); 4: Hołyńska (2000); 5: Tran and Hołyńska (2015); 6: Gutiérrez-Aguirre et al. (2002); 7: Fuentes-Reinés et al. (2017); 8: Hołyńska and Nam (2000); 9: Hołyńska and Brown (2003); 10: Maiphae et al. (2023); 11: Alekseev et al. (2016); 12: Hołyńska and Stoch (2013); 13: Hołyńska et al. (2003); 14: Suárez-Morales et al. (2011); 15: Paz et al. (2016); 16: Mirabdullayev and Urazova (2006); 17: Mirabdullayev and Mirzambetov (2024); 18: Alekseev et al. (2013); 19: Chang (2013); 20: Campbell et al. (2024); 21: Chaicharoen et al. (2011); 22: Saetang et al. (2024); 23: Hołyńska (2006)

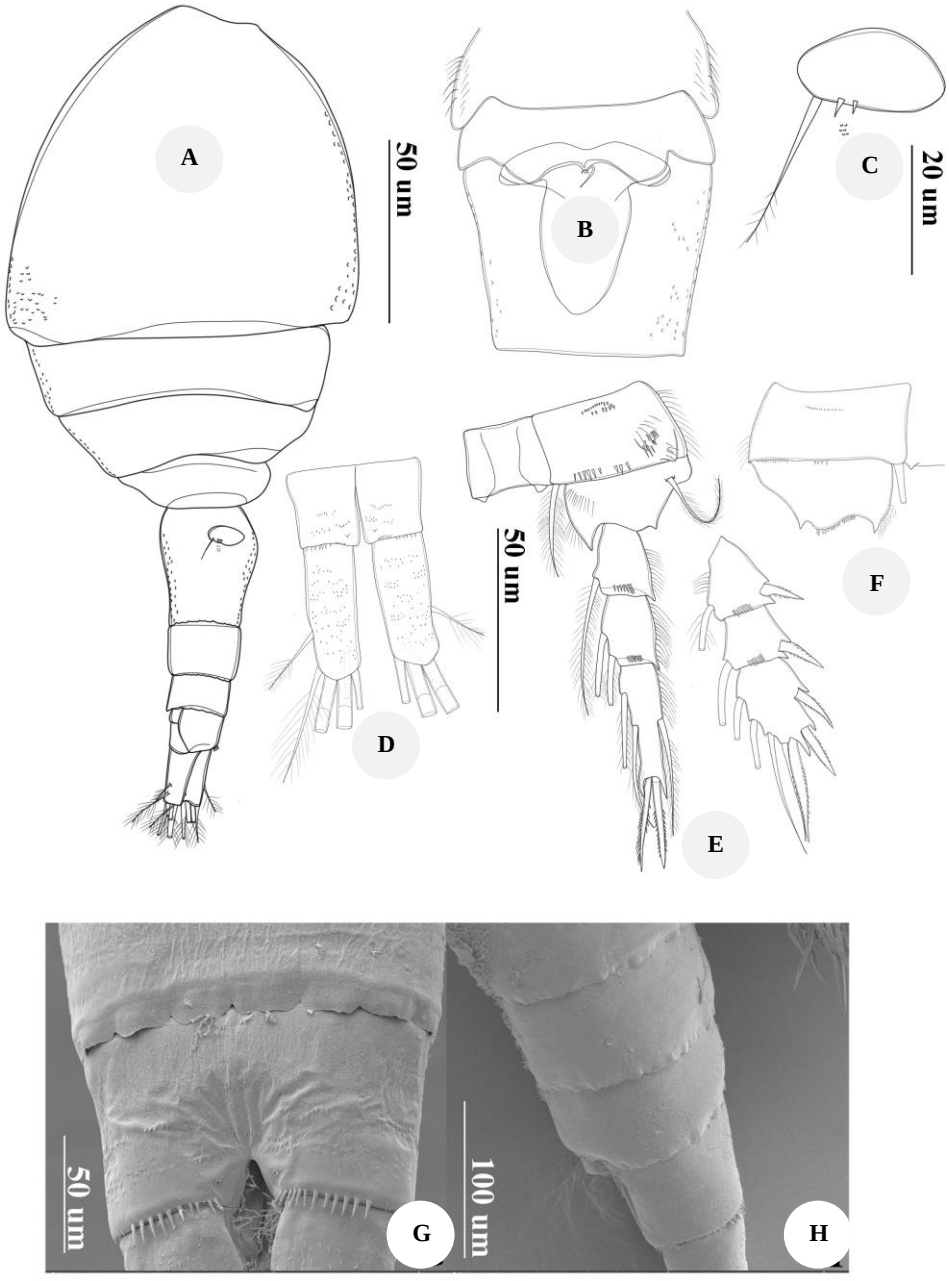

Figure 2. *Mesocyclops woutersi* female. A. Habitus, dorso-lateral view; B. Pediger 5 and genital double-somite, ventral view; C. P6; D. Anal somite and caudal rami, ventral view; E. P4, caudal view; F. P4 protopodite, frontal view; G. Anal somite, ventral view; H. Urosome, lateral view

Microcyclops karvei *(Kiefer and Moorthy, 1935) (Figure 4)*

Material examined. Adult female (n: 1), completely dissected and mounted on a slide, collected from a rice field pool by Watiroyram S. on 4 June 2022 (Nong Khai Province, no. NK38).

Female. Body length 710 µm excluding caudal setae, cephalothorax 1.05 as long as wide. Genital double-somite (Figure 4.A) enlarged anteriorly, convex laterally, about 1.08 times as long as wide. Posterior margin of urostomies with irregularly serrated hyaline fringe. Anal somite with uniform-sized spinules on posterior margin. Caudal rami parallel, about 3.29 times as long as wide. S2 and S3 with spinules at insertion point on ventrolateral side. S6 about 1.33 times as long as S3, both setae shorter than length of caudal ramus. S7 shortest.

