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THESIS

TAXONOMIC REVIEW OF THE CYPRINID FISH GENUS *BARILIUS* HAMILTON, 1822 FROM INDOCHINA (CYPRINIFORMES: CYPRINIDAE)

ANURATANA TEJAVEJ

A Thesis Submitted in Partial Fullfillment of
the Requirements for the Degree of
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Anuratana Tejavej 2010: Taxonomic Review of the Cyprinid Fish Genus *Barilius* Hamilton, 1822 from Indochina (Cypriniformes : Cyprinidae). Master of Science (Fisheries Science), Major Field: Fisheries Science, Department of Fishery Biology. Thesis Advisor: Assistant Professor. Prachya Musikasinthorn, Ph.D.
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The barred cyprinid fish of the genus *Barilius* (Cypriniformes : Cyprinidae) is widely distributed in running waters from Pakistan through India to Indochina. With 16 nominal species the taxonomic status of *Barilius* species in Indochina is problematic. In this review 6 Indochinese species of *Barilius* are recognized: *Barilius bernatziki*, *B. dogarsinghi*, *B. koratensis*, *B. pulchellus*, *B. ornatus*, and *B.* sp. (undescribed species). Of all Indochinese species 2 groups can be differentiated using dorsal fin color pattern *B. pulchellus* and *B.* sp. have dorsal fin with dark pigment concentrated on intermembrane region forming blotch, but *B. pulchellus* has dorsal fin origin further backwards and has more lateral line scales and total vertebrate than *B.* sp.. For species without blotch on intermembrane region *B. dogarsinghi* has strong submarginal dorsal fin band and vertically elongated caudal blotch followed by clear to light patch. *B. bernatziki*, *B. koratensis*, and *B. ornatus* have dorsal fin with dark pigment concentrating mainly at the edge of fin rays not forming blotch. Of these 3 species *B. ornatus* has more total vertebrae and lateral line scales than either *B. bernatziki* or *B. koratensis*. *B. bernatziki* has large and wide caudal blotch and short rostral barbels while *B. koratensis* has no or tiny caudal spot and long rostral barbels. *Barilius huahinensis*, *B. nanensis*, and *Danio ponticulus* are synonyms of *B. koratensis*, while *Barilius barnoides*, *B. infrafasciatus*, *B. caudiocellatus*, and *Danio monshiensis* are synonyms of *B. ornatus*, and *Barilius buddhae*, *Barilius pellegrini*, *Paradaniops macropterus*, and *Daniops nammuensis* are synonyms of *B. pulchellus*.

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Anuratana Tejavej

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INTRODUCTION

The cyprinid of the genus *Barilius* Hamilton, 1822 are generally recognized by their relatively elongate, compressed body with round belly, vertical bars on the body side, 9-17 total anal fin rays, lateral line along the lower part of the body, dorsal profile less convex than ventral profile, absence of danioin notch, and the lack of pigmented, wide horizontal stripe (Hamilton, 1822; Günther, 1868; Day, 1878; Hora, 1921; Smith, 1931, 1945; Koumans, 1937; Kaewpaitoon, 1979; Howes, 1980; Chu, 1984; Kottelat , 1984, 2001a; Talwar and Jhingran, 1991; He and Chen, 1994; Fang, 2001). They are one of the dominant small fishes in the hillstreams and upper rivers over vast area from Pakistan and India eastward to Myanmar and Indochina with 56 nominal species, which 16 are in Indochina (Hamilton, 1822; Günther, 1868; Day, 1878; Hora, 1921; Smith, 1931, 1945; Howes, 1980; Chu, 1984; Kottelat, 1984, 2001a; Talwar and Jhingran, 1991; He and Chen, 1994; Coad, 2010; Vishwanath and Manojkumar, 2002; Mirza, Rafiq, and Awan, 1986; Arunkumar and Singh, 2000; Tilak and Husain, 1990; Selim and Vishwanath, 2002; Roberts, 1989; Eschmeyer *et al.*, 2004). Males of many species are colorful and had tubercles on various body parts (Fowler, 1934a; Talwar and Jhingran, 1991). Most *Barilius* species are generally found in clean and clear mountain streams, but some species live in rivers as well (Smith, 1945; Talwar and Jhingran, 1991).

Even though the first *Barilius* species from Southeast Asia was described in 1883 the taxonomic status of 16 nominal species of *Barilius* in Southeast Asia including Thailand is still problematic. For example many authors still have different opinions about the actual number of valid *Barilius* species found in Thailand (from 3 to 8 species) and which species were synonym with others (Smith, 1945; Kaewpaitoon, 1979; Howes, 1983; Kottelat, 1984; Vidthayanon *et al.*, 1997). In

Thailand species from the the Salween, Maeklong, lower part of Chao Phraya basins and in the South were insufficiently sampled and taxonomic description of species from these areas were usually from sampling from one location with few specimens, such as *Barilius bernatziki* and *B. koratensis* with only one specimens available each (Koumans, 1937; Smith, 1931). These led to descriptions of species based on one or few specimens that might be slightly different from specimens from other locations such as number of barbels and vertical bars as seen in Smith (1931, 1945) and Fowler (1934a, 1934b). As pointed out by Kaewpaitoon (1979), *Barilius* characters such as bars and barbels are highly variable, and specimens with unequal number of bars and barbels on either side of the body are common. Furthermore, in most *Barilius* species many of meristic and morphometric characters are overlapped. On the other hand other authors combined species from different locations (and even different basins) into single species using few specimens from some locations (Kaewpaitoon, 1979). These problems lead to the acceptance of some species such as *Barilius bernartziki* or *B. ornatus* as valid species by some authors (Howes, 1983; Kottelat, 1984) and as species of doubtful status or synonyms of other species by other authors (Kaewpaitoon, 1979, Chu, 1984).

Since *Barilius* species have many variable characters such as color and tubercles that may change with age, season and sex, it might be necessary to collect fresh specimens of both sexes, various sizes and during different stages of spawning readiness and to record, in addition to morphometric and meristic characters, their color, color pattern and tubercle pattern in order to have a complete picture of each species. Comparision of these recorded data with that of original descriptions and type specimens would help solving the taxonomic confusion of Indochinese *Barilius* species and to define the actual number of valid species and their geographic distribution for future use and management.

OBJECTIVES

1. To reorganize and describe valid species of *Barilius* native to Thailand (and some other regions in Indochina as feasible).

2. To determine geographical distribution of *Barilius* species in Thailand (and some other regions in Indochina as feasible).

LITERATURE REVIEW

Review of nominal species of *Barilius* in Indochina

The generic name *Barilius* was elevated from a subgenus status by Bleeker in 1863 of cyprinids of the genus *Cyprinus* that was created by Hamilton in 1822. The type species is *Barilius barila* (formerly *Cyprinus barila* Hamilton, 1822). Hamilton had previously described a cyprinid that was later included into the genus *Barilius* in 1807 as *Cyprinus bendelisis* (now *Barilius bendelisis*). Hamilton included in *Barilius* cyprinids with very long and highly compressed body, body side with numerous rows of incomplete transverse bars or spots, dorsal fin position considerably behind the middle of the body, and lateral line running along the lower half of the body.

Günther (1868) used the generic name *Barilius* for many cyprinids from India and Africa. This genus was redefined by Howes's anatomical and systematic studies published in 1980 and 1983. Howes removed all *Barilius* species from Africa, *Barilius bola*, and *B. guttatus* from Asia out of the genus *Barilius*. According to Howes the generic name *Barilius* was restricted to species from South and Southeast Asia excluding *B. bola* and *B. guttatus* (which became *Raiamas bola* and *Raiamas guttatus*). Talwar and Jhingran (1991) and Rainboth (1996) differentiated *Raiamas* from *Barilius* by the deeper mouth of *Raiamas* (whose end of maxilla surpasses the vertical line from eye). Howes also removed *Barilius auropurpureus* Annandale, 1918 from Lake Inle, Myanmar from *Barilius*, and later placed it in the new genus *Inlecypris*, which has prominent ventral keel. Kaewpaitoon (1979) stated that *Barilius* can be differentiated from *Luciosoma* by having more branched anal fin rays (6 or less in *Luciosoma*). Howes (1983) also stated that the genus *Barilius* itself was polyphyletic and should be separated into 2 groups based on differences on characters such as pectoral and pelvic axial scales (axillary processes), tubercles, and color patterns. Later in 1991 he modified his definition of the two *Barilius* groups. The first group of *Barilius* was characterized by the straight, forwardly directed arms of the mesethmoid and expanded (often modified) lateral processes of the 1st vertebra. Howes's second group of *Barilius* composed of species from South and Southeast

Asia that had parallel rows of tubercles on the lower jaw and distinctive body stripes, and sometimes well-marked sexual dimorphism in color pattern and anal fin shape (Howes, 1991). Also following Howes in the same publication in 1991 Rainboth proposed the generic name *Opsarius* created by McClelland in 1839 to replace the generic name *Barilius* for Howes's second group of *Barilius*. The generic name *Opsarius* was subsequently used by some authors (Rainboth, 1996; Kottelat 1998, 2001a, 2001b; Vidthayanon et al, 1997) but not by others (Talwar and Jhingran, 1991; Zhu, 1995; Doi, 1997; Fang, 1999, 2001). The concept of two groups of *Barilius* itself was not yet followed by many authors such as Talwar and Jhingran (1991).

The first *Barilius* species that was described from specimens collected in Southeast Asia was *Barilius ornatus*. It was described by Sauvage in 1883 using specimens obtained from Dr. Harmand. Sauvage stated that it was from Me-nam (probably the Chao Phraya River) in Thailand. Soon the second *Barilius* species from Southeast Asia, *Barilius barnoides*, was described by Vinciguerra in 1890 from Cachin in northern Myanmar (in Ayeyarwaddy basin). Boulenger (1893) synonymized *Barilius barnoides* with *Barilius ornatus* with references to specimens collected by E. W. Oates at Fort Stedman, Nampandet, Myanmar but he did not explain the reason. Fowler (1958) subsequently replaced Boulenger's *B. ornatus* with the replacement name *Barilius shanensis*. Since Boulenger (1893) gave no reason for making *B. barnoides* junior synonym of *B. ornatus* the replacement is not valid, then Fowler's *B. shanensis* is not available and has to be regarded as a junior synonym of *B. barnoides*. Mukerji (1934) included this species with *B. barila* since he stated that morphometric characters and meristic counts of *B. barnoides* was within range of *B. barila* in Francis Day's collections and the paratype of *B. barnoides* did have barbels (Vinciguerra in 1890 indicated that *B. barnoides* had no barbels) and the infraorbital bones were varied depending on each individual fish and cannot be used as diagnostic character for *B. barnoides*. This treatment was followed by Chinese authors such as Chu (1984) but more recent works from India (such as Talwar and Jhingran, 1991) treated *B. barnoides* as a separate species from *B. barila* by characters such as body depth (3 - 3.3 times in standard length (SL) in B. *barnoides*, 4.6 - 4.8 times in SL in *B. barila*). Kottelat (1984) also pointed out that according to Sen (1976) *B. barila* had

43 -46 lateral line scales while examined specimens of *B. barnoides* (not type specimens) had 39 - 41 lateral line scales. By differences in eye size, caudal peduncle length, prepelvic length, and preanal length he considered *B. barnoides* to be a different species from *B. ornatus*.

Another *Barilius* species, *Barilius barna*, was also reported from Meekalan, Myanmar by Vinciguerra (1890). It was originally described by Hamilton in 1822 (as *Cyprinus barna*) from Yamuna and Brahmaputra rivers in India. According to Hamilton (1822) it was differentiate from other *Barilius* species by having small scales and horizontal golden stripe on the body side. The horizontal stripe was not mentioned in Day's description of *B. barna* (Day, 1878) and later publications (Talwar and Jhingran, 1991). Hora (1921) described a species of *Barilius* from Naga Hills, India in 1921. *Barilius dogarsinghi* Hora was discovered from Etok stream near Chanderkhong, Naga Hills which flew into headwaters of Ayeyarwaddy River in Myanmar.

In 1930s and 1940s many more *Barilius* species from Thailand and South China were described. Smith in 1931 described *B. pulchellus* from Mekang, Chiangmai and *B. koratensis* from Ta Chang, Korat and *B. nanensis* from Nan River and *Danio ponticulus* (later classified in genus Barilius) from Chiangmai in 1945. Fowler in 1934 described *B. buddhae* from Chiangdao, Chiangmai and *B. infrafasciatus* from Maetaeng, Chiangmai and in 1937 *B. huahinensis* from Ban Thung Luang, Hua Hin. *B. bernartziki* from Kapa, north of Phuket was described by Koumans in 1937. *B. pellegrini* was described by Fang in 1938 from Szemao in Mekong basin in Southern China.

In 1960s a few *Daniops* and *Danio* species were described from northern Vietnam and southern China. They were later proved to be previously described *Barilius* species (mostly *B. pulchellus*) by comparing their characters with existing species (Chu, 1984; Kottelat, 2001). They were *Danio monshiensis* Yang & Hwang, 1964 from Yunnan, China; *Paradaniops macropterus* Nyugun & Doan, 1969 from Sinh Ho, Lai Chau Province, Vietnam; and *Daniops nammuensis* Nyugen & Doan,

1969 from Nam Mu stream, Phong Tho District, Lai Chau Province, Vietnam. Both Vietnamese species were redescribed by Mai in 1978.

In the systematic study of Thai *Barilius* by Kaewpaitoon in 1979 *Barilius infrafasciatus* and *B. buddhae* were synonymized with *B. pulchellus* based on similarity in meristic characters on both type specimens and other samples. *B. huahinensis*, *B. nanensis*, and *Danio ponticulus* were synonymized with *B. koratensis* by similar reasons. The status of *B. ornatus* and *B. bernartziki* were left unresolved in this study, though it was mentioned that *B. bernartziki* might be conspecific with *B. koratensis* and *B. ornatus* might be conspecific with *B. infrafasciatus* (which was synonym of *B. pulchellus* in his study). Howes (1983) mentioned that while *B. nanensis*, *B. koratensis*, and *B. huahinensis* have overlapping morphometric and meristic characters, *B. huahinensis* had different body color pattern and number of gill rakers on the 1st ceratobranchial from *B. nanensis*. He discovered barbels on the type specimens of *B. koratensis* (Smith [1931] described *B. koratensis* as having no barbel). Kottelat (1984) followed Smith (1945) decision that *B. buddhae* was conspecific with *B. pulchellus* because of similar characters. He also considered *B. pellegrini* to be conspecific with *B pulchellus* because of overlapped morphometric and meristic characters. He stated that the morphometric and meristic characters of *B. infrafasciatus* and *Danio monshiensis* agreed with *B. barnoides*. In 2001 he turned both *Daniops nammuensis* and *Paradaniops macropterus* into synonym of *Opsarius pulchellus* (Kottelat, 2001). According to him *Daniops nammuensis* was the female and *Paradaniops macropterus* was the male of *Opsarius pulchellus* (Kottelat, 2001).

Barilius caudiocellatus were described by Chu in 1984 from the Salween river basin (Nu Jiang) in Southern China. Vidthayanon *et al.* (1997) reported that there were 5 *Opsarius* species in Thailand: *O. barnoides* in Salween basin, *O. bernartziki* in the South, *O. koratensis* and *O. pulchellus* in Chao Phraya and Mekong basins, and *O. ornatus* in Salween, Chao Phraya and Mekong basins.

Table 1 Nominal species of cyprinid fish genus *Barilius*. * = Indochinese species.

Species	Type Locality
Barilius albunus Günther,1868	Himalayas.
Cyprinus apiatus Valenciennes, 1840	India.
Barilius bakeri Day, 1865	Mundikyum, Cochin, India.
Cyprinus barila Hamilton, 1822	Northern Bengal.
Cyprinus barna Hamilton, 1822	Yamuna and Brahmaputra rivers, India.
Barilius barnoides Vinciguerre, 1890 *	Kachin, Myanmar.
Cyprinus bendelisis Hamilton, 1807	Cedawáti (Vedawati) stream, headwaters of Krishna River near Heriuru, Mysore, India.
Barilius bernartziki Koumans, 1937 *	Kapa, N. W. Peninsular Siam.
Opsarius bicirratus McClelland, 1842	Khyber Pass and Cabul River at Jellalabad (Jalalabad), Afganistan.
Barilius bleekeri Day, 1872	Tributary at Gangrete which joins the Beeas in the Sub-Himalayan range.
Barilius bonarensis Chaudhuri, 1912	Bonar, Gharwal, Uttar Pradesh, western Himalayas, India.
Barilius borneensis Roberts, 1989	Rocky channel in mainstream of Sungai Pinoh, 37 kilometers south of Nangapinoh, Indonesia.
Leuciscus branchiatus McClelland, 1839	Assam and northern parts of Bengal.
Barilius buddhae Fowler, 1934 *	Chieng Dao, Chiangmai, Thailand.
Opsarius canarensis Jerdon, 1849	Canara, southern India.
Barilius caudiocellatus Chu, 1984 *	Mengding, Yunnan, China.
Cyprinus chedra Hamilton, 1822	Northern rivers of Bengal.
Barilius chatricensis Selim and Vishwanath, 2002	Chatrickong River, Manipur, India.
Cyprinus chedrio Hamilton, 1822	Northern Bengal.
Cyprinus cosca Hamilton, 1822	Northern rivers of Bengal and Behar (Bihar), especially the Mahanunda.
Barilius dimorphicus Tilak and Husain, 1990	Song River, easatern Doon Valley, Rajaji National Park, District Dehra Doon, Uttar Pradesh, India.
Barilius dogarsinghi Hora, 1921 *	Etok stream, Naga Hills, India.
Barilius evezardi Day, 1872	Poona (Puna), India.
Barilius infrafasciatus Fowler, 1934 *	Maetaeng River, Chiengmai, Thailand.