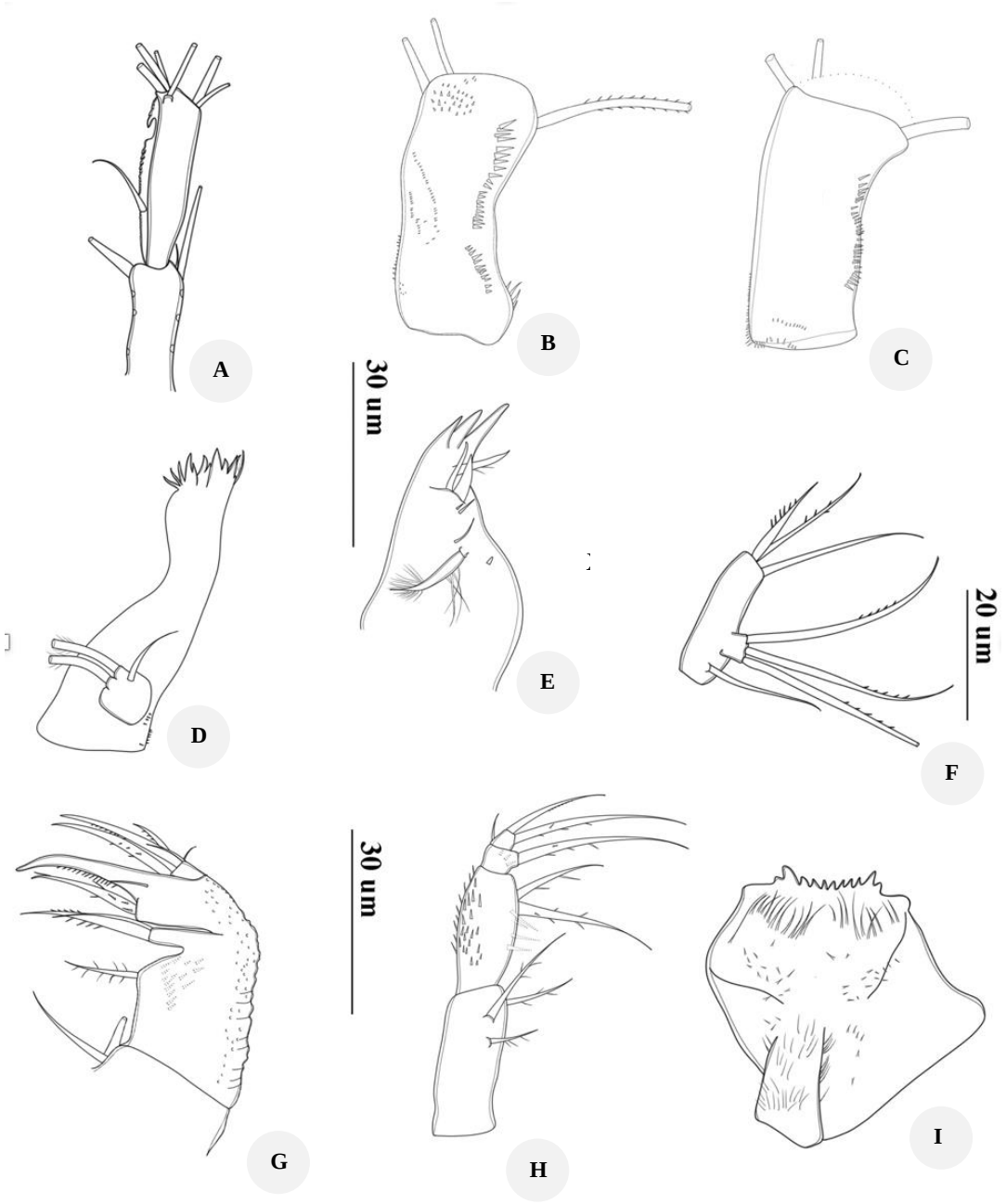

Figure 3. *Mesocyclops woutersi* female. A. Last antennulary segment; B. Antennary basis, caudal view; C. Antennary basis, frontal view; D. Mandible; E. Maxillule; F. Maxillulary palp; G. Maxilla; H. Maxilliped; I. Labrum

Antennule (Figure 4.B) 10-segmented, not reaching posterior margin of cephalothorax. Setal and spine formula as follows: 8.4.8.5+s.2.3.2+a.2.2+a.7+a. Antenna (Figure 4.C) with 2 medial setae on basis. Exp is represented by a single seta. Enp-1-3 with 1, 7, and 7 setae, respectively.

P1-P4 with 2-segmented Exp and Enp; intercoxal sclerites smooth; basis with setules on inner margin. P1 (Figure 4.D) with long inner spine, about 3/4 of Enp-2 length. P4 (Figure 4.E) coxa with spinules on inner distal corner; Enp-2 2.67 times as long as wide; inner apical spine 0.87 times as long as segment bearing it, and 2.26 times as long as outer apical spine. P5 (Figure 4.A) 1-segmented, approximately 2.7 times as long as wide, with long apical seta, without minute spine on medial margin. Lateral seta inserted on pediger 5.

Remarks. The female of *M. karvei* was originally described from India by Kiefer and Moorthy (1935), and later, the female was redescribed along with the first description of male from Uzbekistan by Mirabdullayev and Urazova (2006). The Thai specimen differs from those in India and Uzbekistan in the segmentation of the antennule: it is ten-segmented, similar to the specimens from Uzbekistan, whereas the Indian specimens have a nine-segmented antennule.

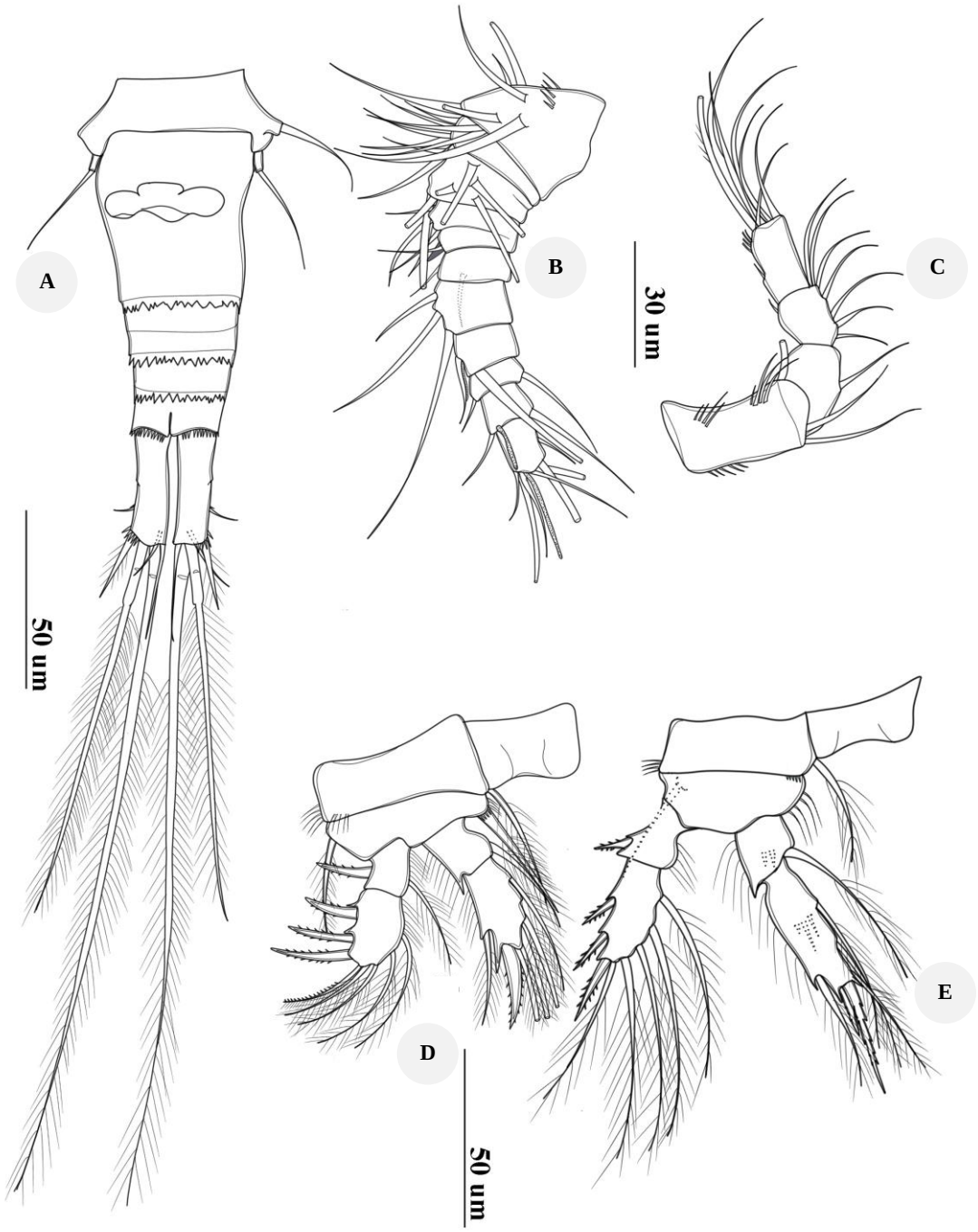

Figure 4. *Microcyclops karvei* female. A. Urosome, ventral view; B. Antennule; C. Antenna; D. P1; E. P4

Microcyclops pachyspina *(Lindberg, 1937) (Figures 5-6)*

Material examined. Adult females (n: 3), completely dissected and mounted on a slide, collected from a roadside canal by Watiroyram S. on 4 June 2022 (Udon Thani Province, no. UD49, 56, 63).

Female. Body length 750-820 µm excluding caudal setae (n: 3). Genital double-somite (Figure 6.A) about 1.15 times as long as wide. Posterior margin of urosomites with irregularly serrated hyaline fringe. Anal somite with uniform-sized spinules on posterior margin. Caudal rami (Figures 6.C, D) parallel, about 3.9 (3.81-3.93) times as long as wide. S3 with spinules at the insertion point. S6 1.44 (1.42-1.44) times as long as S3, and 0.85 (0.81-0.85) times as long as caudal ramus.

Antennule (Figure 5.A) 12-segmented, not reaching posterior margin of cephalothorax. Setal and spines formula as: 8.4.2.6.4.1+s.2.3.2+a.2.2+a.7. Antenna (Figure 5.B) with 2 medial setae on basis. Exp represented by single seta. Enp-1-3 with 1, 6 and 7 setae respectively. Mandible (Figure 5.C). Gnathobase with 6 strongly chitinized teeth, and a small seta dorsally. Coxa with 2 rows of spinules near insertion of palp. Palp with a short seta and 2 long setae.

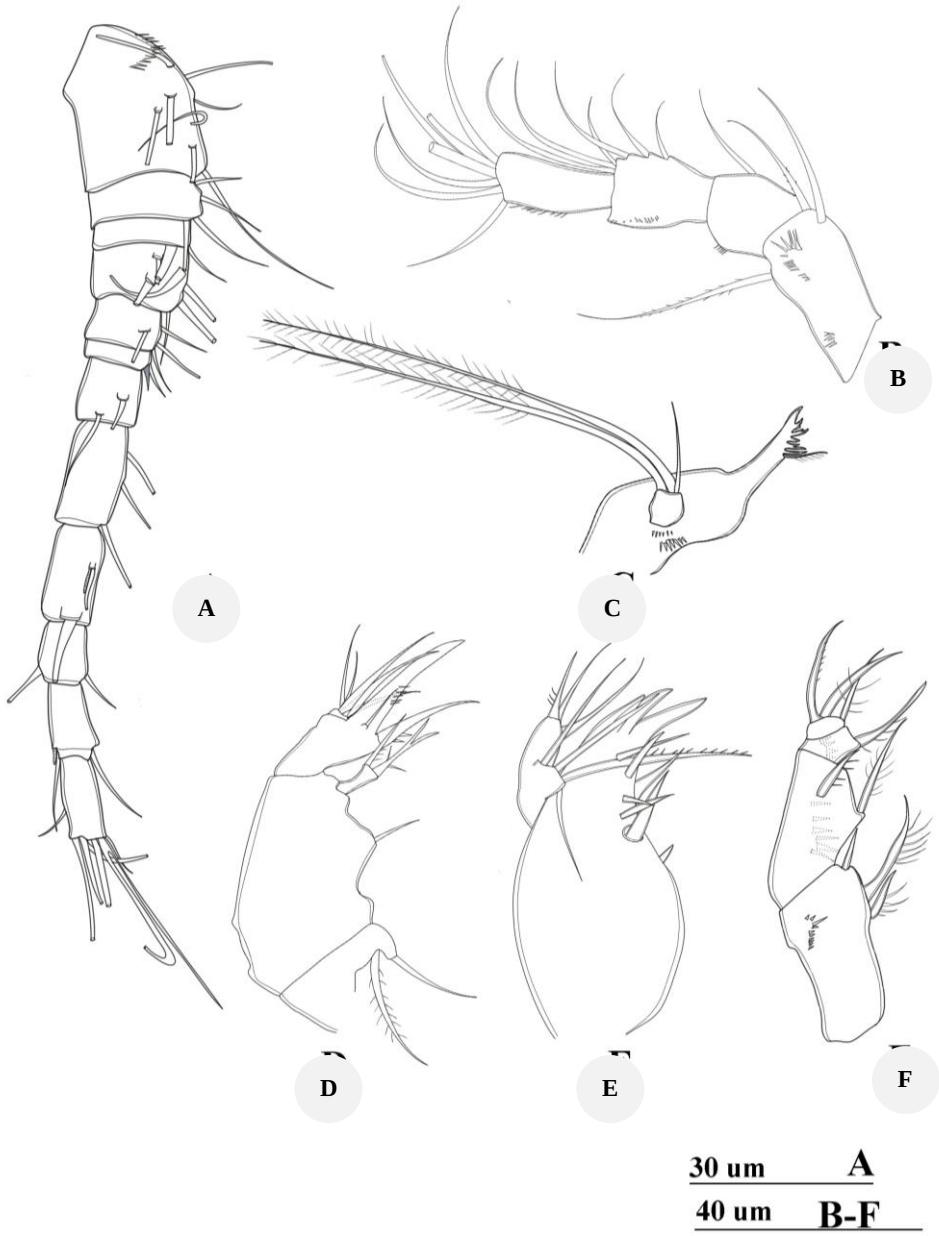

Figure 5. *Microcyclops pachyspina* female. A. Antennule; B. Antenna, caudal view; C. Mandible; D. Maxilla; E. Maxillule; F. Maxilliped

Maxilla (Figure 5.D). Precoxal endite with 2 setae. Coxa with 2 endites: proximal endite with smooth seta; distal endite with 2 spinulate setae. Basis drawn out into 2 claw-like expansions, with slender seta on proximal inner margin. One-segmented Enp, with 3 setae. Maxillule (Figure 5.E). Precoxal arthrite with 3 strongly apical claws, 7 setae on inner margin. Palp with 7 setae.