Table 1 (Continued)

Species	Type Locality
Leuciscus gatensis Valenciennes, 1844	Mountains of Gates, India.
Barilius howsi Barman, 1986	Stream near Sulkapara, Jalpaiguri District, West Bengal, India.
Barilius huahinensis Fowler, 1937 *	Ban Thung Luang, Prachuabkirikhan, Thailand.
Barilius jarayami Barman, 1985	Namdapha Wildlife Sanctuary, Tirap District, Arunachal Pradesh, India.
Barilius koratensis Smith, 1931 *	Ta Chang, Mun River, Nakorn Ratchasima, Thailand.
Opsarius latipinnatus McClelland,1839	Upper Assam.
Barilius lairokensis Arunkumar and Tombi Singh, 2000	Lairok Maru, Moreh, Chandel district, Manipur, India.
Paradaniops macropterus Hao & Hoa, 1969 *	Sinh Ho, Lai Chau Province, Viet Nam.
Opsarius malabaricus Jerdon, 1849	North Malabar, southern India.
Barilius menoni Sen, 1976	Gomatidhara, Madhepura, Saharsa District, northern Bihar, India.
Barilius mesopotamicus Berg, 1932	Gawi River, Tigris River basin, Iraq.
Barilius modestus Day, 1872	Ravi River at Lahore, Pakistan.
Danio monshiensis Yang and Hwang, 1964 *	Yunnan, China.
Barilius morarensis Günther, 1868	Morar River, Gwalior, India.
Daniops nammuensis Hao & Hoa, 1969 *	Nam Mu, Lai Chau, Vietnam.
Barilius nanensis Smith, 1945 *	Nan River, Thailand.
Barilius nelsoni Barman, 1988	Gumti River, South Tripura District, northeastern India.
Barilius ngawa Vishwanath and Manojkumar, 2002	Manipur River, Manipur, India.
Barilius ornatus Sauvage, 1883 *	Menam, Siam.
Barilius papillatus Day, 1869	Cossye River, Orissa, India.
Barilius pellegrini Fang, 1938 *	Szemao, Yunnan, China.
Opsarius piscatorius McClelland, 1842	Seharanpore, Afganistan.
Danio ponticulus Smith, 1945 *	Chiangmai, Thailand.
Barilius pulchellus Smith, 1931 *	Maeklang at Pang Chao, Chiangmai , Thailand.
Barilius radiolatus Günther, 1868	Malva, Madhya Prodesh, India.

Table 1 (Continued)

Species	Type Locality
Barilius rugosus Day,1867	Bowany and Seegoor rivers, and rapid streams along lower slopes of Neilgherries, India.
Cyprinus shacra Hamilton, 1822	Kosi River, Uttar Pradesh, India.
Barilius shacra naseeri Mirza, Rafiq and Awan, 1986	Nullah Seel near Tehsil Pindi Gheb, 52 kilometers from Attock toward south, Pakistan.
Cyprinus tila Hamilton, 1822	Bengal.
Cyprinus tileo Hamilton, 1822	Kosi River, Uttar Pradesh, India.
Cyprinus vagra Hamilton, 1822	Ganges River about Patua [Patna], India.
Barilius vagra pakistanus Mirza and Sadiq, 1978	Fort Monro, D. G. Khan District, Pakistan.

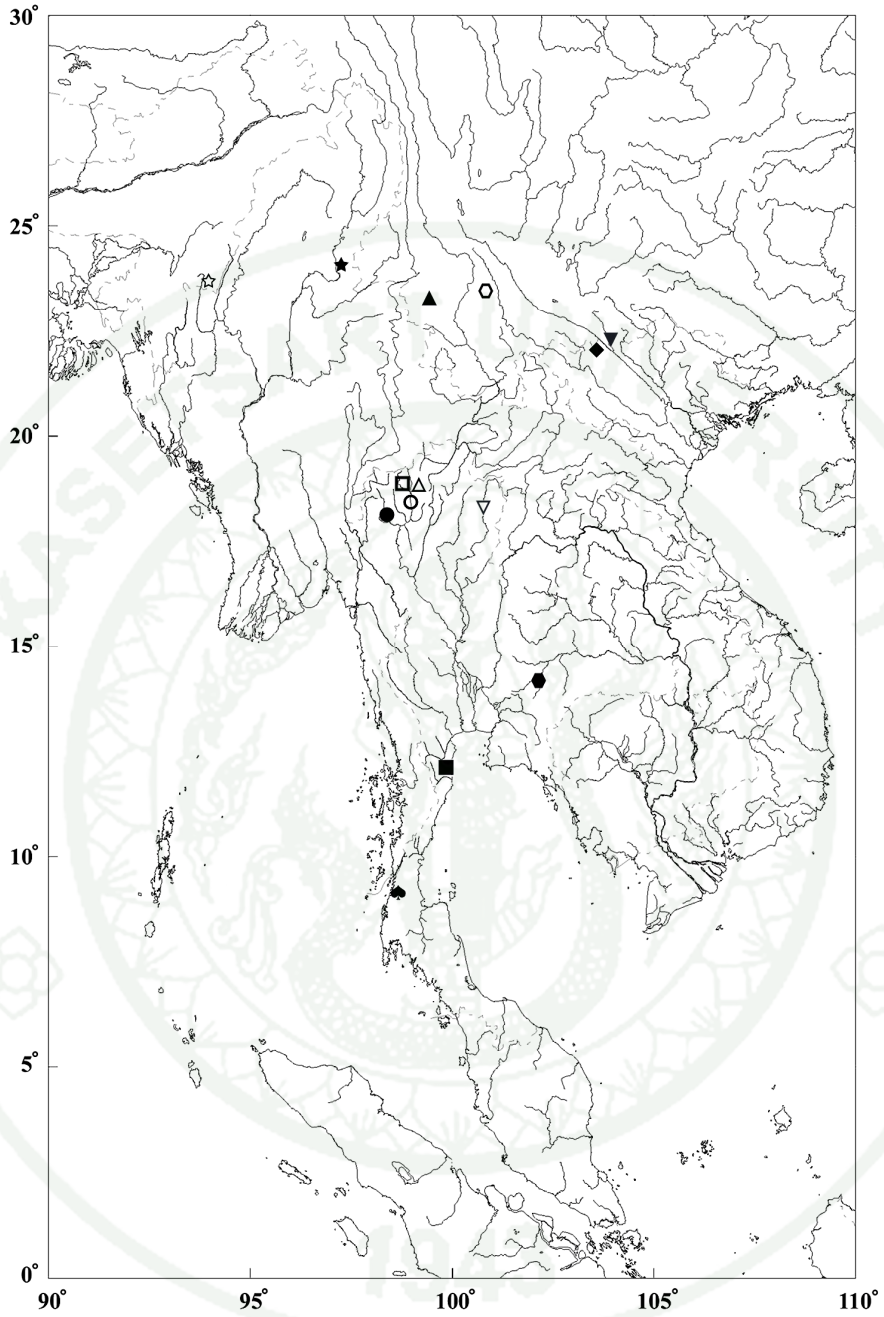

Figure 1 Type localities of nominal species of *Barilius* in mainland Southeast Asia excluding *Barilius ornatus* and *Danio monshiensis*:
● = *B. pulchellus*, ○ = *Danio ponticulus*, ■ = *B. huahinensis*, ⬣ = *B. koratensis*, ▽ = *B. nanensis*, ♠ = *B. bernartziki*, □ = *B. infrafasciatus*, △ = *B. buddhae*, ▲ = *B. caudiocellatus*, ★ = *B. barnoides*, ⭘ = *B. pellegrini*, ☆ = *B. dogarsinghi*, ▼ = *Daniops nammuensis*, ◆ = *Paradaniops macropterus*.

MATERIAL AND METHODS

Materials

1. Most *Barilius* specimens used in this study were collected from various streams and upper parts of rivers in major river systems of Thailand, including type localities of all nominal species described from Thailand or nearby localities as feasible. The survey was performed from November 2003 – November 2009 mainly in the dry season (December-April) because in these months *Barilius* species should be in spawning conditions and some specimens should have fully developed tubercles and coloration. Collected specimens' color and color pattern in live (and after preservation) were recorded. Specimens were preserved in 10% formalin solution for 10 – 14 days. The location was recorded and written on label made of waterproof paper. After fixing in formalin specimens would be soaked in water for 24 hours and then preserved in 75% ethyl alcohol together with the label for study. For photography some live specimens collected were tranquilized by immersion in the ice-water mixture for 10-20 minutes. Specimens were laid on styrofoam sheet, and had their dorsal, pelvic and anal fins fully erected and fixed by using needles to pin them and applied with concentrated formalin solution, then waited for 5-10 minutes for fins to be fixed in erect position. The specimen were photograph either in upright position in photographic tank or in laid down position horizontally in dark plastic box. In either case the specimen would be immersed in the water in order to be accurately photographed. These specimens are then registered and kept at Research Laboratory of Ichthology, Kasetsart University, Bangkok, Thailand (RLIKU) and Ubonratchathani University Natural History Museum of Fisheries, Ubonratchathani, Thailand (UNMF).

2. Additional specimens from Thailand and other countries in the study area are from the following collections:

- Ubonratchathani University Natural History Museum of Fisheries, Ubonratchathani, Thailand (UNMF)

- Maejo University Fishries Museum Reference Collection, Chiang Mai,

Thailand (MJUFM)

- Thailand National History Museum, Pathumthani, Thailand (THNHM)
- Academy of Natural Sciences, Philadephia, U.S.A. (ANSP)
- The Natural History Museum, London, England (BMNH)
- California Academy of Sciences, San Francisco, U.S.A. (CAS, SU)
- Swedish Museum of Natural History, Stockholm, Sweden (NRM)
- Kunming Institude of Zoology, Kunming, China (KIZ)
- Institude of Zoology, Chinese Academy of Sciences, Beijing, China (IOZCAS)
- Zoological Survey of India, Calcutta, India (ZSI)

The geographical scope of the present study which is called as “Indochina” in this study is modified from Kottelat (1989) to include Thailand, Myanmar, Laos, and Cambodia, and excludes Malay Peninsula south of the Tapi basin.

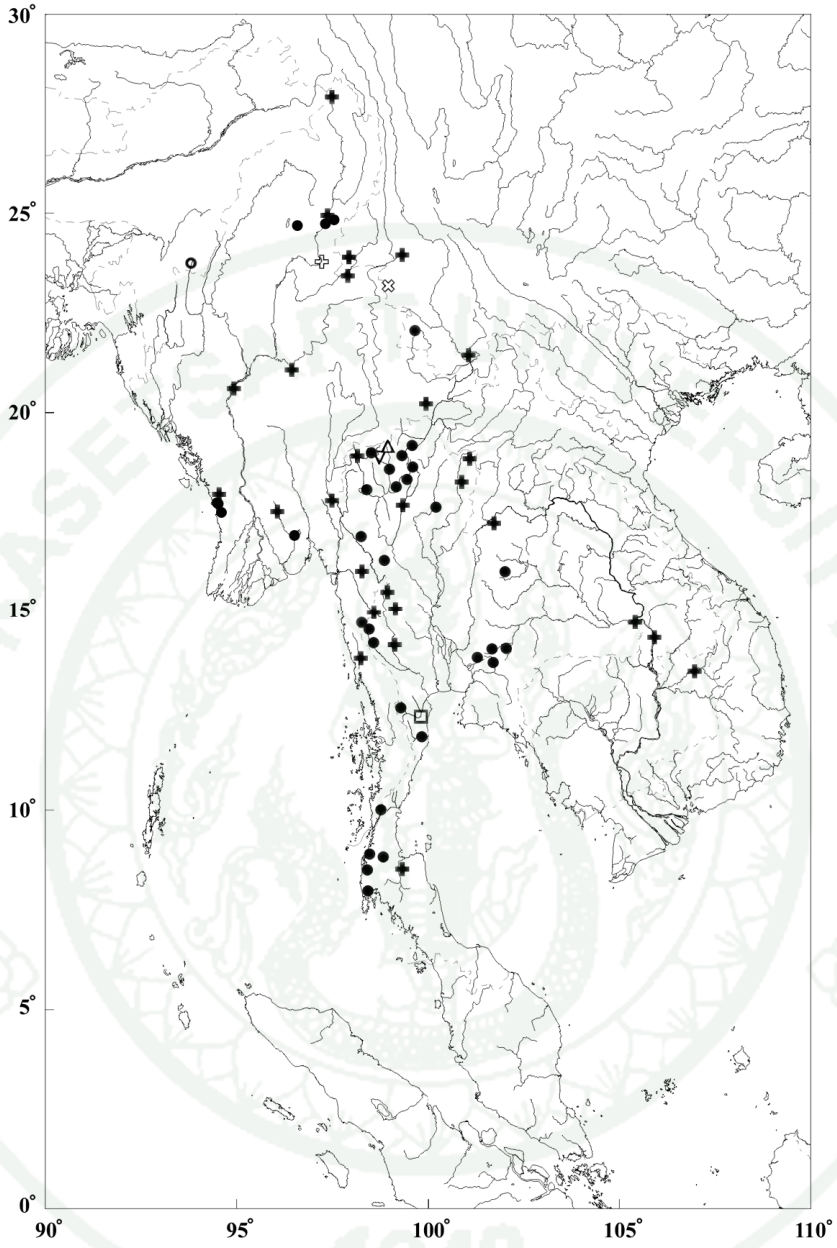

Figure 2 Localities of *Barilius* specimens examined in the present study: ● = survey locations, ✚ = museum collections. ◘ = Holotype and paratypes of *Barilius huahinensis*, ⭘ = Paratype of *Barilius dogarsinghi*, ✣ = Syntype of *Barilius barnoides*, ▵ = Holotype and paratypes of *Barilius buddhae*, ▿ = Holotype and paratypes of *Barilius infrafasciatus*, ⛋ = Syntype of *Barilius caudiocellatus*.

Methods

1. Morphometric measurements were done using vernier caliper (accuracy to 0.01 mm). All meristic counts and morphometric measurements were done on the left side of the specimens if feasible. Both meristic counts and morphometric measurements are based mainly on the methods used by Hubbs and Lagler (1958) with some modifications as follows:

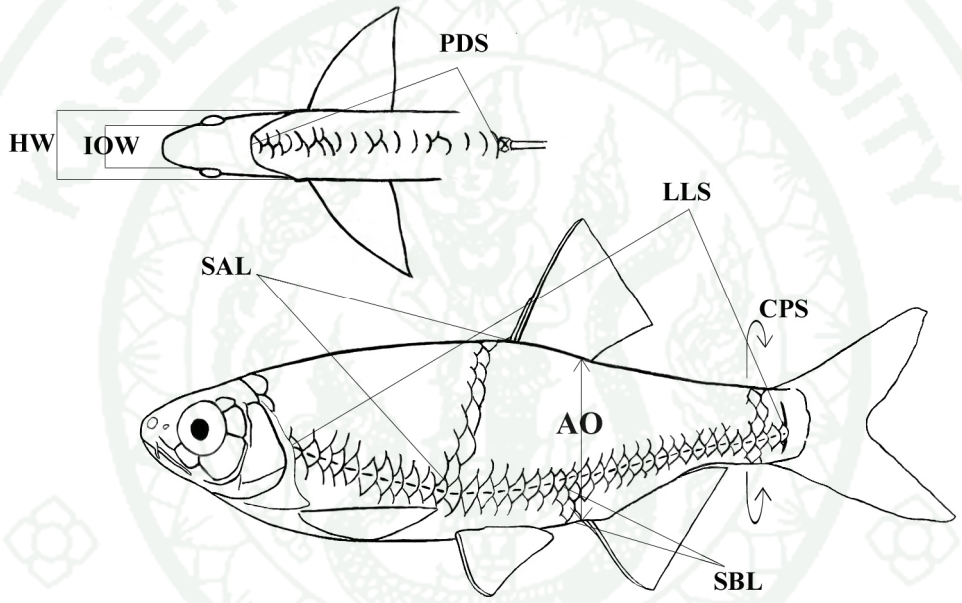

Figure 3 Illustration of *Barilius* showing the scale count methods and methods to measure HW and IOW.

Lateral line scales (LLS):- The total number of tube-bearing scales on the side of the body from the first scale in contact with shoulder girdle to the posterior end of hypural plate.

Predorsal scales (PDS):- The total number of scales on the back beginning from the nape to the origin of dorsal fin along the dorsal midline.

Scales below lateral line (SBL):- Number of scale rows beginning from the

one right at the origin of anal fin base up to the scale below the lateral line (excluding the lateral line scale row).

Scales above lateral line (SAL):- Number of scale rows beginning from the one right below the the predorsal scale at the origin of dorsal fin diagonally down to the scale above the lateral line (not include the lateral line scale row and the predorsal scale adjacent to the dorsal fin ray origin is counted as 0.5 scale row).

Caudal peduncle scales (CPS):- Number of scale rows crossing a line around the narrowest part of the caudal peduncle on both the left side and the right side of the body.

Branched dorsal fin rays (D):- Number of branched rays on dorsal fin.

Branched anal fin rays (A):- Number of branched rays on anal fin.

Pectoral fin rays (P1):- Total number of rays on pectoral fins.

Pelvic fin rays (P2):- Total number of rays on pelvic fins.

Anal fin origin (AO):- The point that anal fin originates in relation to the imaginary straight line to overlapping dorsal fin rays.

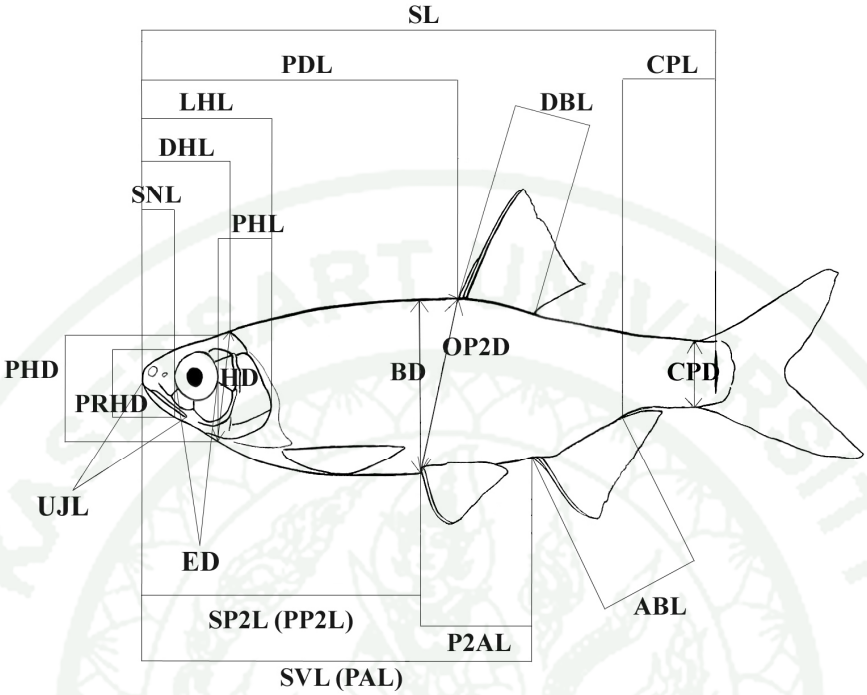

Figure 4 Illustration of *Barilius* showing measurement methods for use in this thesis.

Standard length (SL):- The distance from the most anterior part of snout backward to the posterior end of the hypural plate.

Body depth (BD):- The depth of the body from the origin of pelvic fin base upward perpendicularly to the back.

Depth between the origin of pelvic fin base and the origin of dorsal fin base (OP2D):- The depth of the body from the origin of pelvic fin base upward diagonally to the origin of dorsal fin base.

Caudal peduncle depth (CPD):- The depth of the caudal peduncle at the narrowest part.

Caudal peduncle length (CPL):- The length of the caudal peduncle from the end of anal fin base backward to the end of vertebral column.

Snout-vent length (SVL) or preanal length (PAL):- The distance from the most anterior part of snout backward to the origin of anal fin base.

Predorsal length (PDL):- The distance from the most anterior part of snout backward to the origin of dorsal fin base.

Snout-pelvic fin base length (SP2L) or prepelvic length (PP2L):- The distance from the most anterior part of snout backward to the origin of pelvic fin base.

Pelvic-anal length (P2AL):- The distance from the midline between origin of pelvic fin bases backward to the origin of anal fin base.

Dorsal fin base length (DBL):- The distance from the origin of dorsal fin base backward to the end of dorsal fin base.

Anal fin base length (ABL):- The distance from the origin of anal fin base backward to the end of anal fin base.

Lateral head length (LHL):- The distance from the most anterior part of snout backward to the most posterior part of opercular membrane.

Dorsal head length (DHL):- The distance from the most anterior part of snout backward to the most anterior part of nape.

Head depth (HD):- The depth of head from the most anterior part of nape downward to the most anterior part of chest pad.

Postorbital head depth (PHD):- The depth of head from the vertical line behind the posterior margin of eye.

Head width (HW):- The width across the head between left and right opercles in normal position.

Snout length (SNL):- The distance from the most anterior part of snout backward to the anterior margin of eye.

Preorbital head depth (PRHD):- The depth of head in front of the anterior margin of eye perpendicular to the body in normal position.

Postorbital head length (PHL):- The distance from the posterior margin of eye backward to the most posterior part of opercular membrane.

Interorbital width (IOW):- The bony width between eyes.

Upper jaw length (UJL):- The length of the upper jaw from the most anterior point of premaxilla to the most posterior point of the maxilla.

Eye diameter (ED):- The longest distance between the free orbital rims.

Barbel length:- The length of rostral and maxillary barbels compared with 50% of the distance between the origin of barbel to the end of maxilla (RB-EM) (less than 50% of RB-EM = short, equal or more than 50% of RB-EM = long)

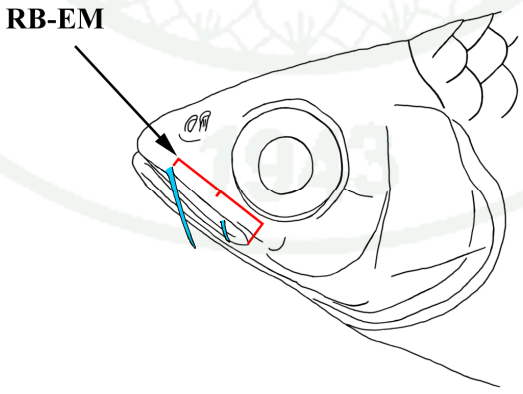

Figure 5 Illustration of *Barilius* head showing the measurement method of barbel length for this study (RB-EM) (left = rostral barbels, right = maxillary barbels). Rostral barbels are often hidden under rostral groove.

2. The color pattern and other external characters were observed and recorded. The number of vertebrae was counted from radiograph. The method used for vertebrae count in this study is based mainly on Roberts (1989) in that abdominal, caudal and total vertebrae are counted, in which the first caudal vertebrae is identified as having its hermal spine posterior to the anteriormost anal fin pterygiophores, and all vertebrae in front of it are abdominal vertebrae. All vertebrae are counted including the Weberian apparatus and posterior urostyle. External sexual characters used to determine male are based on Pathani and Gaur (1989). Individuals with extensive body and head tuberculation, expansion on chest and pectoral, pelvic, dorsal and anal fins, and enhanced coloration are presumed to be alpha male.

3. The data from meristic counts and morphometric measurements were put together, analyzed, and compared to each other and existing species data in order to determine each species of *Barilius*. The frequency distribution table and chart were done using Microsoft Excel program. The differences of overlapping data were analyzed using ANOVA or ANCOVA if necessary. The resulting data would be compared to the data from the original description and type specimen of existing *Barilius* species. The scientific name of each *Barilius* species would then be assigned.

Places and duration

The specimens' measurement and data analysis were done mainly at Research Laboratory of Ichthology, Kasetsart University (RLIKU). The study period was June 2003 – May 2010.

RESULTS AND DISCUSSION

Recognized *Barilius* species in Indochina

From this study of the 16 nominal species of *Barilius* found in Indochina only 6 species are recognized; 5 valid nominal species and one undescribed species discovered. They are listed below with synonyms in parentheses.

Valid nominal species:

Barilius bernatziki
Barilius dogarsinghi
Barilius koratensis (*B. huahinensis*, *B. nanensis*, *Danio ponticulus*)
Barilius ornatus (*B. barnoides*, *B. caudiocellatus*, *B. infrafasciatus*, *Danio monshiensis*)
Barilius pulchellus (*B. buddhae*, *B. pellegrini*, *Daniops nammuensis*, *Paradaniops macropterus*)

Undescribed species:

Barilius sp.

Comparision of characters for the diagnosis of *Barilius* species in Indochina

1. Color pattern

1.1 Body color pattern

The pattern of vertical bars on the flank of *Barilius* species in this study is shown in figure 6. In most specimens of *Barilius* species in this study there is one row of vertical bars beginning from immediately behind the operculum to the caudal base in front of the caudal peduncle. The last 1-2 bars in some species are fused with the caudal spot. The vertical bars on the anterior part of the flank are deep, and often cross the upward-bending lateral line, while bars on the posterior part are constricted and often do not cross the lateral line. In few specimens the vertical bar can split horizontally to form secondary row of bars (figure 7A) or vertically to become double vertical bars (figure 7B). Most species in this study have 5-17 bars and these bars are 1-2 exposed scale wide, but *B. koratensis* sometimes have less than 5 bars that are often 1 exposed scale wide or less and one specimen in this study has no vertical bar at all. The narrow black or deep brown horizontal stripe reported in the original description of the nominal species *Barilius huahinensis*, *Barilius nanensis* and *Danio ponticulus* (all junior synonyms of *B. koratensis*) are, according to Kaewpaitoon, originated from horizontal skeletogeneous septum between epaxial and hypaxial muscle masses. This line is found on some preserved specimens of all *Barilius* species described in this study.

1.2 Dorsal fin color pattern

The schematic diagram of dorsal fin color pattern of *Barilius* species in this study is shown in figure 8. In all *Barilius* species in this study the anterior tip region of dorsal fin has no or few dark or black pigment, and appears clear or with bright, light color. Generally dark pigments are scattered around fin rays, but depending on species they can concentrate on parts of fin. Dark pigments on the dorsal fin of *B. pulchellus* and *B.* sp. from 3rd branched dorsal fin ray backwards are

concentrated into blotch mainly in the intermembrane region between rays on the outer half of the fin to adjacent to the anterior edge of branched rays (figure 8A), while in other species in this study dark pigments do not form blotch. In blotchless species *B. dogarsinghi* dark pigments concentrate mainly in the middle of the fin forming more or less distinct to conspicuous band (figure 8B). In *B. bernatziki*, *B. koratensis*, and *B. ornatus* dark pigments on dorsal fin from 2nd branched dorsal fin ray backwards are more or less concentrated along the rim of dorsal fin rays and the adjacent membrane from fin base outwards, not forming blotch (figure 8C).

1.3 Color pattern on caudal region

The schematic diagram of color pattern on caudal region of *Barilius* species in this study is shown in figure 9. Large and highly distinctive caudal blotch is found on *B. bernatziki*, *B. dogarsinghi*, and some populations of *B. ornatus*. Vertical caudal blotch (figure 9A) is formed by vertically oriented, enlarged caudal blotch at the base of caudal fin (*B. dogarsinghi*). Other large caudal blotch (figure 9B) are formed by the fusion of enlarged horizontal caudal spot and the last 1-2 body bars with dark pigments (preserved specimens) or black, blue or green color (in life and fresh specimens) overlay (*B. bernatziki* and some populations of *B. ornatus*), often associated with bright and light color region adjacent to the top and bottom of the caudal spot, increasing its conspicuousness. *B. koratensis*, many populations of *B. ornatus*, and *B. pulchellus* have one small distinct caudal spot, faint spot or no spot (figure 9B). In life *B. koratensis* has bright bluish-whitish reflective region on the outer edge of upper and lower caudal lobe (Figure 22B-C).

1.4 Pigmentation on the ventral side of the lower jaw

Many specimens of *B. koratensis* examined in this study have concentration of dark pigments (in preserved specimens) on the middle of the ventral side of the lower jaw (figure 27). In life this color pattern can be blue to black. Other *Barilius* species in this study lack this feature.

2. Sexual dimorphism

In this study the secondary sexual characters: the expansion of chest and fins, extensive tuberculation on head and body, and enhanced coloration on males are found on individuals of *Barilius bernatziki*, *B. dogarsinghi*, *B. ornatus*, *B. pulchellus*, and *B.* sp.. These individuals are presumed to be alpha males in this study. Body tubercles on presumed alpha males of *Barilius bernatziki* and *B. ornatus* cover the entire flank, but in *B. dogarsinghi*, *B. pulchellus* and *B.* sp. body tubercles cover mainly on the posterior part of the flank. From species whose life and fresh presumed alpha male can be observed *Barilius bernatziki* and *B. ornatus* have orange to reddish to bronze coloration on the lower part of the body, and sometimes the upper part is suffused with orange to bronze cast over the normal green coloration. The orange to bronze color is found on the area around pectoral fin base, and sometimes on the area around the infraorbitals and opercle too. In *B. pulchellus* the presumed alpha male has brilliant coloration. The body color turns bright greenish-gold to gold, the dorsal fin turns bright red with intermembrane blotchs expand, pectoral fins turn bright yellow to orange, pelvic fins turn bright yellow, pink or orange with bright white, pink or orange outer margin, the anal fin turns bright yellow to orange with grange outer margin in some specimens, and the area from the whole lower jaw to the chest, belly to the origin of anal fin turn bright orange. In *B. koratensis* specimens with fin and chest expansion is not found, and only a few individuals with extensive head and jaw tuberculation is found, so these specimens are referred to as presumed male. Presumed alpha males are illustrated in figure 11, 18C, 29B, 30A, 31B, 32B, 33B-C, 39B, 40, 41, 42B, 47C.

3. Head region

3.1 Tuberculation pattern on the head

The general tuberculation pattern on the head of presumed alpha male and normal specimens of *Barilius* species in this study is illustrated in figure 16, 20, 25, 36, 44, and 49. In general *Barilius* has tubercles on dentary arranged in pararell

rows but incomplete order, and sometimes tiny to small tubercles scattering on the snout and top of head, and few around eye, opercle, and branchiostegal region. In presumed alpha male these tubercles increase in size and numbers, and often appear around the eye including infraorbital region. These tubercles are generally not arranged in order, however. Both normal and presumed alpha male of *B. pulchellus* have far larger dentary tubercles than all other *Barilius* species, and presumed alpha male sometimes has its tubercles in front of the eye and branchiostegal region even larger than the dentary tubercles (figure 44). The dentary tubercles on the outer and inner rim of mandible are arranged in the most orderly fashion in *B. pulchellus*, and less so in other species.

3.2 Barbels

Although barbels are sometimes absent from either or both side of the head of *Barilius* speciemens, in specimens with complete barbels there are 2 pairs of barbels: the rostral and maxillary barbels illustrated in figure 16, 20, 25, 36, 44, and 49. The rostral barbel is often hidden under the rostral groove and need to be pried out carefully in many cases. In *B. bernatziki*, *B. ornatus*, and *B.* sp. both rostral and maxillary barbels are short and often very tiny, with length generally far shorter than 50% distance between the origin of rostral barbel to the end of maxilla. *B. pulchellus* has short maxillary barbel, but the rostral barbel length ranges from short to often as long as or slightly longer than 50% distance between the origin of rostral barbel to the end of maxilla. *B. koratensis* has short maxillary barbel, but the rostral barbel length ranges from as long as 50% distance between the origin of rostral barbel to the end of maxilla to about as long as the distance between the origin of rostral barbel to the end of maxilla. *B. dogarsinghi* is the only *Barilius* species in this study with both rostral and maxillary barbel range from about as long as 50% distance between the origin of rostral barbel to the end of maxilla to about as long as the distance between the origin of rostral barbel to the end of maxilla.

3.3 Pharyngeal teeth

Pharyngeal jaw and teeth of *Barilius* species in this study are illustrated in figure 16, 20, 25, 36, 44, and 49. Pharyngeal teeth of *Barilius* in this study are triserial, (1-3)-(3-4)-5, with each tooth slightly hooked with none to small grinding surface similar to many cyprinids such as tooth of *Danio* and *Devario* species illustrated in Fang (2001). The tooth on the front row and sometimes the uppermost tooth of the middle row are generally smaller and less developed than other rows and dislodges easily, and can be lost when the flesh is removed during preparation.

Figure 6 Color pattern of preserved specimens of *Barilius* species in this study. A) *B. bernatziki*, B) *B. dogarsinghi*, C) *B. koratensis*, D) *B. ornatus*, E) *B.pulchellus*, and F) *B.* sp..

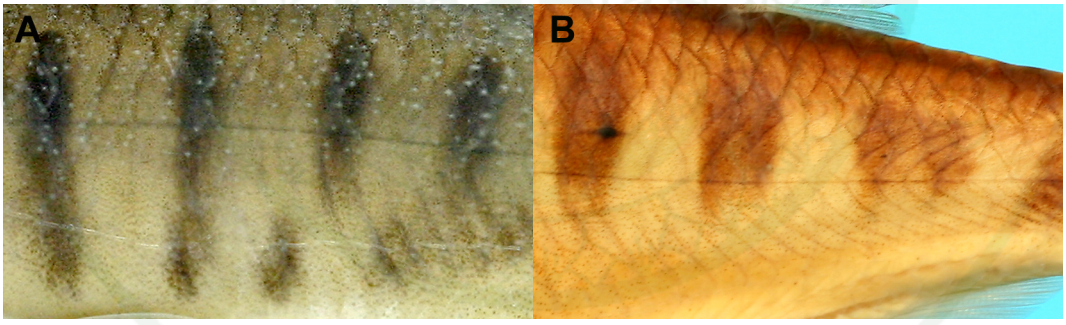

Figure 7 Examples of deviation of body bars from the general body bar pattern of *Barilius*. A) Horizontal splitting of the lower part of the body bar to form the secondary row of body bar. B) Vertical splitting of the anterior and posterior part of the body bar to form double bar pattern.

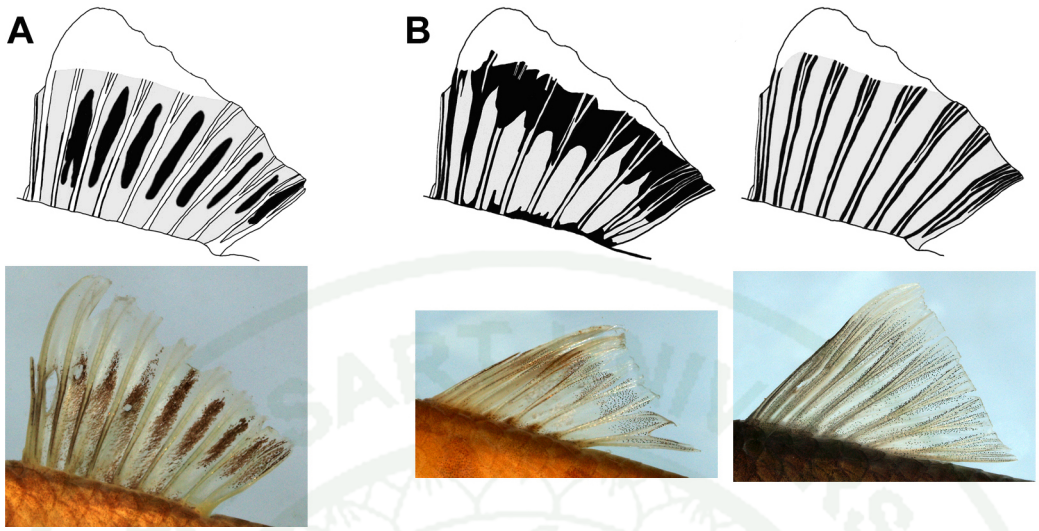

Figure 8 Schematic diagram of dorsal fin color pattern of *Barilius* species in this study. A) dark pigments concentrate in the intermembrane region between branched dorsal fin rays forming blotch (found in *B. pulchellus* and *B.* sp.), B) dark pigments not forming blotch but concentrate on the middle of dorsal fin forming strong submarginal band (found in *B. dogarsinghi*) (middle) or align along the edge of dorsal fin rays (found in *B. bernatziki*, *B. koratensis*, and *B. ornatus*) (right).

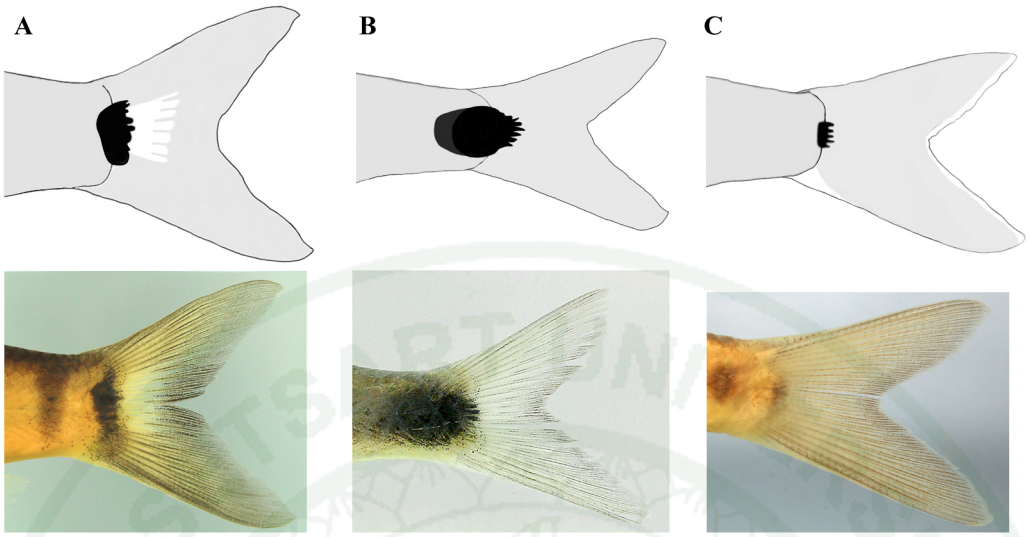

Figure 9 Schematic diagram of color pattern of the caudal region of *Barilius* species in this study. Vertical caudal blotch (A) found in *B. dogarsinghi* is formed by vertically enlarged caudal spot at the base of caudal fin followed by bright or light color region of the caudal fin adjacent to it. *B. bernatziki* and some populations of *B. ornatus* have large caudal blotch (B) that compose of the fusion of enlarged caudal spot and the last 1-2 body bars (B). Other populations of *B. ornatus*, *B. pulchellus*, *B. koratensis* and *B.* sp. have a small caudal spot (C), faint spot or no spot.