Maxilliped (Figure 5.F). Syncoxa with 2 spinulate setae and one smooth seta on inner margin; with short row of spinules on outer margin. Basis with 2 spinulate setae on inner margin, and row of strong spinules on frontal surface. Enp-1 with inner seta and a group of tiny spinules on frontal surface. Enp-2 with 3 apical setae.

P1-P4 with 2-segmented Exp and Enp; intercoxal sclerites smooth. P1-P3 basis with setules on inner margin, while P4 with short spinules. P1 (Figure 6.E) basis with long inner spine, reaching distal end of Enp-2. P4 (Figure 6.F) coxa with 3-4 spinules on inner distal corner on frontal surface; Enp-2 2.54 times as long as wide; inner apical spine 0.57 times as long as segment and 1.61 times as long as outer apical spine. P5 1-segmented, about 2.7 times as long as wide; with long apical seta and minute spinule on medial margin. Lateral seta inserted on pediger 5 (Figures 6.A, B).

Remark. Based on biometrics provided by Mirabdullayev and Mirazambetov (2024), specimens of *M. pachyspina* from Thailand have a slightly longer inner apical spine on the female P4 Enp-2 than those from the population in Central Asia, relative to both the segment bearing it and the outer apical spine.

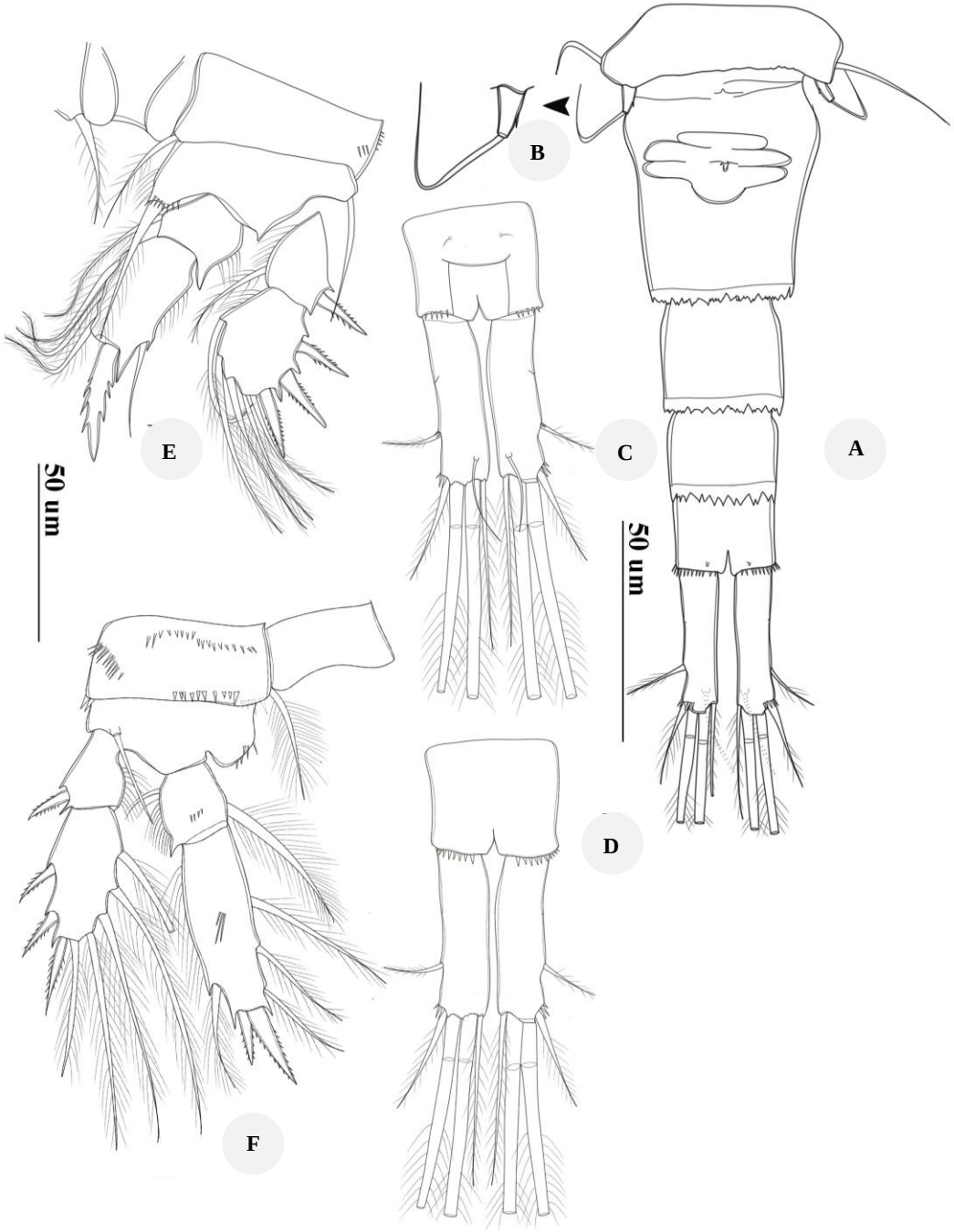

Figure 6. *Microcyclops pachyspina* female. A. Urosome, ventral view; B. P5; C. Anal somite and caudal rami, dorsal view; D. Anal somite and caudal rami, ventral view; E. P1; F. P4

Discussion

The results revealed that species composition and distribution have changed when compared to historical data, highlighting dynamic shifts in the copepod communities within the Mekong River Basin of Thailand. Among the 42 known calanoid copepod species of Thailand (Sanoamuang and Dabseepai 2021), 15 species were not observed in the present study. These species can be divided into two groups: species outside the Mekong River Basin including *Heliodiaptomus viduus*, *Neodiaptomus meggitti*, *N. schmackeri*, *N. siamensis*, *Tropodiaptomus hebereri*, and *Tropodiaptomus* sp.; and species within the Mekong River Basin including *Arctodiaptomus* sp., *D. orientalis*, *M. uenoi*, *Mongolodiaptomus* sp. (= *M. phutakaensis*) *N. songkhramensis*, *Phyllodiaptomus christineae*, *P. roietensis*, *P. surinensis*, and *Paradiaptomus greeni*. However, the species discussed within the Mekong River Basin herein also include those from the Chi River Basin, as the literature traditionally uses the term 'Mekong River Basin' without specifying localities within northeastern Thailand, as mentioned in the introduction. Consequently, the number of absent species appears higher than expected

because species from the Chi River Basin, outside the defined study area, have been included.