4. Meristic counts

From 10 characters used 7 characters show strong distinction in at least one species in the group, which are supported by ANOVA {F-value>100 with 99.99% confidence level ($p<0.001$)}. They are count of number of branched dorsal fin rays (D), branched anal fin rays (A), anal fin origin (AO), lateral line scales (LLS), scales above lateral line (SAL), predorsal scales (PDS), and caudal peduncle scales (CPS). These results are shown in table 2-8.

5. Morphometric measurements

From 21 characters used 3 characters show strong distinction in at least one species in the group, which are supported by ANCOVA {F-value>100 with 99.99% confidence level ($p<0.001$)}. They are measurement of Predorsal length (PDL), Head depth (HD), and Upper jaw length (UJL). Compared to Meristic counts and observation on morphology and coloration they are not as useful, however. These results are shown in table 10, 12, 14, 19, 25, and 28.

6. Total vertebrae count

The number of total vertebrae for each *Barilius* species is shown in table 9. Difference in number of total vertebrae in at least one species is support by ANOVA {F-value>100 with 99.99% confidence level ($p<0.001$)}.

Table 2 The number of branched dorsal fin rays of *Barilius* species in this study.

Branched Dorsal Fin Rays	**6**	**7**	**8**	**9**
Barilius bernatziki (N=26)		23	3	
Barilius dogarsinghi (N=11)		11		
Barilius koratensis (N=180)	3	175	2	
Barilius ornatus (N=197)		179	17	1
Barilius pulchellus (N=75)		11	63	1
Barilius sp. (N=21)		21		

Table 3 The number of branched anal fin rays of *Barilius* species in this study.

Branched Anal Fin Rays	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Barilius bernatziki (N=26)	2	23	1				
Barilius dogarsinghi (N=12)		10	2				
Barilius koratensis (N=180)	8	88	78	6			
Barilius ornatus (N=197)		26	132	38	1		
Barilius pulchellus (N=75)			7	44	16	4	4
Barilius sp. (N=21)	1	20					

Table 4 The number of branched dorsal fin ray that is at the opposite of the origin of anal fin of *Barilius* species in this study.

Anal Fin Origin	**simple rays**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**not overlapped**
Barilius bernatziki (N=26)				1	6	13	6		
Barilius dogarsinghi (N=12)			1	8	3				
Barilius koratensis (N=180)				24	114	40	2		
Barilius ornatus (N=197)			1	13	26	38	53	59	7
Barilius pulchellus (N=75)	15	9	35	15	1				
Barilius sp. (N=21)						9	9	3	

Table 5 The number of scales on the lateral line scale row of *Barilius* species in this study.

Lateral Line Scales	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**
Barilius bernatziki (N=26)	8	16	1	1										
Barilius dogarsinghi (N=12)								1	4	5	2			
Barilius koratensis (N=180)		8	24	58	53	31	6							
Barilius ornatus (N=197)							9	37	46	47	27	23	6	2
Barilius pulchellus (N=75)							16	18	26	10	5			
Barilius sp. (N=21)	4	11	6											

Table 6 The number of scale rows above the lateral line scale row of *Barilius* species in this study.

Scales Above Lateral Line	**6**	**7**	**8**
Barilius bernatziki (N=26)	26		
Barilius dogarsinghi (N=12)		4	8
Barilius koratensis (N=180)	118	62	
Barilius ornatus (N=197)	12	98	87
Barilius pulchellus (N=75)		46	29
Barilius sp. (N=21)		21	

Table 7 The number of predorsal scales of *Barilius* species in this study.

Predorsal Scales	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
Barilius bernatziki (N=26)	2	9	14	1									
Barilius dogarsinghi (N=12)								2	7	3			
Barilius koratensis (N=180)	10	35	75	47	13								
Barilius ornatus (N=196)			1	7	23	38	72	44	7	4			
Barilius pulchellus (N=75)						5	10	24	21	8	4	2	1
Barilius sp. (N=21)	2	6	11	2									

Table 8 The number of circumpeduncle scales of *Barilius* species in this study.

Circumpeduncle Scales	10	11	12	13	14	15	16	17
Barilius bernatziki (N=26)	3	4	19					
Barilius dogarsinghi (N=12)						5	7	
Barilius koratensis (N=179)					78	46	55	
Barilius ornatus (N=197)		1	34	42	105	13	2	
Barilius pulchellus (N=75)		6	35	14	20			
Barilius sp. (N=21)		1	20					

Table 9 The number of total vertebrae of *Barilius* species in this study.

Total vertebrae	33	34	35	36	37	38	39	40	41	42	43
Barilius bernatziki (N=18)			17	1							
Barilius dogarsinghi (N=8)						2	5	1			
Barilius koratensis (N=146)		1	26	85	34						
Barilius ornatus (N=141)						8	43	43	32	14	1
Barilius pulchellus (N=57)						1	18	34	4		
Barilius sp. (N=20)	2	18									

Key to Indochinese species of *Barilius*

1 a. Dorsal fin with dark pigment concentrating at the middle of intermembrane to adjacent to anterior side of branched ray forming conspicuous blotch (figure 8A)….....2

b. Dorsal fin without concentrated dark blotch at the middle of intermembrane (figure 8B).....3

2. a. Scales on the lateral line to the end of hypural plate 36 or more, total vertebrae 38 or more, anal fin origin opposite 0-4th branched dorsal fin ray…….. ……...*Barilius pulchellus*

b. Scales on the lateral line to the end of hypural plate 32 or less, total vertebrae 34 or less, anal fin origin opposite 5th -7th branched dorsal fin ray.....*Barilius* sp.

3. a. Large and deep vertical caudal blotch present, not fused with last 1-2 vertical bars followed behind by large clear to bright light region (figure 9A), dorsal fin pigments form strong submarginal band (figure 8B)….....*Barilius dogarsinghi*

b. Caudal spot absent, small or fusing with last 1-2 vertical bars forming large, horizontally elongate caudal blotch, but never as deep vertical bar and not followed behind by clear to bright light region (figure 9B-C), dorsal fin pigments align mainly along edge of dorsal fin ray (figure 8B)……...4

4. a. Number of scales on the lateral line to the end of hypural plate 37 or more (rarely 36), total vertebrae 38 or more……..*Barilius ornatus*

b. Number of scales on the lateral line to the end of hypural plate 35 or less, (rarely 36), total vertebrae 37 or less.……..……...……..…5

5. a. Large caudal blotch present (figure 9B), short rostral barbels (less than 50% distance between origin of rostral barbel and end of maxilla but usually much shorter or rudimentary), vertical bar on flank never less than 5, no light to reflective patch on the outer rim of caudal fin……..*Barilius bernatziki*

b. Caudal spot absent or tiny, long rostral barbels (more than 50% distance

between origin of rostral barbel and end of maxilla), sometimes less than 5 vertical bars on the flank, in life with light to reflective patch on the outer rim of caudal fin……..…….…….....*Barilius koratensis*

Description of the cyprinids genus *Barilius* in Indochina

***Barilius bernatziki* Koumans, 1937**

(fig. 10-15)

Barilius bernatziki Koumans, 1937: 61-64, Figure 1 (type locality: Kapa, N. W. Peninsular Siam).

Diagnosis. A *Barilius* species reaching around 90 mm SL that is distinguished from all other congeners by the combination of large and wide caudal blotch at caudal base form by the fusion of enlarged caudal spot at caudal base and the last vertical body bar on the flank (figure 10-14), 33 scales or less on the lateral line scale row to the end of hypural plate, and head depth 18.79-21.75 %SL.

Description. (based on 26 specimens, 23.35-90.7 mm SL) Meristic and morphometric measurements are shown in Table 10-11, respectively.

Branched dorsal fin rays 7-8, branched anal fin rays 8-10, pectoral fin rays 12-15, pelvic fin rays 7-9, 30-33 scales in lateral line scale row to the end of hypural plate, 2-4 scales more to the end of caudal base. 6 scale rows above lateral line (predorsal scale row not included), 2-3.5 rows below. 14-16 scales in predorsal scale row. Scales in Circumpeduncle scale row 10-12. Axillary process at the anterior base of pectoral fin and axillary scale at the anterior base of pelvic fin well developed.

Body oblong, deep (depth 26.12-38.81 %SL) and compressed with ventral profile more convex than dorsal profile. Head deep (depth 18.79-21.75 %SL) and compressed (width 11.8-14.2 %SL), snout slightly blunt to acute. Caudal peduncle long (length 17.2-22.02 %SL) and narrow (depth 10.23-12.61 %SL) near caudal base. Mouth large (upper jaw length 9.71-12.11 %SL), oblique, terminal, with maxilla extends to the range from vertical from the anterior margin of eye to vertical from the middle of the eye. In some specimens lower jaw projects beyond upper jaw. Lower

jaw with none to slight notch with none to slight emargination in the upper jaw. Barbels 2 pairs (often missing on either side), both rostral and maxillary barbels short and tiny with length far shorter than 50% distance between the origin of rostral barbels and the corner of the mouth (figure 18). Rostral barbels generally under rostral grooves. Eye large (eye diameter 6.95-12.21 %SL) but eye size generally decreases with body length. Infraorbital bones large. Total vertebrae (N=18) 35-36, abdominal vertebrae (N=18) 18-19, caudal vertebrae (N=18) 16-18. Presumed alpha male with greatly enlarged chest (figure 14).

Dorsal fin origin behind and near the posterior half of the body (not including caudal fin) with narrow base, straight to slightly concave in most specimens, convex with middle and posterior branched rays lengthened in presumed alpha male, the posterior tip often surpasses the vertical from the posterior base of anal fin in presumed alpha male (figure 11). Anal fin origin at the vertical from between 3rd-6th branched dorsal fin rays, the first 3-4 branched rays elongated creating concave margin, these rays enlarged and thickened in presumed alpha male, in Presumed alpha male the margin is less concave or straight. Lower lobe of caudal fin longer or equal to upper lobe. Pectoral fin large and often reaches the anterior base of pelvic fin. Pelvic fin origin far in front of dorsal fin origin, anterior tip not reaching the anterior origin of anal fin, posterior tip generally not reach the anterior origin of anal fin but often reach the anterior origin of anal fin in presumed alpha male.

Tuberculation. In presumed alpha male numerous small tubercles cover the whole body, head and parts of fins (figure 11). Numerous tiny tubercles often scatter over lower jaw region. Dentary tubercles on presumed alpha male generally up to around 5 incomplete rows in large specimens, anterior ones larger than posterior ones, and more distinct on the outer and inner edges of dentary. Large tubercles on side of snout, end of maxilla, front of eye, top of eye, all area below eye, opercle and branchiostegal region (figure 15). Smaller tubercles on the whole side of the body, generally up to around 6 tubercles per scale in large specimens. Small tubercles on snout, dorsum, and dorsal generally up to around 12 tubercles per dorsal scale in large specimens. Tubercles also cover the outer surface of pectoral and pelvic fins, part of

dorsal and anal fins, and the upper lobe of caudal fin. In most other specimens tubercles restrict mainly to snout and dentary, and not as numerous nor as large as on presumed alpha male (figure 15).

Color. In life and fresh specimens: dorsum greenish to grayish, side green to silvery depending on light angle, belly silvery in most specimens (figure 10-11). Presumed alpha male often with yellowish to slightly reddish orange belly that does not include lower jaw region but sometimes reaches lower opercle. Body side with 5-12 blue vertical bars not including the last bar that fuse with caudal spot; each bar generally 1-2 scale wide, most bars in front of anal fin generally reach or cross lateral line. These bars are often broken up into double bars both vertically and horizontally (figure 15-16), and often the number of bars on either side of the body is not equal. Last bar on the side fuses with enlarged caudal spot at the fleshy end of caudal base by overlying bluish pigment to form large greenish to dark blue blotch 3-5 scale high and 3-6 scales long (figure 10-14). The caudal blotch extends into the anterior region of caudal fin. All bars may become indistinct depending on light reflection and mood of the fish, and small specimens generally have stronger coloration than large specimens. Presumed alpha male sometimes has faint bars. Pectoral and pelvic fins clear to orangish or pinkish. Anal fin clear to yellowish orange. Caudal fin with dark margins on principal rays, outer parts of branched rays, and the whole branched rays in the middle of the fin; caudal fin membrane clear to yellowish. Dorsal fin clear to pinkish with dark pigment on rays and membrane, concentrating at the edge at the side of dorsal fin rays forming one indistinct horizontal stripe halfway on the anterior part of dorsal fin. In most specimens dark pigment on the first 3-5 branched dorsal rays do not reach the tip of the fin leaving clear, white or pinkish anterior dorsal fin tip (figure 10, 14), but in presumed alpha male dark pigment expands toward the anterior dorsal fin tip (figure 11).

In preserved specimens: usually the red, blue and green color and reflectivity would disappear after preservation. Dorsum dark brown, lighter below. All dark pigment in fins, body bars and caudal blotch turn dark brown to black. In some specimens the dark pigment overlay the caudal blotch fades away, revealing the last

bar and caudal spot underneath. A dark and thin horizontal stripe sometimes appears along the middle of the body side from behind the opercle down to the caudal base.

Distribution. *Barilius bernatziki* is found in streams and rivers west of Tenasserim Range from Taninthayi division in Myanmar and from Ranong Province to western part of Phangnga Province in Thailand (figure 17).

Habitat. *Barilius bernatziki* are found in many types of running waters from small slow streams to fast rivers with mud, sand to gravel substrates, but it prefers clear running waters with gravel bottoms with rocks (figure 16).

Remarks. In the original description Koumans stated that in *B. bernatziki* the caudal peduncle length was about as long as caudal peduncle depth. It is unlikely for *Barilius* species to have either extremely short or extremely deep caudal peduncle. Measurement from the natural size figure in the original description shows that its caudal peduncle length is 17.36%SL, which agrees within the range of specimens in this study. Both the original description and the figure in the original description show the large caudal mark (figure 13), and the number of lateral line scales (31) and scales above the lateral line (6) agrees within the range of specimens used in this study.

The discovery of *Barilius bernatziki* from Taninthayi Division in Myanmar, though not surprising, does extend the distribution of *B. bernatziki* far up north toward the northern region of Tenasserim Range. From the southern range in the original description the place name “Kapa” was in northwestern part of peninsular Thailand. This region generally comprises of area west of Chumporn Province down to Phuket Province (which is an Island south of Phangnga Province) that includes Ranong Province and western part of Phangnga Province. The place name “Kapa” is not found on modern maps but there are 2 districts with similar names: Kapoe and Kapong (eg. Periplus TravelMaps: Thailand Regional Maps: Ko Samui and Nelles Road Atlas: Southeast Asia). *Barilius bernatziki* is common in streams and rivers in both districts, and both districts are not far north of Phuket island (around 120 km and

30 km respectively). The author has the same opinion as Kaewpaitoon (1979) that Kapoe District may be the same place as "Kapa" in the original description.

The only *Barilius* species that have low number of lateral line scales comparable to *B. bernatziki* are *B. koratensis* and *B*. sp. Both *B. koratensis* and *B.* sp. do not have large caudal blotch characteristic of *B. bernatziki*. *B. bernatziki* differs, further apart from the presence of characteristic large caudal blotch, from *B. koratensis* by having deeper head (18.79-21.75%SL) than *B. koratensis* (16.19-19.83%SL), longer dorsal head length (18.88-25.37%SL vs. 16.42-22.94%SL), and shorter rostral barbels not reaching half the distance between the origin of rostral barbels and the corner of the mouth versus reaching half the distance between the origin of rostral barbels and the corner of the mouth or more in *B. koratensis*. *B. bernatziki* has shallower head than *B*. sp. (18.79-21.75%SL vs. 21.82-25.49%SL). *Barilius bernatziki* can be distinguish from all *Barilius* species presently recognized as valid by having less lateral line scales (30-33 vs. more than 36) (data from Talwar and Jhingran, 1991; Coad, 2010; Vishwanath and Manojkumar, 2002; Mirza, Rafiq, and Awan, 1986; Arunkumar and Singh, 2000; Tilak and Husain, 1990; Selim and Vishwanath, 2002; and Roberts, 1989).

Material examined. RLIKU 1386 (8) 37.97-78.63 mm SL, Kapoe District, Ranong Province, Thailand, 7 April 2004; RLIKU 1387 (8) 52.08-61.2 mm SL, Kapong District, NW Phangnga Province, Thailand, 8 April 2004; RLIKU 1388 (1) 68.7 mm SL, Chiewlian County, Kapoe District, Ranong Province, Thailand, 21 April 2006; UNMF 00572 (1) 72.75 mm SL, Ban TungMaphrao, NW Ranong Province, Thailand, 7 April 2004; UNMF 00573 (6) 34.75-69.45 mm SL, Huai Hinwoor, NW Ranong Province, Thailand, 3 May 2003; UNMF 00574 (1) 90.7 mm SL, Huai Hinwoor, NW Ranong Province, Thailand, 20 July 2004; UNMF 0050 (1) 23.35 mm SL, Malwe Mountain, Tavoy, Taninthayi Division, Myanmar, 20-30 November 2003, Mr. Tin Win.

Table 10 Morphometric measurements (in %SL) of *Barilius bernatziki* (* = measurements from the figure in the original description).

Measurements (%SL)	*Barilius bernatziki* (original description)	*Barilius bernatziki* (N=26)		
		range	mean	SD
Standard length (mm)	107 mm (TL?)	23.35-90.7	-	-
Body depth	30.77	26.12-31.81	28.33	1.44
Pelvic-dorsal depth	31.71 *	27.62-33.85	29.79	1.62
Caudal peduncle depth	10.98 *	10.23-12.61	11.22	0.58
Caudal peduncle length	17.36 *	17.2-22.02	19.15	1.06
Preanal length	65.85 *	65.84-74.09	69.54	2.34
Predorsal length	56.1 *	54.5-64.29	58.86	2.15
Prepelvic length	52.44 *	47.03-56.29	51.55	2.11
Pelvic-anal fin length	15.85 *	17.65-21.46	19.58	1.11
Dorsal fin base length	18.29 *	10.49-16.76	14.03	1.42
Anal fin base length	19.51 *	13.28-20.18	16.6	1.52
Lateral head length	25	26.32-29.56	27.27	0.9
Dorsal head length	19.51 *	18.88-25.37	21.36	1.34
Head depth	20.73 *	18.79-21.75	20.27	0.84
Head width	-	11.8-14.2	12.73	0.62
Snout length	6.1 *	7.18-9.73	8.09	0.59
Preorbital head depth	12.2 *	10.36-13.78	11.65	1.04
Postorbital head depth	18.9 *	16.98-20.32	18.36	0.82
Postorbital length	10.98 *	10.48-13.5	11.76	0.77
Interorbital width	-	8.06-11.39	8.89	0.64
Eye diameter	6.71 *	6.95-12.21	9.28	1.21
Upper jaw length	13.41 *	9.71-12.11	10.81	0.7
Head depth (%lhl)	80.95 *	68-81.12	74.35	2.66
Snout length (%lhl)	23.81 *	25-33.45	29.69	2.1
Postorbital length (%lhl)	47.62 *	38.03-50.2	43.17	2.97
Interorbital width (%lhl)	-	29-43.26	32.63	2.61
Eye diameter (%lhl)	28.85 *	25.87-45.42	34.04	4.24
Upper jaw length (%lhl)	46.15 *	35-44.18	39.66	2.44

Table 11 Meristic counts and other characteristics of *Barilius bernatziki* (* = measurements from the figure in the original description).

Counts	*Barilius bernatziki* (original description)	*Barilius bernatziki* (N=26)		
		range	mean	SD
Origin of anal fin opposite branched dorsal fin rays	4th *	3rd (1), 4th (6), 5th (13), 6th (6)	4.92	0.8
Pectoral fin rays	15	12 (3), 13 (7), 14 (15), 15 (1)	13.54	0.76
Pelvic fin rays	9	7 (4), 8 (16), 9 (6)	8.08	0.63
Branched dorsal fin rays	8	7 (23), 8 (3)	7.12	0.33
Branched anal fin rays	9	8 (2), 9 (23), 10 (1)	8.96	0.33
Lateral line scales	31+2	[30 (8), 31 (16), 32 (1), 33 (1)] + (2-4)	30.81	0.69
Scale rows above lateral line	6	6 (26)	6	0
Scale rows below lateral line	3.5	2 (3), 2.5 (8), 3 (9), 3.5 (6)	2.85	0.49
Predorsal scales	17	14 (2), 15 (9), 16 (14), 17 (1)	15.54	0.71
Circumpeduncle scales	12	10 (3), 11 (4), 12 (19)	11.62	0.7
Total vertebrae (N=18)	-	35 (17), 36 (1)	35.06	0.24
Abdominal vertebrae (N=18)	-	18(14), 19 (4)	18.22	0.43
Caudal vertebrae (N=18)	-	16 (4), 17 (13), 18 (1)	16.83	0.51

Figure 10 *B. bernatziki* RLIKU 1388. 68.7 mm SL. Chiewlian County, Kapoe District, Ranong Province, Thailand.

Figure 11 *Barilius bernatziki* UNMF 00574. 90.7 mm SL. Huai Hinwoor, NW Ranong Province, Thailand. Presumed alpha male but with orange belly color disappearing quickly after death. Note the greatly enlarged chest and dorsal, anal and pelvic fins that also occurs in presumed alpha male specimens of Indochinese *Barilius* species in this study except *B. koratensis*.

Figure 12 *B. bernatziki* RLIKU 1387. 59.73 mm SL. Kapong District, northwestern region of Phangnga Province, Thailand.

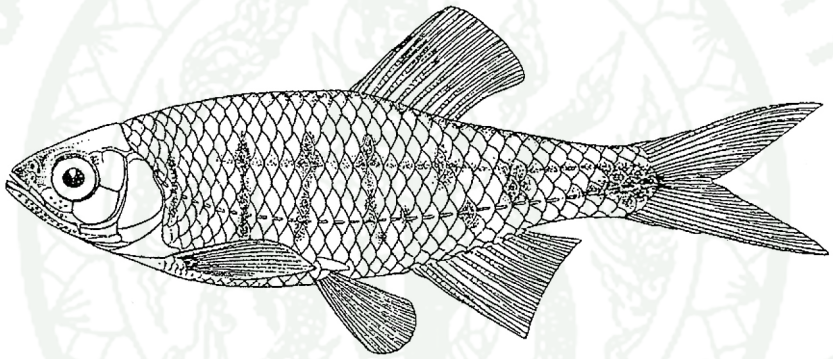

Figure 13 Figure of *B. bernatziki* from the original description (Koumens, 1937).

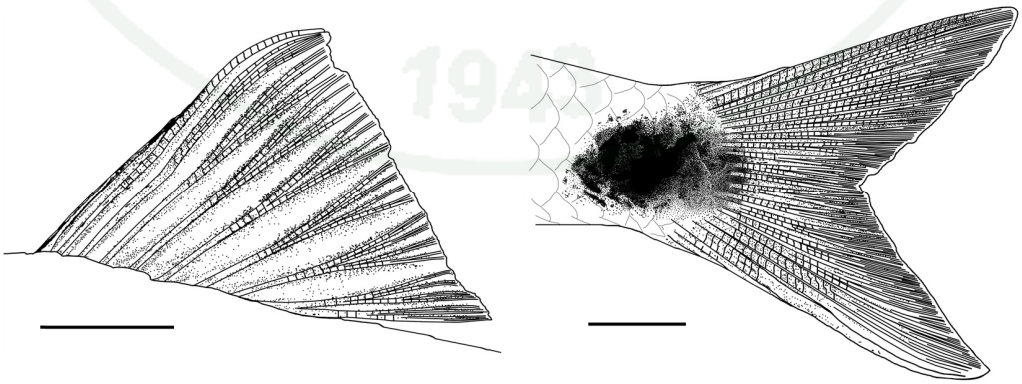

Figure 14 Diagram of dorsal fin (RLIKU 1388, 68.7 mm SL) and caudal region (RLIKU 1388, 68.7 mm SL) of *B. bernatziki*. Scale bar = 5 mm.

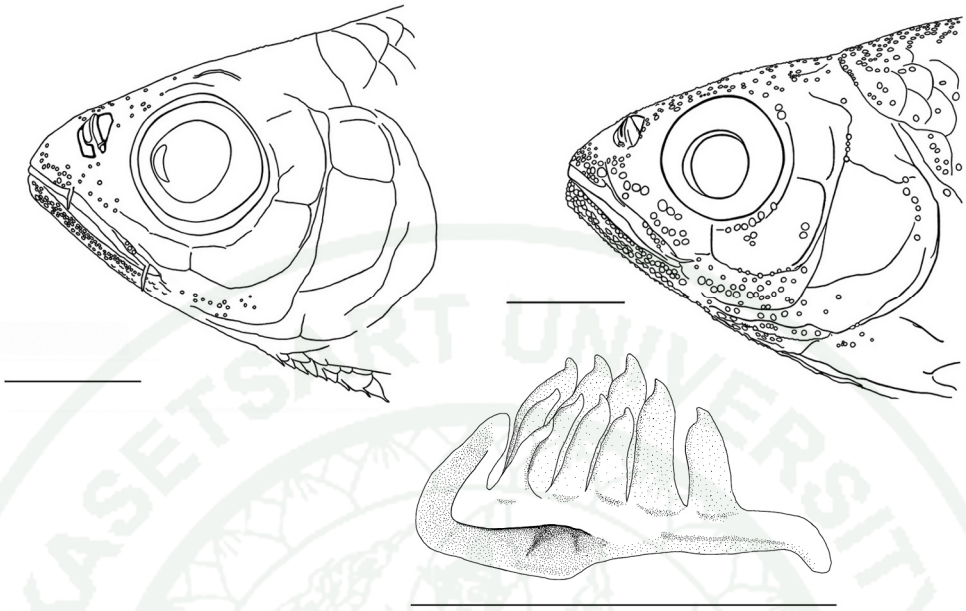

Figure 15 Diagram of right pharyngeal teeth (ventro-mesial view) (RLIKU 1386, 54.25 mm SL) and head of normal (left = RLIKU 1387, 59.73 mm SL) and presumed alpha male (right = RLIKU 1387, 58.2 mm SL) of *B. bernatziki*. Scale bar = 5 mm.

Figure 16 Tributary of Kapoe River at Kapoe District, Ranong Province, Thailand. Apart from *B. bernatziki* many stream fishes can be found together with brackish water fishes at this location.

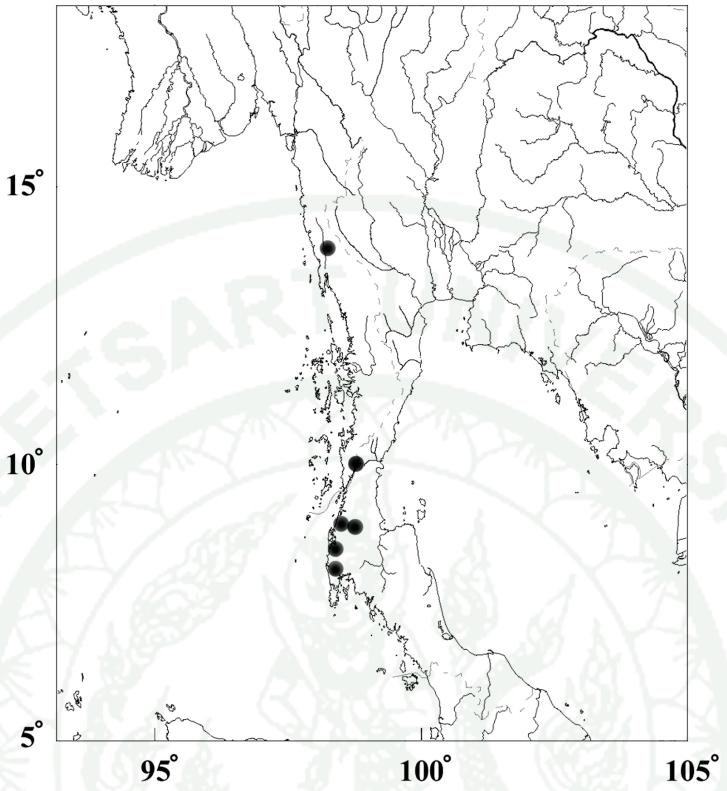

Figure 17 The locality of *B. bernatziki* examined in this study.

Barilius dogarsinghi Hora, 1921

(fig. 18-20)

Barilius dogarsinghi Hora, 1921: 191-193, text-Figure 3(a-c) (type locality: Etok stream near Chanderkhong, Naga Hills, India).

Diagnosis. A *Barilius* species reaching around 70 mm SL that is distinguished from all other congeners by the highly conspicuous caudal marking consisting of deep vertical caudal blotch that does not extend deep into caudal fin but followed by the clear to light region at the middle of caudal fin base (figure 18-19), the strong submarginal band on the dorsal fin, long rostral and maxillary barbels that are equal or more than 50% of the distance between the origin of rostral barbels and the corner of the mouth, lateral line scales 37-40, predorsal scales 21-25, branched anal fin rays 9-10, and having dorsal fin placement far backwards with anal fin origin at the vertical from between 1st-4th branched dorsal fin rays.

Description. (based on 11 specimens, 45.5-65.63 mm SL) Meristic and morphometric measurements are shown in Table 12-13, respectively.

Branched dorsal fin rays 7, branched anal fin rays 9-10, pectoral fin rays 12-13, pelvic fin rays 8-9, 37-40 scales in lateral line scale row to the end of hypural plate, 2-3 scales more to the end of caudal base. 7-8 scale rows above lateral line (predorsal scale row not included), 3.5-5 rows below. 21-25 scales in predorsal scale row. Scales in Circumpeduncle scale row 15-17. Axillary process at the anterior base of pectoral fin and axillary scale at the anterior base of pelvic fin well developed.

Body oblong, deep (depth 27.24-33.84 %SL) and compressed with ventral profile more convex than dorsal profile, but not as streamlined as other Barilius in Indochina. Head deep (depth 18-22.02 %SL) and compressed (width 10.68-14.64 %SL), snout blunt to acute. Caudal peduncle long (length 14.1-20.4 %SL) and narrow near caudal base (depth 10.51-12.5 %SL). Mouth moderately large (upper

jaw length 8.38-10.89 %SL), oblique, terminal, with maxilla extends to the range from vertical from the anterior margin of eye to vertical from the anterior 1/6 of eye. In some specimens lower jaw projects beyond upper jaw. Lower jaw without notch but the upper jaw has slight emargination. Barbels 2 pairs (sometimes missing on either side), both rostral and maxillary barbels long with length equal to or longer than 50% distance between the origin of rostral barbels and the corner of the mouth (figure 23). Rostral barbels often under rostral grooves. Eye large (eye diameter 5.98-8.08 %SL) but eye size generally decreases with body length, from diameter slightly longer than snout length in small specimens to slightly shorter than snout length in large specimens, but generally smaller than other Indochinese *Barilius* of comparable size. Infraorbital bones often smaller than other Indochinese *Barilius* (figure 20). Total vertebrae (N=8) 38-40, abdominal vertebrae (N=8) 19-21, caudal vertebrae (N=8) 18-19. Presumed alpha male with enlarged chest (figure 18C).

Dorsal fin origin behind and near the posterior half of the body (not including caudal fin); with narrow base, straight to slightly concave in most specimens, convex with middle and posterior branched rays lengthened in presumed alpha male, the posterior tip often surpasses the vertical from the posterior base of anal fin in presumed Presumed alpha male, and sometimes almost reach the posterior tip of anal fin (figure 18C). Anal fin origin at the vertical from between 1^{st}-4^{th} branched dorsal fin rays, the first 3-4 branched rays elongated and sometimes creating concave margin, these rays and simple rays enlarged and thickened in presumed alpha male reducing its concavity, and with the elongation of posterior branched rays resulting in round anal fin. Lower lobe of caudal fin generally longer or equal to upper lobe. Pectoral fin large, not reach the anterior base of pelvic fin. Pelvic fin origin far in front of dorsal fin origin, anterior tip not reaching the anterior origin of anal fin, posterior tip generally not reach the anterior origin of anal fin but often reach the anterior origin of anal fin in presumed alpha male.

Tuberculation. In presumed alpha male tubercles cover parts of the body, head (figure 18C) and parts of fins. Dentary tubercles on presumed alpha male generally up to around 2-4 incomplete rows in large specimens, anterior ones larger

than posterior ones, and more distinct on the outer and inner edges of dentary. Large tubercles on side of snout, end of maxilla, front of eye, top of eye, all area below eye, opercle and branchiostegal region. In presumed alpha male tubercles on the cheek (area below eye) can be numerous (figure 18C and 20). Large tubercles on the posterior side of the body of tuberculated and presumed alpha male, generally 1-3 tubercles per scale in large specimens. Smallest tubercles on snout, head dorsum, and dorsal generally up to around 4-5 tubercles per dorsal scale in large specimens. Tubercles also cover the outer surface of pectoral and pelvic fins, part of dorsal and anal fins, and the upper lobe of caudal fin. In most other specimens tubercles restrict mainly to snout and dentary, and not as numerous nor as large as on presumed alpha male.

Color. In fresh specimens: depending on light condition dorsum brownish to greenish to grayish, side silvery or greenish or bluish depending on light angle, belly white to silvery in most specimens (figure 18A). Body side with 6-9 blue vertical bars not including the caudal spot; each bar generally 2-3 scale wide, most bars in front of anal fin generally reach or cross lateral line. Often the number of bars on either side of the body is not equal. Vertical caudal blotch consists of enlarge, strongly pigmented, vertically oriented caudal blotch concentrated at caudal base, about 1-2 exposed scales wide and 2-3 exposed scales high, and not extend far into the anterior region of caudal fin, and the region immediately behind the caudal spot lacks dark pigment and often opaque white to yellowish, highlighting the caudal base (figure 18A). Sometimes this light region is followed behind by concentration of dark pigments between and around caudal fin rays. All bars may become indistinct but generally they remain strong. Pectoral fins clear to yellowish, orangish or pinkish, sometimes with dark pigment on pectoral fin rays. Pelvic fins clear to orange or reddish, with white to yellowish, pinkish or bluish first ray and the anterior margin of fins. Anal fin clear to pinkish or orangish with white anterior tip and often with some dark to black pigments on the membrane between anal fin rays and between branches of rays, with the strong orange to reddish coloration restrict to the distal half of the fin in normal specimens. Caudal fin generally clear to yellow with dark margins on caudal fin rays except the inner central region adjacent to the caudal spot, which

remains generally clear of most dark pigment. Dorsal fin clear to pinkish with strong dark to black pigment on rays and membrane, concentrating at the edge at the side of dorsal fin rays forming one deep horizontal stripe at the middle of dorsal fin, with whitish, yellowish to orangish dorsal fin margin.

In preserved specimens: usually the red, green, orange and blue coloration and reflectivity is generally lost. Dorsum dark brown, lighter below. All dark pigment in fins, body bars and caudal blotch turn dark brown to black. Fin membrane may become opaque. A dark and thin horizontal stripe sometimes appears along the middle of the body side from behind the opercle down to the caudal base.

Distribution. *Barilius dogarsinghi* is found in tributaries of the Ayeryawaddy River in Myanmar, including part of headwaters that originate from Manipur in India where types were collected (figure 21).

Habitat. In the original description *Barilius dogarsinghi* was listed in the list of fishes from streams with rocky bed in the southern watershed of the Naga Hills.

Remarks. The holotype and paratype of *B. dogarsinghi*, as adult, still has the caudal blotch that was supposed to be presented only in young fish according to the original description by Hora. The paratype appears to have maxillary barbels that are shorter than other specimens examined, but the barbels are relatively as thick as in other specimens. It is possible that the maxillary barbels are shortened in large specimens, but it is also likely that the tips of the barbels are broken off. It also has 21 predorsal scales that is 1 scale more than the number in the original description. The holotype's photograph shows regulary large and long maxillary barbels on left side, and has 22 predorsal scales.