Among the nine species within the Mekong River Basin, *Mongolodiaptomus* sp. (Khon Kaen Province), *P. roietensis* (Nakhon Ratchasima and Roi Et provinces), *P. surinensis* (restricted to Surin Province) and *P. greeni* (Khon Kaen Province) have been documented in the Chi River Basin or occur outside the study area. This reasonably explains their absence in the present study. Additionally, two species were not observed due to their rarity or narrow distributions: *Arctodiaptomus* sp. was collected from running water in the Mun River, Ubon Ratchathani Province (with only one male specimen recorded), and *D. orientalis* was recorded from only five sites in Ubon Ratchathani Province. *Dentodiaptomus orientalis* is considered a very rare species and was found in only 3.1% of the total sites (Sanoamuang and Watiroyram 2021). In contrast, *M. uenoi*, *N. songkhramensis*, and *P. christineae* are more widely distributed, occurring in 1-3 river basins across the country. *Mongolodiaptomus uenoi* was originally described from Taiwan and later redescribed by Reddy et al. (2000) based on samples from Kalasin, Nong Bua Lam Phu, and Chaiyaphum provinces, which are outside the study area. However, Tungpunyaporn (2003) and Wansuang (2004) reported the occurrence of *M. uenoi* from Sakhon Nakhon and Nakhon Phanom provinces in the Songkhram River Basin (Figure 25 in Tungpunyaporn (2003).

Additionally, *M. uenoi* and *M. mekongnensis* were found in Ubon Ratchathani in the Mun River Basin by Wansuang (2004). *Mongolodiaptomus uenoi* and *M. mekongnensis* exhibit very similar fifth legs in males, requiring special caution during identification. Therefore, the distribution of both species in the Mekong River Basin needs to be revised. *Neodiaptomus songkhramensis* was originally described from the Sakon Nakhon, Udon Thani, and Nakhon Phanom provinces within the Songkhram River Basin, and was later found in Ubon Ratchathani Province (Sanoamuang and Athibai 2002; Wansuang 2004). Although it appears to have a wide distribution, it is uncommon to find. Based on other research projects, it has not been found in Nakhon Phanom Province for at least the past three years (Watiroyram, personal communication). *Phyllodiaptomus christineae* was originally described from the Chao Phraya River (Central Thailand) and Mun River (Northeast Thailand) basins. It was later found in the Mun River Basin by Lekchan (2003) and Wansuang (2004). However, based on photographic evidence of the male fifth leg, it appears that the specimens should be identified as *P. parachristineae* (Figure 55 in Lekchan (2003); Figure 75 in Wansuang (2004); Figure 6 in Sanoamuang and Watiroyram (2023)). *Phyllodiaptomus parachristineae* is most similar to *P. christineae*, which likely led to the species being identified as *P. christineae* in prior research conducted before 2023.

The occurrence data presented here extends the previously recorded geographic range of several species. *Mongolodiaptomus loeiensis* is an uncommon species, initially described by the second author from a single locality in Loei Province. It was collected from another locality in Nong Khai Province during the present study and remains endemic to the Mekong River Basin in Thailand. *Mongolodiaptomus mekongnensis* was initially known only from the Mun River Basin, extending downstream to Laos, Cambodia, and Vietnam. However, it has now been found extending upstream to the Songkhram River Basin. Similarly, *M. pectinidactylus*, an uncommon species previously reported in Roi Et and Ubon Ratchathani provinces within the Mun River Basin (Sanoamuang 2002), was found to have extended its distribution to Sakon Nakhon and Nakhon Phanom provinces within the Songkhram River Basin in the present study. *Phyllodiaptomus parachristineae* is a fairly common species in the Mun River Basin and Cambodia and has now also been observed in the Songkhram River Basin. *Phyllodiaptomus thailandicus* which was previously reported only outside the northeastern region, specifically in the eastern and southern Thailand, was observed in the present study at several sites in the Mekong and Songkhram River Basins. This species is now considered fairly common and remains endemic to Thailand. Lastly, *Tropodiaptomus megahyaline*, an uncommon species initially recorded in Bueng Kan Province in the Songkhram River Basin, is now found to extend as far as Nong Khai Province in the Mekong River Basin.

Most cyclopoid copepods in epigean habitats have been reported from the northeastern part of the country due to the fact that the collection effort was the greatest in this region of Thailand (Sanoamuang 1999; Alekseev and Sanoamuang 2006). However, research on cyclopoid copepods in this region has been sporadic and irregular, and many species still present taxonomic problems compared to calanoid copepods. Therefore, only the successfully identified species are counted and discussed in this study. The studies by Sanoamuang (1999) and Alekseev and Sanoamuang (2006) are the most frequently cited publications on cyclopoid diversity in the country, and most of the samples in these studies were collected from the tributaries of the Mekong River Basin. Sanoamuang (1999) reported 13 species, and Alekseev and Sanoamuang (2006) later reported 24 species. This was the most recent fieldwork on cyclopoid copepods in the study area that has been published, although some new species have been sporadically reported (Saetang et al. 2021, et al. 2024; Saetang and Maiphae 2023). Among the 42 recorded species, 37 were found in the Mekong River Basin, and 20 of them were identified in the present study (Table 3).

Cyclopoid copepods are more widely distributed than calanoid species when comparing their ranges in Tables 1 and 2, which contrasts with those found in subterranean waters. Cyclopoid dispersal generally occurs across different zoogeographical regions, whereas calanoid copepods are typically confined to a single region. Thus, their distribution is less useful in species identification. *Microcyclops karvei* was first reported from a pond in Khon Kaen Province and a lake in Sakon Nakhon Province by Alekseev and Sanoamuang (2006), but only two females were collected, which led to its uncertain status at the time. The species shows considerable geographic variation in the morphological features, also manifested in the

segmentation of antennule in female. In the present study, it was identified as *M. karvei* according to the recent taxonomy.