The only other *Barilius* species with both pairs of barbels as long as or longer than 50% distance between the origin of rostral barbels and the corner of the mouth is *B. shacra*, but it has elongated body and 59-70 scales on the lateral line scale row (Day, 1878; Talwar and Jhingran, 1991). *Barilius radiolatus*, *B. shacra naseeri*, *B.*

dimorphicus, and *B. tileo* have more than 45 lateral line scales (Talwar and Jhingran, 1991; Mirza, Rafiq, and Awan, 1986; Tilak and Husain, 1990), so they and *B. shacra* are distinct from all Indochinese *Barilius* species which have 43 or less. Most Indian *Barilius* species with lateral line scales less than 38 (*B. bakeri*, *B. barna*, *B. canarensis*, *B. evezardi*, *B. gatensis*, and *B. modestus*) have less predorsal scales than Indochinese *B. dogarsinghi*, *B. ornatus*, and *B. pulchellus* with more than 36 lateral line scales (generally 16 or less vs. 17 or more) (Day, 1878; Talwar and Jhingran, 1991). *B. chatricensis* also has 15 predorsal scales but with 38 lateral line scales (Selim and Vishwanath, 2002). Of Indian species with less than 50 lateral line scales and more than 16 predorsal scales (*B. barila*, *B. bendelisis*, *B. lairokensis*, *B. ngawa*, and *B. vagra*) none has large vertical caudal blotch presented in *B. dogarsinghi* (Day, 1878; Talwar and Jhingran, 1991; Arunkumar and Singh, 2000; Vishwanath and Manojkumar, 2002). *B. mesopotamicus* has 43 lateral line scales or more, no caudal blotch and tiny or no maxillary barbel (Coad, 2010). *B. borneensis* has only 7 branched anal fin rays (Roberts, 1989) which is fewer than *B. dogarsinghi* and all other Indochinese species.

Although the range of eye diameter of *B. dogarsinghi* overlapped with other Indochinese *Barilius*, the average eye diameter of *B. dogarsinghi* is 6.83%SL (standard deviation = 0.54) which is lower than other Indochinese *Barilius* in this study.

With specimens collected from Pagan and Pang Lung River it is confirmed that *B. dogarsinghi* distribution is much wider than previously thought, and it can be expected to be found in other streams and tributaries of the Ayeryawaddy drainage.

Material examined. ZSI F9983/1 (holotype) (1), 73.2 mm SL, Etok stream near Chanderkhong, Naga Hills, India, 1921?, Zoological Survey India; ANSP 89754 (paratype) (1), 65.63 mm SL, Same data.

RLIKU 1366 (1) 51.95 mm SL, Pagan city market, Pagan, Myanmar, 14 August 1995, Musikasinthorn, P.; RLIKU 1367 (9) 50.6-62.2 mm SL, Pang Lung

River, on the road between Mandalay and Shan, August 1995, Musikasinthorn, P..

Table 12 Morphometric measurements (in %SL) of *Barilius dogarsinghi*. Data of holotype from Musikasinthorn, P..

Measurements (%SL)	*Barilius dogarsinghi* (holotype)	*Barilius dogarsinghi* (N=11)		
		range	mean	SD
Standard length (mm)	73.2	45.5-65.63	-	-
Body depth	29.03	27.24-33.84	31.18	1.82
Pelvic-dorsal depth	-	29.64-35.8	33.58	1.88
Caudal peduncle depth	11.27	10.51-12.38	11.77	0.55
Caudal peduncle length	17.62	14.4-20.4	18	1.95
Preanal length	68.92	68.17-74.95	71.28	2.37
Predorsal length	61.95	61.19-66.88	63.44	1.52
Prepelvic length	52.46	48.41-56.37	52.83	2.47
Pelvic-anal fin length	-	16.59-22.14	19.48	1.44
Dorsal fin base length	15.44	12.77-16.33	14.60	1.09
Anal fin base length	18.72	16.23-19.2	17.52	1.09
Lateral head length	25.48	24.16-28.03	25.87	1.17
Dorsal head length	-	18.09-21.65	20.12	1.07
Head depth	21.52	18-22.02	20.2	1.25
Head width	12.7	10.68-13.75	12.49	0.75
Snout length	8.2	7.15-10.06	8.43	0.87
Preorbital head depth	15.37	10.2-15.7	12.47	1.34
Postorbital head depth	17.35	15.11-19.89	17.48	1.43
Postorbital length	-	12.08-15.24	13.19	0.98
Interorbital width	7.17	7.47-8.97	8.22	0.42
Eye diameter	5.40	5.98-8.08	6.83	0.54
Upper jaw length	8.54	8.38-10.89	9.64	0.7
Head depth (%lhl)	84.45	74.5-87.4	78.09	4.2
Snout length (%lhl)	32.17	25.52-38.82	32.62	3.32
Postorbital length (%lhl)	-	43.1-58.82	51.05	3.91
Interorbital width (%lhl)	28.15	28.64-36.04	31.82	2.3
Eye diameter (%lhl)	21.18	22.95-30.37	26.43	2.21
Upper jaw length (%lhl)	33.51	33.27-41.78	37.26	2.4

Table 13 Meristic counts and other characteristics of *Barilius dogarsinghi*. Data of holotype from Musikasinthorn, P..

Counts	*Barilius dogarsinghi* (holotype)	*Barilius dogarsinghi* (N=11)		
		range	mean	SD
Origin of anal fin	2nd	3rd (8), 4th (3)	3.27	0.47
Pectoral fin rays	12	12 (4), 13 (7)	12.64	0.5
Pelvic fin rays	9	8 (9), 9 (2)	8.18	0.4
Branched dorsal fin rays	-	7	7	0
Branched anal fin rays	9	9 (9), 10 (2)	9.18	0.4
Lateral line scales	38 + 1	[37 (1), 38 (3), 39 (5), 40 (2)] + (2-3)	41	0.89
Scale rows above lateral line	8	7 (4), 8 (7)	7.64	0.5
Scale rows below lateral line	4	3.5 (4), 4 (4), 4.5 (2), 5 (1)	4	0.5
Predorsal scales	22	21 (4), 22 (6), 23 (3), 25 (1)	22.09	0.7
Circumpeduncle scales	16	15 (5), 16 (6)	15.55	0.52
Total vertebrae (N=8)	-	38 (2), 39 (5), 40 (1)	38.86	0.64
Abdominal vertebrae (N=8)	-	19 (1), 20 (6), 21 (1)	20	0.53
Caudal vertebrae (N=8)	-	18 (2), 19 (6)	18.75	0.46

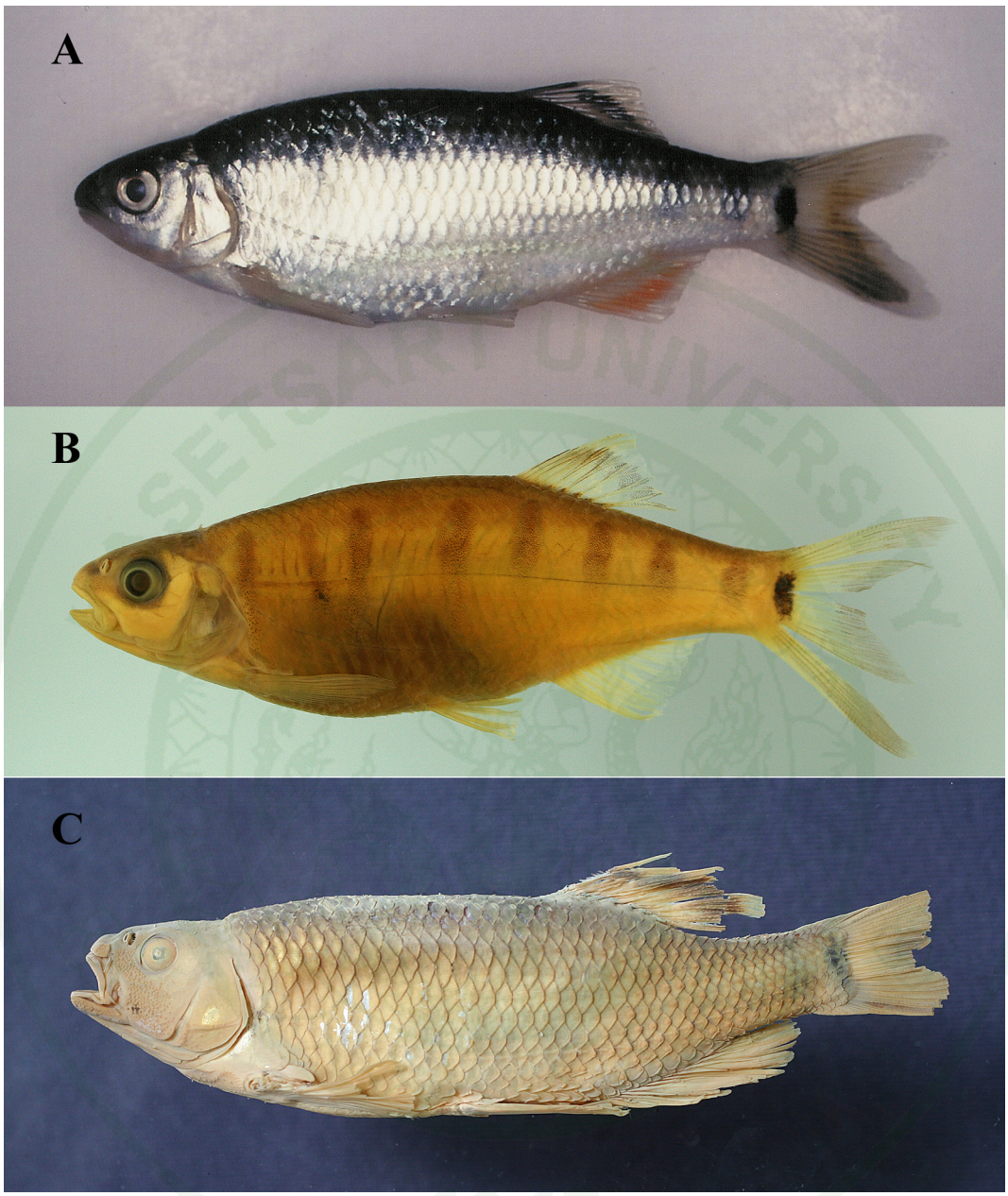

Figure 18 *B. dogarsinghi* A) RLIKU 1367. ca. 58 mm SL. Pang Lung River, tributary of the Ayeyarwaddy River on the road between Mandalay and Shan, Myanmar, B) RLIKU 1367. 54.85 mm SL. Same data as A, C) ZSI F9983/1. 73.2 mm SL. Holotype. Etok stream near Chanderkhong, Naga Hills, Manipur, India. Presumed alpha male. Photograph of figure 21A and C by Prachya Musikasinthorn.

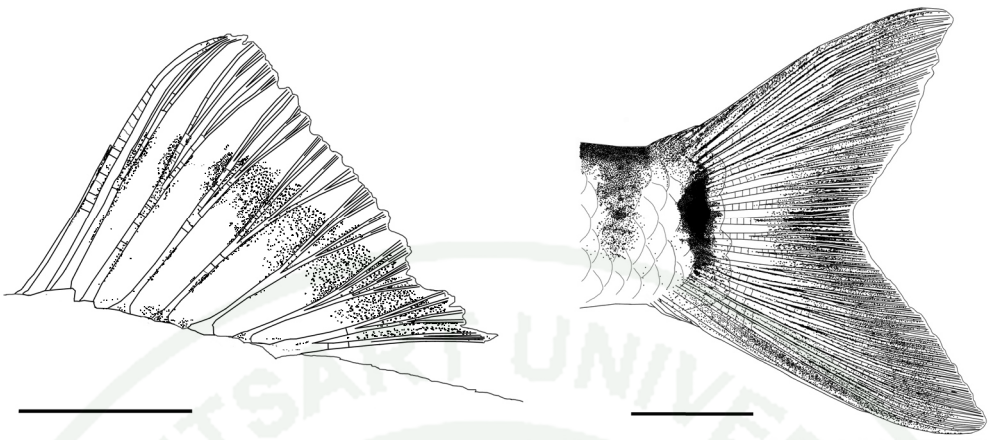

Figure 19 Diagram of dorsal fin (RLIKU 1367, 56.65 mm SL) and caudal region (RLIKU 1367, 56 mm SL) of *Barilius dogarsinghi*. Scale bar = 5 mm.

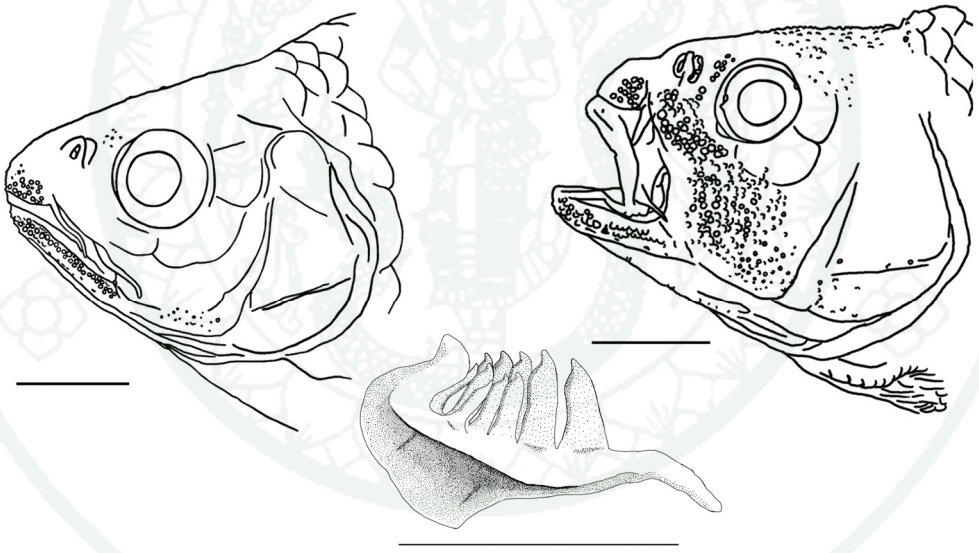

Figure 20 Diagram of right pharyngeal teeth (ventro-mesial view) (RLIKU 1367, 54.8 mm SL) and head of normal (left = RLIKU 1367, 62.2 mm SL) and presumed alpha male (right = ZSI F9983/1, 73.2 mm SL) of *Barilius dogarsinghi*. Scale bar = 5 mm.

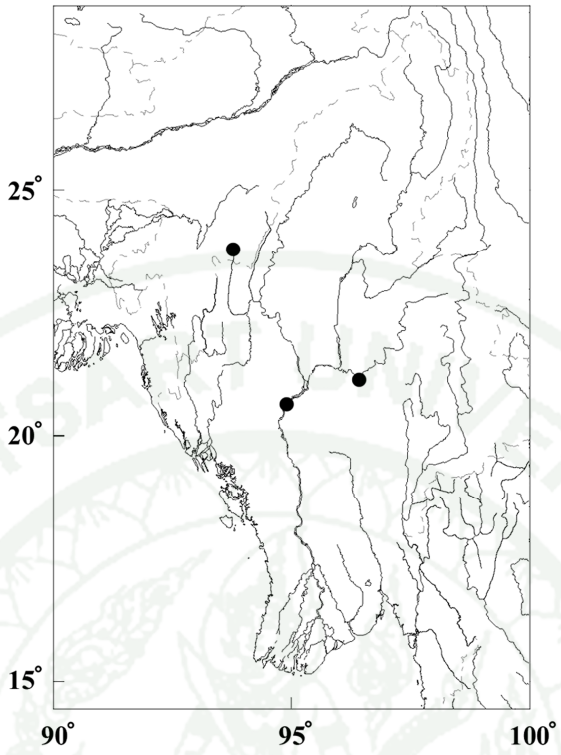

Figure 21 The locality of *B. dogarsinghi* examined in this study.

***Barilius koratensis* Smith, 1931**

(fig. 22-25, 27)

Barilius koratensis Smith, 1931: 16-17, Figure 7 (type locality: Mun River at Tachang, Nakorn Ratchasima Province, Northeastern Thailand).

Barilius huahinensis Fowler, 1937: 347-348, Figure 9, 10 (type locality: Ban Thung Luang, Prachuabkirikhan Province, Western Thailand).

Barilius nanensis Smith, 1945: 155-157, Figure 23 (type locality: Nan River at Ban Pa Khwang, Northern Thailand).

Danio (Allodanio) ponticulus Smith, 1945: 100-101, Figure 8 (type locality: Chiangmai Province, Northern Thailand).

Diagnosis. A *Barilius* species reaching around 90 mm SL that is distinguished from all other congeners by the combination of small number of lateral line scales count at 31-35 scales to the end of hypural plate (rarely 36), absence of large caudal blotch or large caudal spot, head depth less than 20%SL, generally long rostral barbels that is mostly longer than 50% distance between its origin and the end of maxilla, predorsal scales 14-18, branched anal fin rays 8-11, and total vertebrae 37 or less. Other less consistence differences from other *Barilius* are the presence of blue to black marking at the middle of the lower jaw, presence of bright bluish-whitish reflective region on the outer edge of upper and lower caudal lobe in life. *B. koratensis* is the only Indochinese *Barilius* that can have fewer than 5 body bars or no bar at all.

Description. (based on 180 specimens, 32.25-86.15 mm SL) Meristic and morphometric measurements are shown in Table 14-15, respectively.

Branched dorsal fin rays 6-8, branched anal fin rays 8-11, pectoral fin rays 10-13, pelvic fin rays 7-9, 31-36 scales in lateral line scale row to the end of hypural plate, 1-4 scales more to the end of caudal base. 6-7 scale rows above lateral line (predorsal scale row not included), 2-3.5 rows below. 14-18 scales in predorsal scale row. Scales in Circumpeduncle scale row 14-16. Axillary process at the anterior base

of pectoral fin and axillary scale at the anterior base of pelvic fin well developed.

Body oblong, moderately deep (depth 22.11-32.49%SL) and compressed (width 8.06-11.72%SL) with ventral profile more convex than dorsal profile. Head moderately deep (16.19-19.83%SL) and compressed, snout slightly blunt to acute. Caudal peduncle long (length 15.2-23.3%SL) and narrow (depth 9.25-13.3%SL) near caudal base, but appears rather broad when compared with other Indochinese *Barilius*. Mouth large (upper jaw length 8.74-11.65%SL), oblique, terminal, with maxilla extends to the range from vertical from the anterior margin of eye to vertical from about 2/5 of eye diameter. Lower jaw often with no to slight notch with corresponding emargination in the upper jaw. Barbels 2 pairs (sometimes missing on either side), maxillary barbels generally short but rostral barbels length generally at least as long as 50% distance between the origin of rostral barbels and the corner of the mouth, and often as long as the whole distance between the origin of rostral barbels and the corner of the mouth (figure 25). Rostral barbels often under rostral grooves. Eye large (eye diameter 6.17-9.8%SL) but eye size generally decreases with body length, from diameter longer than snout length in small specimens to slightly shorter than snout length in large specimens. Infraorbital bones large. Total vertebrae (N=146) 34-37, abdominal vertebrae (N=122) 16-20, caudal vertebrae (N=122) 16-20.