Mesocyclops woutersi and *M. pachyspina* were reported for the first time in the country, but both exhibit some variation across different populations. *Microcyclops pachyspina* from Thailand has a slightly longer inner apical spine on the P4 Enp-2 in female compared to both the segment bearing it and the outer apical spine. Regarding the nine biometric characters proposed by Mirabdullayev and Mirzambetov (2024), only the length of the apical spine of the P4 Enp-2 in female shows a significant difference in the Thai population, but this is likely a variation or could indicate a subspecies-level differentiation. However, more data on the biometric characteristics for the Thai samples are required. *Mesocyclops woutersi* was originally described from Papua New Guinea in 1987 and later redescribed by Hołyńska (2000), et al. (2003), and Dela Paz et al. (2016), but microcharacter on the body surface was lacking. Therefore, the presence of tiny spinules on caudal ramus is new observation for the species.

Table 3. List of freshwater cyclopoid copepods in the tributaries of the Mekong River Basin of Thailand in comparison to the overall species found in country

Species	Northeastern Thailand (Mekong River Basin)			Other reports from outside the study area
	Sanoamuang (1999)[1]	Alekseev and Sanoamuang (2006)[2]	The present study[3]	
Afrocyclops henrii[*]				Alekseev and Sanoamuang (2006)
Cyptocyclops bicolor	●		●	Bricker et al. (1978)
Cyptocyclops linjanticus		●		
Diacyclops nanus[*]				Boonsom (1984)
Eucyclops arcanus		●		
Eucyclops euacanthus		●		
Eucyclops microdenticulatus		●		
Eucyclops pacificus		●		
Eucyclops serrulatus	●	●		
Ectocyclops phaleratus	●			
Ectocyclops polyspinosus			●	Alekseev and Sanoamuang (2006)
Ectocyclops rubescens	●			
Tropocyclops confinis		●		
Tropocyclops prasinus	●	●		Bricker et al. (1978)
Tropocyclops tenellus		●		
Macrocyclops albidus[*]				Alekseev and Sanoamuang (2006)
Macrocyclops fuscus		●		
Macrocyclops neuter[*]				Alekseev and Sanoamuang (2006)
Mesocyclops affinis		●	●	
Mesocyclops aspericornis	●	●	●	
Mesocyclops ferjemurami			●	Sanoamuang (2002)
Mesocyclops kayi			●	
Mesocyclops ogunnus		●	●	
Mesocyclops pehpeiensis[*]				Alekseev and Sanoamuang (2006)
Mesocyclops splendidus	●			
Mesocyclops thermocyclopoides	●	●	●	
Mesocyclops woutersi			●	
Microcyclops karvei		●	●	
Microcyclops pachyspina			●	
Microcyclops rubellus		●	●	
Microcyclops varicans	●	●		Bricker et al. (1978)
Paracyclops affinis		●	●	
Paracyclops fimbriatus	●			Boonsom (1984)
Paracyclops vagus		●		
Thermocyclops crassus	●		●	Boonsom (1984)
Thermocyclops decipiens	●	●	●	
Thermocyclops maheensis		●	●	
Thermocyclops oryzae			●	
Thermocyclops rylovi		●	●	
Thermocyclops taihokuensis	●	●		
Thermocyclops vermifer			●	Maiphae et al. (2023)
Thermocyclops wolterecki		●	●	
Total	13	24	20	

Note: 1: Approximately 250 samples from 120 sites (90% of the samples were collected from northeastern Thailand); 2: 20 sites (14 sites were located in northeastern Thailand); 3: All 480 samples were collected from the Mekong River Basin; ●: Presence of the species; *: Species not found in the Mekong River Basin

Although the number of species identified in this study is lower than the total species accumulation in the region (20 species out of 37 species in the Mekong River Basin, see Table 3), one species new to science (*T. oryzae*) and two cyclopid species (*M. woutersi* and *M. pachyspina*) were recorded as new for the country, having been discovered during the study (Saetang et al. 2024; present study). This is due to the limited number of samples and incomplete coverage of the region. In addition, a poor understanding of the taxonomy and geographic variation of the morphological traits, especially in species of Cyclopidae hinders faunistic studies in the country. Nowadays, microcharacters such as the ornamentation of the antenna, mouthparts, and protopod of the swimming legs are essential for species classification and identification in some genera but have often been neglected in older publications. Therefore, more fieldwork in the region is required to verify species and revise species diversity, which is beneficial for biodiversity monitoring.

In conclusion, this study provides an overview of the species composition of copepods in the tributaries of the lower Mekong River Basin in Thailand, focusing on three river basins that directly join the Mekong River. Field studies have been lacking over the past decade, but copepod communities continue to change over time due to human activities and climate change. New knowledge was gained from field studies conducted between 2020 and 2023, including the discovery of a new species and newly recorded species at both the national and regional levels. However, many species were not observed, especially the previously mentioned calanoids, which are easier to compare in terms of species richness than cyclopoids, which have a poor taxonomic background. Additional field sampling with expanded coverage of the Mekong River Basin is needed for future studies. In terms of taxonomy, morphological differences among cyclopoid species reflect variations among different populations, which are of interest. Microcharacters and morphometric data of cyclopoid copepods have been increasingly used in recent studies, whereas they were not provided in the older species descriptions. A full description of species should first be completed before the diversity and distribution in the area can be accurately recognized.

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REFERENCES

Alekseev VR, Chaban O. 2021. New records of continental cyclopids (Crustacea: Copepoda: Cyclopiformes) from Eastern Siberia and Russian Far East. Arthropoda Sel 30 (4): 503-520. DOI: 10.15298/arthsel.30.4.06.

Alekseev VR, Haffner DG, Vaillant JJ, Yusoff FM. 2013. Cyclopoid and calanoid copepod biodiversity in Indonesia. J Limnol 72 (s2): 245-274. DOI: 10.4081/jlimnol.2013.s2.e12.

Alekseev VR, Sanoamuang L. 2006. Biodiversity of cyclopoid copepods in Thailand with a description of *Afrocyclops henrii* sp. n. Arthropoda Sel 15 (4): 277-290.

Alekseev VR, Yusoff FM, Fefilova EB. 2016. Continental copepod biodiversity in North-Eastern Borneo, Malaysia. Arthropoda Sel 25 (2): 183-197. DOI: 10.15298/arthsel.25.2.05.

Areerachakul N, Prongnuch S, Longsomboon P, Kandasamy J. 2022. Quantitative Precipitation Estimation (QPE) rainfall from meteorology radar over Chi Basin. Hydrology 9 (10): 1-8. DOI: 10.3390/hydrology9100178.

Boonmak P, Sanoamuang L. 2022. Diversity of freshwater calanoid copepods (Crustacea: Copepoda: Calanoida) in southern Vietnam with an updated checklist for the country. Diversity 14 (7): 523. DOI: 10.3390/d14070523.

Boonsom J. 1984. The freshwater zooplankton of Thailand (Rotifera and Crustacea). Hydrobiologia 113: 223-229. DOI: 10.1007/BF00026610.

Bricker KS, Wongrat L, Gannon JE. 1978. Composition and distribution of crustacean plankton in twelve inland water bodies of Thailand. J Fish Environ 10: 1-14.

Campbell LM, MacLeod K, Fugere V, Cabana G, Witty L, Morissette O. 2024. First records of non-indigenous cyclopoid copepod *Thermocyclops crassus* (Fischer, 1853) in Eastern Canada. BioInvasions Rec 13 (1): 161-170. DOI: 10.3391/bir.2024.13.1.14.

Chaicharoen R, Sanoamuang L, Hołyńska M. 2011. A review of the genus *Thermocyclops* (Crustacea: Copepoda: Cyclopoida) in Cambodia. Zool Stud 50 (6): 780-803.

Chaicharoen R, Sanoamuang L. 2022. Distribution and diversity of diaptomid copepods in freshwater habitats of Cambodia (Crustacea: Copepoda: Calanoida: Diaptomidae). Diversity 14 (11): 1-16. DOI: 10.3390/d14110903.

Chang YC. 2013. Invertebrate Fauna of Korea. National Institute of Biological Resources, Ministry of Environment, Korea.

Dela Paz ES, Hołyńska M, Papa RDS. 2016. *Mesocyclops* and *Thermocyclops* (Copepoda, Cyclopidae) in the major Visayas Islands (central Philippines). Crustaceana 89: 787-809. DOI: 10.1163/15685403-00003547.

Dussart B, Defaye D. 2006. World Directory of Crustacea Copepoda of Inland Waters, Volume 2: Cyclopiformes. Backhuys Publishers, Leiden.

Fuentes-Reinés JM, Suárez-Morales E, Granados-Martínez CE. 2017. First occurrence of *Mesocyclops aspericornis* (Daday, 1906) (Copepoda: Cyclopoida) in northern Colombia. Check List 13 (2): 1-6. DOI: 10.15560/13.2.2076.

Gutiérrez-Aguirre MA, Cervantes-Martínez A. 2016. Taxonomic evaluation of eleven species of *Microcyclops* Claus, 1893 (Copepoda, Cyclopoida) and description of *Microcyclops inarmatus* sp. n. from America. ZooKeys 603: 33-69. DOI: 10.3897/zookeys.603.7480.

Gutiérrez-Aguirre MA, Suárez-Morales E, Silva-Briano M. 2002. The Afro-Asian *Mesocyclops aspericornis* (Daday) (Copepoda, Cyclopidae) in Mexico: Comments on morphology and distribution. Crustaceana 75 (11): 1349-1361. DOI: 10.1163/156854002321629781.

Hołyńska M, Brown M. 2003. Three new species of *Mesocyclops* GO Sars, 1914 (Copepoda, Cyclopoida) from Australia and Burma, with comments on the *Mesocyclops* fauna of Australia. Crustaceana 75: 1301-1334. DOI: 10.1163/156854002321629763.

Hołyńska M, Nam VS. 2000. A new oriental species of *Mesocyclops* (Copepoda: Cyclopidae). Hydrobiologia 429 (1): 197-206. DOI: 10.1023/A:1004018631265.

Hołyńska M, Reid JW, Ueda H. 2003. Genus *Mesocyclops* Sars, 1914. In: Ueda H, Reid JW, Dumont HJF (eds). Copepoda: Cyclopoida Genera *Mesocyclops* and *Thermocyclops*, Guides to the Identification of the Microinvertebrates of the Continental Waters of the World. Backhuys Publishers, Leiden, The Netherland.

Hołyńska M, Stoch F. 2013. *Mesocyclops* (Crustacea, Copepoda, Cyclopidae) in the South Pacific Islands. Zool Anz 251 (3): 237-252. DOI: 10.1016/j.jcz.2011.09.004.

Hołyńska M. 2000. Revision of the Australasian species of the genus *Mesocyclops* Sars,1914 (Copepoda: Cyclopidae). Annal Zool 50 (3): 363-447.

Hołyńska M. 2006. On species of the genus *Thermocyclops* (Copepoda: Cyclopoidae) occurring in northern Queensland, Australia. Annal Zool 56 (2): 335-367.

Huys R, Boxshall GA. 1991. Copepod Evolution. The Ray Society, London.

Kiefer F, Moorthy VN. 1935. Eine neue Art der Gattung *Cyclops* (Crustacea, Copepoda) aus Indien. Zool Anz 111: 220-222.

Lekchan S. 2003. Distribution of Fairy Shrimps and Zooplankton in Temporary Waters in Changwat Maha Sarakham and changwat Roi Et Provinces. [Dissertation]. Khon Kaen University, Khon Kaen. [Thai]

Lindberg K. 1937. Trois Cyclopides (Crustacés Copépodes) nouveaux de l'Inde. Rec Indian Mus 39 (2): 99-103. DOI: 10.26515/rzsi/v39/i2/1937/162291.

Maiphae S, Saetang T, Jantawong N, Wongkamhaeng K, Piyasaengthong N. 2023. Diversity of zooplankton in the rice fields in Suphan Buri Province, Thailand, with a new record of cyclopoid copepod. Diversity 15 (10): 1054. DOI: 10.3390/d15101054.

Mekong River Commission. 2024. Mekong Basin. www.mrcmekong.org/about/mekong-basin.

Mirabdullayev IM, Mirzambetov AN. 2024. On morphology and taxonomy of *Microcyclops pachyspina* (Lindberg, 1937) (Crustacea: Copepoda: Cyclopidae), and the genus *Microcyclops* Claus, 1893 in Central Asia. Munis Entomol Zool 19 (1): 120-126.

Mirabdullayev IM, Urazova RS. 2006. Redescription of the female and first description of the male of *Microcyclops karvei* (Kiefer & Moorthy, 1935) (Copepoda, Cyclopoida). Zool Middle East 38: 57-62. DOI: 10.1080/09397140.2006.10638165.

Paz ESPD, Hołyńska M, Papa RD. 2016. *Mesocyclops* and *Thermocyclops* (Copepoda, Cyclopidae) in the major Visayas Islands (central Philippines). Crustaceana 89 (6-7): 787-809. DOI: 10.1163/15685403-00003547.

Polpanich O-U, Bhatpuria D, Santos TF, Krittasudthacheewa C. 2022. Leveraging multi-source data and digital technology to support the monitoring of localized water changes in the Mekong region. Sustainability 14 (3): 1739. DOI: 10.3390/su14031739.

Prabnakorn S, Ruangpan L, Tangdamrongsub N, Suryadi F, Fraiture C. 2021. Improving flood and drought management in agricultural river basins: An application to the Mun River Basin in Thailand. Water Policy 23 (5): 1153-1169. DOI: 10.2166/wp.2021.011.

Reddy RY, L. Sanoamuang & H. J. Dumont, 1998. A note onthe Diaptomidae of Thailand, including redescription of threespecies and description of a new species (Copepoda, Calanoida). Hydrobiologia 361: 201–223.