Dorsal fin origin behind and near the posterior half of the body (not including caudal fin); with narrow base, straight to slightly concave in most specimens. Anal fin origin at the vertical from 3rd – 6th branched dorsal fin rays, the first 3-4 branched rays elongated creating concave to straight margin. Lower lobe of caudal fin longer or equal to upper lobe. Pectoral fin large, often reaches the anterior base of pelvic fin. Pelvic fin origin far in front of dorsal fin origin, anterior tip and posterior tip not reaching the anterior origin of anal fin.

Tuberculation. Some individuals with tiny to small tubercles cover the body, head (figure 25) and parts of fins. Dentary tubercles on tuberculated individuals smaller than all other Indochinese *Barilius* and generally up to around 6-9 incomplete

rows in large specimens, anterior ones larger than posterior ones, and concentrate on the tip and outer and inner edges of dentary. Small tubercles on side of snout, end of maxilla, front of eye, top of eye, all area below eye, the middle of the lower jaw, opercle and branchiostegal region. Some individuals also have tiny tubercles covering back and side of the body. Tubercles also cover the outer surface of pectoral fins. In most other specimens fewer tubercles restrict mainly to snout and dentary.

Color. In life and fresh specimens: dorsum greenish to brownish to grayish, side mainly silvery to gray but sometimes bluish to greenish depending on light angle, belly white to silvery in most specimens (figure 22). Body side with 0-17 blue vertical bars; each bar generally 1/2-1 exposed scale wide, bars in front of anal fin frequently reach or cross lateral line. The number of bars on either side of the body is not always equal. The caudal spot, if present, does not extend far into the anterior region of caudal fin. All bars may become indistinct depending on light reflection and mood of the fish. There is a blue to black elongate mark at the middle of lower jaw in many specimens (figure 27). Pectoral and pelvic fins clear to yellowish. Anal fin clear but some individuals have yellow to orange anterior tip. Caudal fin clear to yellow with dark margins on principal rays, outer parts of branched rays, and the whole branched rays in the middle of the fin (figure 22B-C). The outer edge of both upper and lower principal rays often have irridescent white to light blue or light green coloration that disappear soon after death (figure 22B-C). Dorsal fin clear to yellow (figure 22A-C) with dark pigment on rays (figure 24). In most specimens dark pigment on the first 3-5 branched dorsal rays reach only half of the rays leaving distal half of the dorsal fin clear with distinct illusion of dark band at the middle of fin and yellowish base, with larger area of clear to white dorsal fin tip than other *Barilius* species with similar dorsal fin color pattern.

In preserved specimens: dorsum dark brown, lighter below. All dark pigment in fins, body bars and caudal blotch turn dark brown to black. A dark and thin horizontal stripe often appears along the middle of the body side from behind the opercle down to the caudal base.

Distribution. *Barilius koratensis* is a widespread species that is found in streams and tributaries down to the middle region of the Chao Phraya, Maeklong and Tapi basin. It is also found in streams draining to Pasak and Bangpakong River (figure 28). In the Mekong basin apart from Chee and Mun River in Thailand it is also found in Yunnan (He and Chen, 1994), Laos (Kottelat, 2001b) and Cambodia. Freyhof, Serov & Nguyen (2000) list *B. koratensis* in the checklist of freshwater fishes from Dong Nai River in South Vietnam.

Habitat. *Barilius koratensis* are found mainly in running waters from small slow streams to moderately fast rivers with mud, sand to gravel substrates (figure 26), but it seems to prefer clear running waters with gravel bottoms with rocks. Unlike many other Indochinese *Barilius* it can be found in lowland river. It is often found in small schools and also in large schools as reported in the original description. In mountain streams it can be found together with *B. pulchellus* or *B. ornatus*.

Remarks. Only a few highly tuberculated specimens of *Barilius koratensis* were captured, and their chest and fins are not yet found to enlarge as conspicuously as other *Barilius* species in this study. Although many life and fresh specimens in most locations collected have yellow to orange blotch near the anterior tip of anal fin (figure 22B-C), this blotch disappears soon after preservation.

The presence of narrow and few vertical bars on many specimens of *Barilius koratensis*, the presence of long rostral barbels, the lack of note on thin horizontal stripe in Indochinese *Barilius* in general, having only one type specimens for the original description of *B. koratensis*, and the original description of *B. koratensis* as a species without barbel had caused many confusion and subsequent description of synonyms in the past. In the original description *B. huahinensis* and *B. nanensis* were separated from *B. koratensis* mainly by the lack of barbel in the original description of *B. koratensis*. Vertical bars on type specimen was overlooked for the original description of *Danio ponticulus* (Kaewpaitoon, 1979) but it is shown in the figure accompanied the description (figure 23C). Rostral barbels (which are long) and

maxillary barbels are subsequently founded on the type specimen of *B. koratensis* independently by Sontirat in Kaewpaitoon (1979) and by Howes (1983). Kaewpaitoon (1979) lists the number of circumpeduncle scales from type specimens of *B. koratensis*, *B. huahinensis*, and *D. ponticulus* at 14 which are in range of variation of *B. koratensis* in this study. Data of circumpeduncle scales from holotype of *B. huahinensis* examined by Mark Sabaj, although listed at 12-13, did note that some circumpeduncle scales are missing (table 17). According to findings in this study and Kaewpaitoon (1979) number of vertical bars on *Barilius* can be quite varied so it is not suitable character to diagnose *Barilius* species. From the present study (table 14-18), studies by Kaewpaitoon and Howes, and conclusion by Kottelat (1984) morphometric and meristic characters and overall appearances of *B. koratensis*, *B. huahinensis*, *B. nanensis*, and *Danio ponticulus* are within range of specimens examined in this study, with lateral line scales 31-35 (rarely 36), circumpeduncle scales 13-16, long rostral and short maxillary barbels, lack of caudal blotch, and presence of vertical bars without wide pigmented horizontal stripe, with *B. koratensis* as the first available name and the other species names as junior synonyms.

The only *Barilius* species with the combination of long rostral barbels and short maxillary barbels apart from *Barilius koratensis* are *Barilius vagra* (Day, 1878; Talwar and Jhingran, 1991), *B. mesopotamicus* (Coad, 2010), and some specimens of *B. pulchellus*. Data of *B. vagra* from Talwar and Jhingran (1991) and *B. mesopotamicus* from Coad (2010) show that both species have many more scales on the lateral line than *B. koratensis* (38 or more vs. 31-36) and *B. vagra* has more predorsal scales (21-26 vs. 14-18), however. *B. pulchellus* has 19 or more predorsal scales, larger dentary tubercles, and dorsal fin color pattern with dark pigment concentrated in intermembrane region forming blotch. With less than 37 lateral line scales *B. koratensis* is distinct from all other *Barilius* species which has 37 lateral line scales or more (*B. bakeri*, *B. barila*, *B. barna*, *B. bendelisis*, *B. canarensis*, *B. evezardi*, *B. gatensis*, *B. modestus*, *B. radiolatus*, *B. shacra*, *B. tileo*, *B. shacra naseeri*, *B. dimorphicus*, *B. lairokensis*, *B. ngawa*, *B. chatricensis*, and *B. borneensis*) according to Talwar and Jhingran (1991), Vishwanath and Manojkumar (2002), Mirza, Rafiq, and Awan (1986), Arunkumar and Singh (2000), Tilak and Husain

(1990), Selim and Vishwanath (2002), and Roberts (1989). While Roberts (1989) stated that *B. borneensis* from Borneo is similar in body shape, fin positions, body and dorsal fin coloration to *B. nanensis* and *Danio ponticulus* which are junior synonyms of *B. koratensis* in this study, *B. borneensis* has short rostral barbels at 1/3 eye diameter which is shorter than 50% distance between the origin of rostral barbels and the corner of the mouth, and has no maxillary barbel (*B. koratensis* has long rostral barbels at 50% distance between the origin of rostral barbels and the corner of the mouth or more and short maxillary barbels), number of branched dorsal fin rays at 9 (*B. koratensis* at 6-8), fewer number of branched anal fin rays than any Indochinese *Barilius* at 7, and scales on the lateral line at about 39 (*B. koratensis* at 31-36).

Material examined. ANSP 60203 *Barilius huahinensis* (holotype), 72.2 mm SL, Ban Thung Luang, village on coastal plain in SW Siam, 10 miles NW of Hua Hin, 10 miles inland from sea, 9 January 1934, R.M. deSchuensee, examined by Sabaj, M.; ANSP 60203 *Barilius huahinensis* (paratypes), (8) 36.4-67 mm SL, same data.

RLIKU 1376 (15) 47.95-86.15 mm SL, Stream near Khao Yai, Nakorn Ratchasima Province, Thailand. 27 January 2004; RLIKU 1352 (1) 42.33 mm SL, Tributary of Mekong River, Champasak, Laos, 22 September 2002, Prachya Musikasinthorn and co.; RLIKU 1353 (6) 36.65-49.25 mm SL, Kong Jiam District, Mekong River, Ubon Ratchathani Province, Thailand, 18 June 2005, Nathanant and co.; RLIKU 1377 (9) 33.15-53.5 mm SL, Huai Satyai, Pranburi District, Prachuap Khiri Khan Province, Thailand, 25 August 2003; RLIKU 1378 (3) 69.85-79.05 mm SL, Huai Ou Rong, Thong Pha Phum District, Kanchanaburi Province, Thailand, 31 March 2004, collected from fishermen; RLIKU 1379 (12) 34.4-46.35 mm SL, Mae Taeng River, Mae Taeng District, Chiang Mai Province, Thailand, 9 December 2004; RLIKU 1380 (3) 45.8-52.5 mm SL, Ban Pong Wang, Lampang Province, Thailand, 10 May 2003; RLIKU 1354 (6) 50.2-62.7 mm SL, Sobprab County, Sobprab District, Lampang Province, Thailand, 4 January 1993, Prachya Musikasinthorn; RLIKU 392 (6) 52.3-67.1 mm SL. Nan River, Muang Jang County, Phu Wiang Subdistrict, Nan Province, Thailand. 29 April 2004, Amornchai Lothongkarm; RLIKU 1381 (10) 45.1-69.4 mm SL, Lam Phraya Tharn, Ban Wang Hin, Kabhinburi District,

Pracheenburi Province, Thailand, 4 December 2003; UNMF 00563 (4) 43.8-50.2 mm SL, Mo Ket, Ban Na San, Tapi River, Surat Thani Province, Thailand, 11 October 2006, Chaiwut Grudpan; UNMF 00555 (10) 40-50.1 mm SL, Nong Yang Reservoir, Non Yang County, Chakaratch District (near Ta Chang), Nakorn Ratchasima Province, Thailand, 22 May 2004; UNMF 00556 (9) 45.8-62.1 mm SL, Phupaman District, Khon Kaen Province, Thailand, 9 April 2005; UNMF 00557 (20) 38.9-67.4 mm SL, Pachee River, Suanpeung District, Ratchaburi Province, Thailand, 10 October 2002; UNMF 00558 (6) 63.85-82.4 mm SL, Tributary of Kwai Noi River, Sanklaburi District, Kanchanaburi Province, Thailand, 1 April 2004; UNMF 00554 (4) 47.95-86.15 mm SL, Stream near Khao Yai, Nakorn Ratchasima Province, Thailand. 27 January 2004; UNMF 00559 (3) 47.2-55.45 mm SL, Huai Sai, Doi Saket District, Chiang Mai Province, Thailand, 21 March 2003; UNMF 00560 (6) 45.5-58.1 mm SL. Same Data, 8 May 2003; UNMF 00562 (3) 57.43-63.3 mm SL. Stream near Jedsaonoi Falls, Sraburi Province, Thailand, 14 December 2003; UNMF 00561 (10) 36.9-55.93 mm SL, Muang District, Phrae Province, Thailand, 20 May 2005; THNHM UNCAT (3) 59.4-66.75 mm SL, Huai Kha Khaeng at Khao Bandai (at Huai Mae Ti confluence), Thailand, 18 January 1991, Tyson Roberts et.al; THNHM F000128. (15) 38.6-58.75 mm SL, Hwai Mae Hoi, Ban Nam Tok Mae Klang, Ban Luang Subdistrict, Chom Thong District, Chiang Mai Province, Thailand, 20 October 2000, Veera Vilasri; THNHM UNCAT (4) 32.23-44.65 mm SL, Mekong mainstream E of Chiang Khan, Loei Province, Thailand, 11-12 March 1990, Tyson Roberts; CAS 93386 (4) 49.8-57.7 mm SL, O Champha, 4-8 km upstream from its mouth into Tonle San Near Te Veng, Ratanakiri Province, Cambodia, 14-15 February 1994, Roberts, Tyson R.and Witte, Kai-Erik.

Table 14 Morphometric measurements (in %SL) of *Barilius koratensis* (* = from data from type specimens in Kaewpaitoon {1979}, ** = from figure in the original description).

Measurements (%SL)	*Barilius koratensis* (original description) N=1	*Barilius koratensis* (N=180)		
		range	mean	SD
Standard length (mm)	45 *	32.23-86.15	-	-
Body depth	28.57	22.11-32.49	26.28	1.89
Pelvic-dorsal depth	30.51 **	23.39-34.08	28.39	1.97
Caudal peduncle depth	11.86 **	9.25-13.3	11.42	0.69
Caudal peduncle length	15.25 **	15.2-23.3	19.09	1.32
Preanal length	69.49 **-	60.51-70.19	65.55	1.75
Predorsal length	54.24 **-	54.29- 61.72	57.97	1.43
Prepelvic length	49.15 **-	44.3-51.99	48.1	1.39
Pelvic-anal fin length	22.03 **	13.34-21.72	18.37	1.35
Dorsal fin base length	15.25 **	12.20-17.43	14.95	0.98
Anal fin base length	19.49 **	16.13-21.94	18.9	1.15
Lateral head length	27.7 *	22.4-28.18	24.85	1
Dorsal head length	18.64 **	16.42-22.94	19.1	1.07
Head depth	20.34 **	16.19-19.83	17.73	0.66
Head width	-	8.06-11.72	9.96	0.66
Snout length	7.76 *	5.99-9.65	7.48	0.67
Preorbital head depth	13.56 **	8.73-12.08	10.11	0.61
Postorbital head depth	17.8 **-	11.66-17.45	15.65	0.72
Postorbital length	9.99 *	9-13.35	11.34	0.67
Interorbital width	8.86 *	6.91-9.5	8.14	0.54
Eye diameter	7.76 *	6.17-9.8	8.15	0.67
Upper jaw length	7.63 **	8.74-11.65	10.04	0.54
Head depth (%lhl)	85.71 **	64.32-81.22	71.41	2.83
Snout length (%lhl)	28 *	23.3-38.91	30.11	2.55
Postorbital length (%lhl)	44 *	37.44-52.76	45.65	2.44
Interorbital width (%lhl)	32 *	26.29-38.53	32.81	2.33
Eye diameter (%lhl)	28 *	26.79-39.06	32.81	2.18
Upper jaw length (%lhl)	32.14 **	33.63-45.35	40.42	2

Table 15 Meristic counts and other characteristics of *Barilius koratensis* (* = from data from type specimens in Kaewpaitoon {1979}, ** = from figure from the original description).

Counts	***Barilius koratensis* (original description) N=1**	***Barilius koratensis* (N=180)**		
		range	**mean**	**SD**
Origin of anal fin opposite branched dorsal fin rays	6th **	3rd (24), 4th (114), 5th (40), 6th (2)	4.11	0.62
Pectoral fin rays	13 *	10 (1), 11 (28), 12 (92), 13 (59)	12.16	0.69
Pelvic fin rays	8 *	7 (29), 8 (147), 9 (4)	7.86	0.41
Branched dorsal fin rays	7	6 (3), 7 (175), 8 (2)	6.99	0.17
Branched anal fin rays	10	8 (8), 9 (88), 10 (78), 11 (6)	9.46	0.64
Lateral line scales	34	[31 (8), 32 (24), 33 (58), 34 (53), 35 (31), 36 (6)] + (2-4)	33.52	1.16
Scale rows above lateral line	7	6 (118), 7 (62)	6.34	0.48
Scale rows below lateral line	2	2 (64), 2.5 (6), 3 (101), 3.5 (9)	2.65	0.51
Predorsal scales	17	14 (10), 15 (35), 16 (75), 17 (47), 18 (13)	16.11	0.98
Circumpeduncle scales	14 *	14 (78), 15 (46), 16 (55)	14.87	0.85
Total vertebrae (N=146)	-	34 (1), 35 (26), 36 (85), 37 (34)	36.04	0.66
Abdominal vertebrae (N = 122)	-	16 (4), 17 (29), 18 (80), 19 (8), 20 (1)	17.78	0.65
Caudal vertebrae (N = 122)	-	16 (1), 17 (15), 18 (65), 19 (38), 20 (2)	18.21	0.71

Table 16 Morphometric measurements (in %SL) of nominal species of *Barilius* synonymized with *Barilius koratensis*. Data of *B. huahinensis* Holotype by Sabaj, M. (* = from data from type specimens in Kaewpaitoon {1979}, ** = from figure from the original description, *** = from photograph of type specimens).

Measurements (%SL)	***Barilius huahinensis*** **(holotype)**	***Barilius nanensis*** **(original description)** **N=7**	***Danio ponticulus*** **(=original description)** **N=1**
Standard length (mm)	72.2	51.5-68 *	55 *
Body depth	28.95	25.7-30.6 *	25.4 *
Pelvic-dorsal depth	30.47	33.33 **	27.68 ***
Caudal peduncle depth	11.22	12.28 **	11.61 ***
Caudal peduncle length	20.22	15.79 **	15.18 ***
Preanal length	69.11	72.81 **	66.96 ***
Predorsal length	56.09	60.53 **	59.82 ***
Prepelvic length	51.25	54.39 **	50 ***
Pelvic-anal fin length	18.42	21.93 **	17.86 ***
Dorsal fin base length	15.51	15.79 **	15.93 **
Anal fin base length	17.45	15.79 **	20.35 **
Lateral head length	25.62	22.7-27.1 *	22.7 *
Dorsal head length	18.28	17.54 **	18.75 ***
Head depth	18.64	21.05 **	17.86 ***
Head width	11.91	-	-

Table 16 (Continued)

Measurements (%SL)	*Barilius huahinensis* (holotype)	*Barilius nanensis* (original description) N=7	*Danio ponticulus* (=original description) N=1
Snout length	7.06	4.81-7.45 *	5.49 *
Preorbital head depth	12.47	12.28 **	11.61 ***
Postorbital head depth	17.59	19.3 **	16.96 ***
Postorbital length	12.19	8.92-12.14 *	10.71 ***
Interorbital width	8.73	7.29-11.19 *	9.92
Eye diameter	7.06	7.09- 8.47	7.94
Upper jaw length	10.11	10.53 **	10.71 ***
Head depth (%lhl)	73.51	82.76 **	76.92 ***
Snout length (%lhl)	27.57	21.2-27.5 *	26.67
Postorbital length (%lhl)	47.57	39.3-44.8 *	50 ***
Interorbital width (%lhl)	34.05	32.1-41.3 *	41.66
Eye diameter (%lhl)	27.58	28-31 *	33.33
Upper jaw length (%lhl)	39.46	41.38 **	46.15 ***

Table 17 Meristic counts and other characteristics of nominal species of *Barilius* synonymized with *Barilius koratensis*. Data of *B. huahinensis* Holotype by Sabaj, M. (* = from data from type specimens in Kaewpaitoon {1979}, ** = from figure from the original description).