Reddy RY, Sanoamuang L, Dumont HJ. 2000. Amended delimitation of *Mongolodiaptomus* against *Neodiaptomus* and *Allodiaptomus* and redescription of the little known *Mongolodiaptomus uenoi* (Kikuchi, 1936) from Thailand (Copepoda: Calanoida: Diaptomidae). Hydrobiologia 418: 99-109. DOI: 10.1023/A:1003859908612.

Reid JW. 1998. How "cosmopolitan" are the continental cyclopoid copepods? Comparison of North American and Eurasian faunas, with description of *Acanthocyclops parasensitivus* sp. n. (Copepoda: Cyclopoida) from the U.S.A. Zool Anz 236: 109-118.

Saetang T, Koompoot K, Watiroyram S, Maiphae S. 2024. A new species of *Thermocyclops* Kiefer, 1927 (Crustacea, Copepoda, Cyclopoida, Cyclopidae) from temporary habitats, with a discussion on the diversity and distribution of the genus in Thailand. Zoosyst Evol 100 (4): 1211-1230. DOI: 10.3897/zse.100.129089.

Saetang T, Maiphae S. 2023. Diversity of the genus *Tropodiaptomus* Kiefer, 1932 (Crustacea, Copepoda, Calanoida, Diaptomidae) in Thailand, with the description of two new species. Zoosyst Evol 99 (2): 399-422. DOI: 10.3897/zse.99.105511.

Saetang T, Sanoamuang L, Maiphae S. 2021. A new species of genus *Tropodiaptomus* Kiefer, 1932 (Crustacea: Copepoda: Calanoida: Diaptomidae) from Thailand. J Nat Hist 54: 2297-2322. DOI: 10.1080/00222933.2020.1843726.

Sanoamuang L, Athibai S. 2002. A new species of *Neodiaptomus* (Copepoda, Diaptomidae) from temporary waters in northeast Thailand. Hydrobiologia 489: 71-82. DOI: 10.1023/A:1023202519395.

Sanoamuang L, Dabseepai P. 2021. Diversity, distribution and habitat occurrence of the diaptomid copepods (Crustacea: Copepoda: Diaptomidae) in freshwater ecosystems of Thailand. Water 13 (17): 2381. DOI: 10.3390/w13172381.

Sanoamuang L, Watiroyram S. 2018. *Mongolodiaptomus mekongensis*, a new species of copepod (Copepoda, Calanoida, Diaptomidae) from temporary waters in the floodplain of the lower Mekong River Basin. Raffles Bull Zool 66: 782-796.

Sanoamuang L, Watiroyram S. 2020. *Phyllodiaptomus* (*Phyllodiaptomus*) *roietensis*, a new diaptomid copepod (Copepoda, Calanoida) from temporary waters in Thailand and Cambodia, with a key to the species. Zookeys 911: 1-20. DOI: 10.3897/zookeys.911.38496.

Sanoamuang L, Watiroyram S. 2021. A new species of copepod (Copepoda: Calanoida) from the floodplain of the lower Mekong River Basin in Thailand and Cambodia, with an amended diagnosis of the genus *Dentodiaptomus* Shen & Tai, 1964. Raffles Bull Zool 69: 414-427.

Sanoamuang L, Watiroyram S. 2023. *Phyllodiaptomus parachristineae*, a new species of copepod (Copepoda, Calanoida, Diaptomidae) from the floodplain of the lower Mekong River Basin in Thailand and Cambodia. ZooKeys 1168: 403-424. DOI: 10.3897/zookeys.1168.104636.

Sanoamuang L. 1999. Species composition and distribution of freshwater Calanoida and Cyclopoida (Copepoda) of north-east Thailand. In: Schram FR, Klein JVC (eds). Crustaceans and Biodiversity Crisis. Brill Academic Publishers, Leiden. DOI: 10.1163/9789004630543_018.

Sanoamuang L. 2002. Freshwater Zooplankton: Calanoid Copepods in Thailand. Klangnanatham Publishers, Khon Kaen.

Shrestha S, Bhatta B, Talchabhadel R, Virdis SGP. 2018. Integrated assessment of the landuse change and climate change impacts on the sediment yield in the Songkhram River Basin, Thailand. Sci Total Environ 263: 1610-1622. DOI: 10.1016/j.catena.2021.105859.

Sor R, Ngor PB, Lek S, Chann K, Khoeun R, Chandra S, Hogan ZS, Sarah E, Null SE. 2023. Fish biodiversity declines with dam development in the Lower Mekong Basin. Sci Rep 13: 8571. DOI: 10.1038/s41598-023-35665-9.

Suárez-Morales E, Mercado-Salas NF, Morales-Ramírez A. 2011. Morphological variability and distribution of the exotic Asian *Mesocyclops thermocyclopoides* (Copepoda: Cyclopoida) in the Neotropical region. Zoologia 28 (5): 673-679. DOI: 10.1590/S1984-46702011000500016.

Tran DL, Dang NT, Ho TH. 2020. The freshwater copepod genus *Mesocyclops* (Copepoda, Cyclopoida, Cyclopidae) in Vietnam. Acad J Biol 42 (4): 1-16. DOI: 10.15625/2615-9023/v42n4.15310.

Tran DL, Hołyńska M. 2015. A new *Mesocyclops* with archaic morphology from a karstic cave in Central Vietnam, and its implications for the basal relationships within the genus. Ann Zool 65 (4): 661-686. DOI: 10.3161/00034541ANZ2015.65.4.010.

Tungpunyaporn P. 2003. Distribution of Fairy Shrimps and Zooplankton in Temporary Waters in Sakhon Nakhon and Nakhon Phanom Provinces. [Dissertation]. Khon Kaen University, Khon Kaen. [Thai]

Van de Velde I. 1987. New *Mesocyclops* species (Copepoda, Cyclopidae) from Papua New Guinea. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Biologie 57: 149-162.

Wansuang P. 2004. Species Diversity of Rotifers, Cladocerans and Copepods in Temporary Waters in Ubon Ratchathani Province. [Dissertation]. Khon Kaen University, Khon Kaen. [Thai]

Watiroyram S, Sanoamuang L. 2017. A new species of *Mongolodiaptomus* Kiefer, 1938 from northeast Thailand and a key to the species (Crustacea: Copepoda, Calanoida, Diaptomidae). Zookeys 710: 15-32. DOI: 10.3897/zookeys.710.13941.

Watiroyram S. 2021. Cave-dwelling Copepods in Thailand. KKU Printing House, Khon Kean. [Thai]

Watiroyram S. 2024. Spatial and Temporal Distribution of Copepod Communities in the Mekong River Basin of Thailand. [Research Project]. Nakhon Phanom University, Nakhon Phanom. [Thai]