Counts	***Barilius huahinensis*** **(holotype)**	***Barilius nanensis*** **(original description)** **N=7**	***Danio ponticulus*** **(original description)** **N=1**
Origin of anal fin opposite branched dorsal fin rays	4th	5th **	3rd **
Pectoral fin rays	12	11-13 *	11
Pelvic fin rays	7	8-9 *	8
Branched dorsal fin rays	8	7	7
Branched anal fin rays	11	9- 10 *	10
Lateral line scales	34-35	32- 34 *	31
Scale rows above lateral line	ca. 7	7-7.5 *	6
Scale rows below lateral line	ca. 3	2-2.5 *	1.5 *
Predorsal scales	ca. 14	16-18 *	14
Circumpeduncle scales	12-13 (scales missing)	14	14 *

Table 18 Selected characters of nominal species of *Barilius* synonymized with *Barilius koratensis*.

characters	***B. koratensis***	***B. huahinensis***	***B. nanensis***	***D. ponticulus***	**specimens examined (N=180)**
Lateral line scales	32	34-35	32-34	31	31-36
Circumpeduncle scales	14	14	14	14	14-16
Rostral barbels	long	long	long	long	long
Maxillary barbels	short	short	short	short	short
Vertical bars	yes	yes	yes	yes	yes
Wide horizontal stripe	no	no	no	no	no
Caudal blotch	no	no	no	no	no

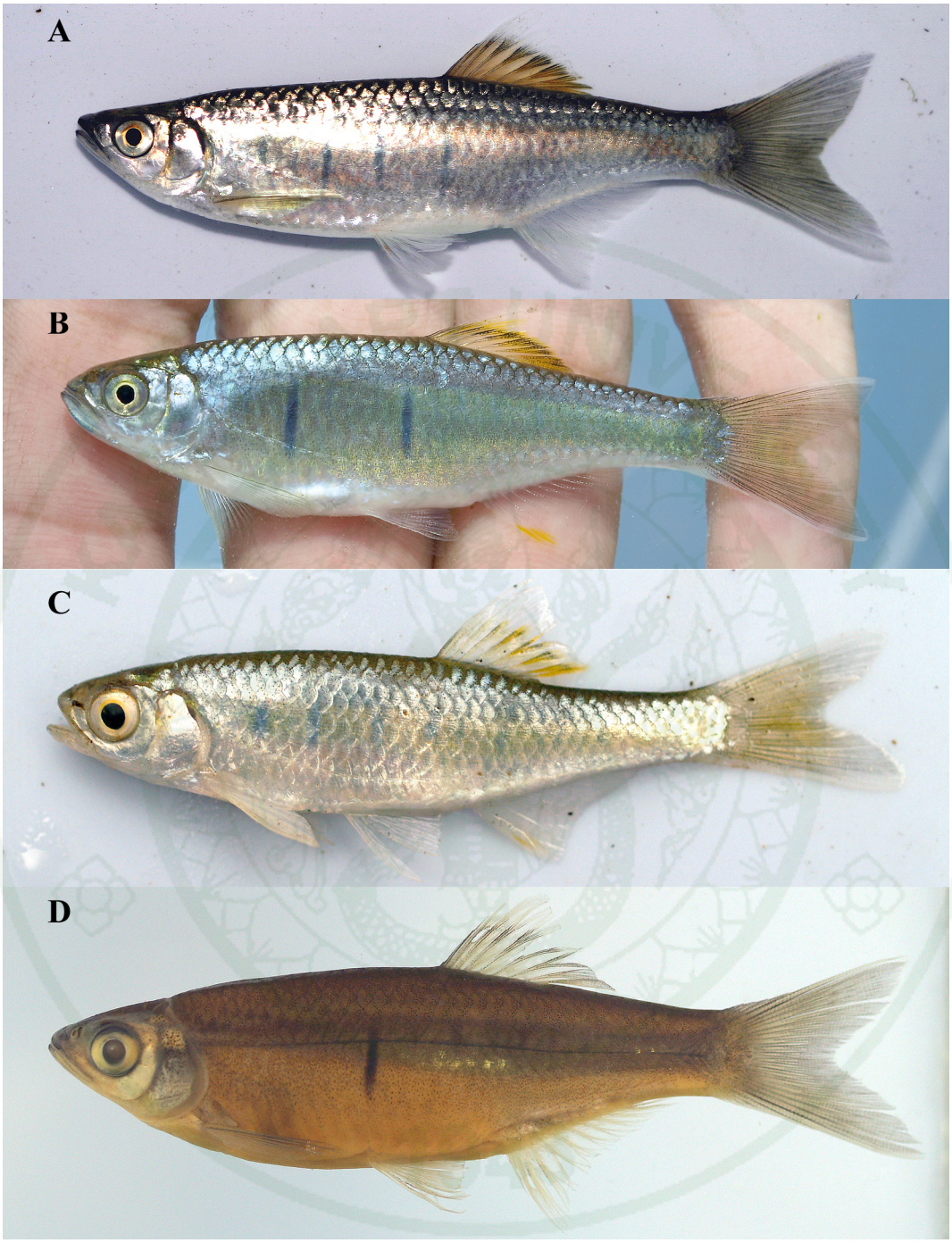

Figure 22_ *Barilius koratensis* A) RLIKU 1376. 86.15 mm SL. Stream near Khao Yai, tributary of Mun River, Nakorn Ratchasima Province, Thailand, B) ca. 70 mm SL. Tributary of Kwai Noi River, Thongpapoum District, Kanchanaburi Province, Thailand. Not preserved, C) UNMF 00561. ca. 50 mm SL. Tributary of Yom River, Muang District, Phrae Province, Thailand, D) RLIKU 1376. 63.9 mm SL.

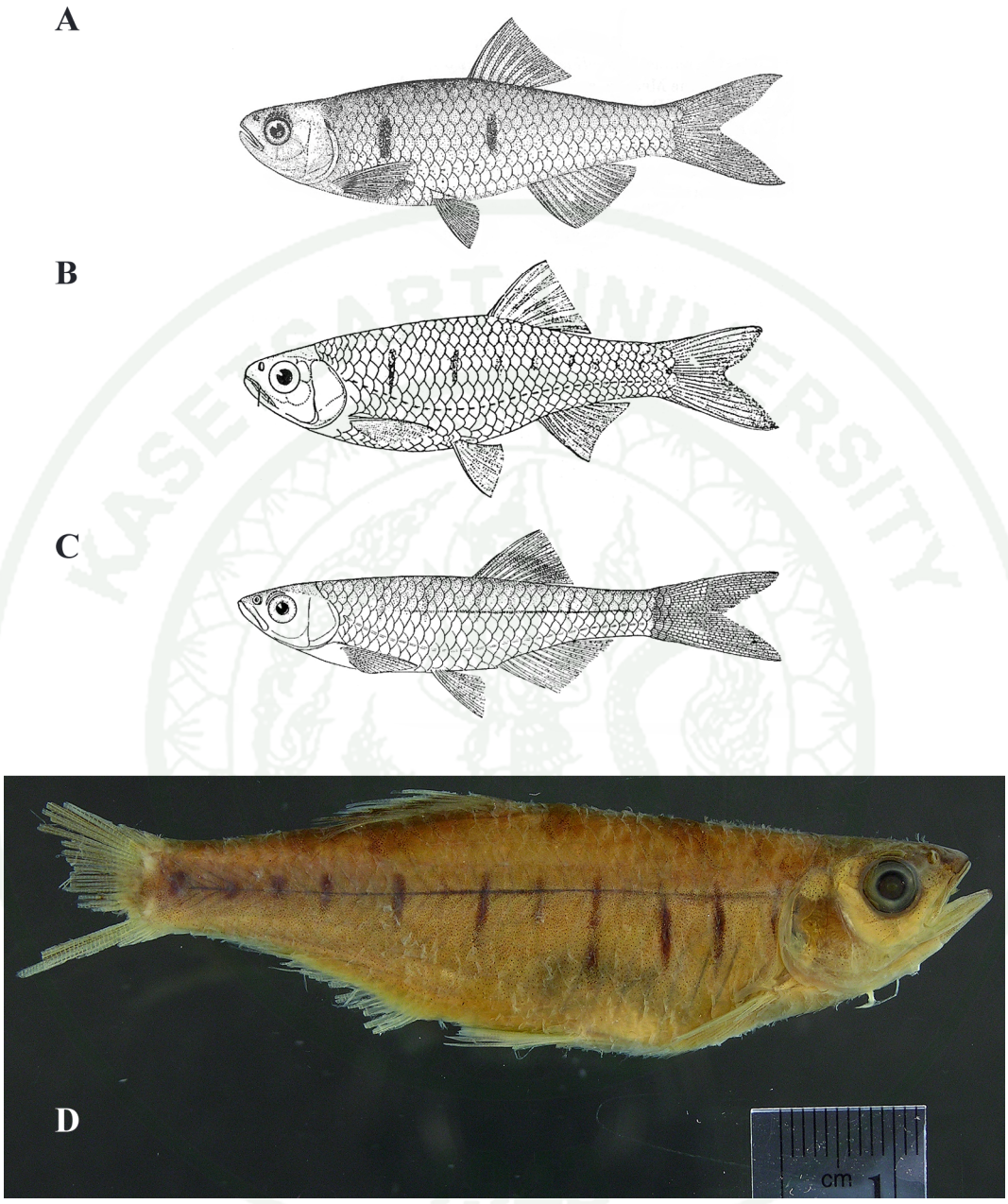

Figure 23 A-C Figures of *Barilius koratensis* and junior synonyms of *B. koratensis* in this study from original descriptions. A) *Barilius koratensis* (Smith, 1931), B) *Barilius nanensis* (Smith, 1945), C) *Danio ponticulus* (Smith, 1945), D) ANSP 60203. Holotype of *Barilius huahinensis*. 72.2 mm SL. Ban Thung Luang, village on coastal plain in SW Siam, 10 miles NW of Hua Hin, 10 miles inland from sea. ANSP photograph.

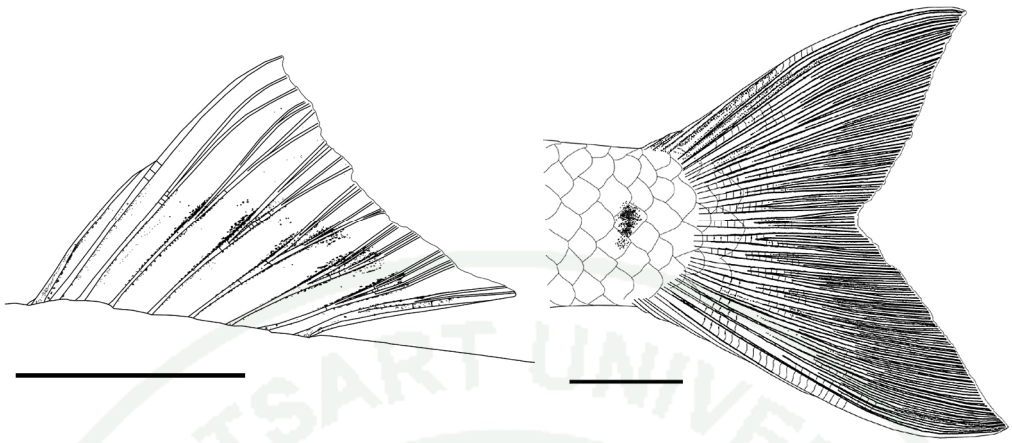

Figure 24 Diagram of dorsal fin (RLIKU 1376, 50.75 mm SL) and caudal region (RLIKU 1376, 58.3 mm SL) of *B. koratensis*. Scale bar = 5 mm.

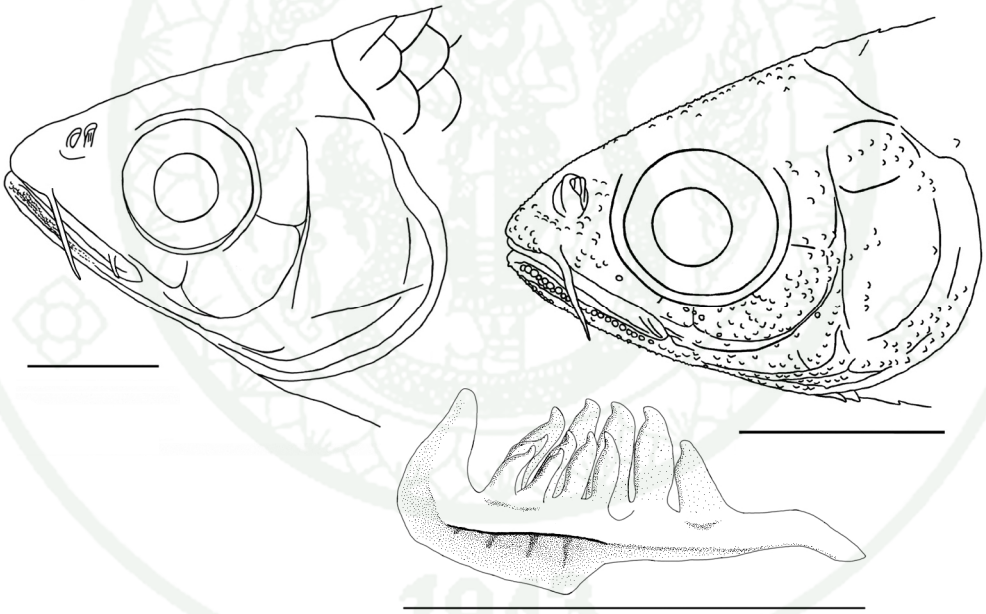

Figure 25 Diagram of right pharyngeal teeth (ventro-mesial view) (RLIKU 1376, 56.8 mm SL) and head of normal (left = RLIKU 1376 63.9 mm SL) and presumed male (right = UNMF 00561, 40.75 mm SL) of *B. koratensis*. Scale bar = 5 mm.

Figure 26 *Barilius koratensis* habitat: Huai Sai, Doi Saket District, Chiang Mai Province, Thailand (above), Huai Nam Wa, tributary of Nan River, Nan Province, Thailand (below). Photograph of Huai Nam Wa by Nonn Panitvong.

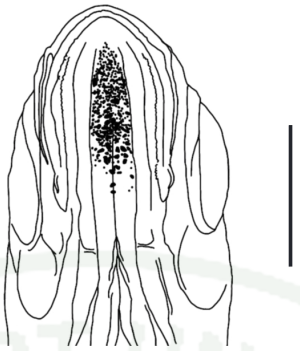

Figure 27 Diagram of the the concentration of dark pigment at the lower jaw that is found on many specimens of *B. koratensis* but not other *Barilius* species in this study (RLIKU 1376, 63.9 mm SL). Scale bar = 5 mm.

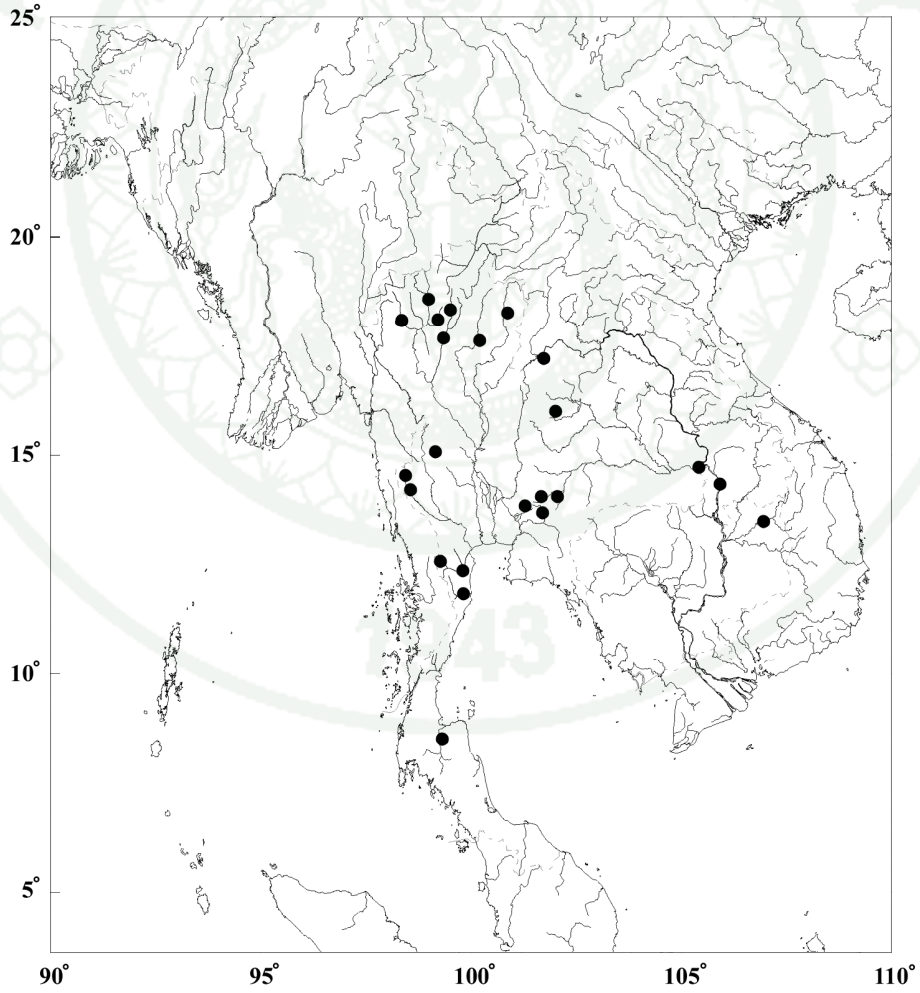

Figure 28 Locality of *Barilius koratensis* in this study.

Barilius ornatus Sauvage, 1883

(fig. 29-36)

Barilius ornatus Sauvage, 1883: 153-154 (type locality: Menam, Siam).

Barilius barnoides Vinciguerra, 1890: 307-310, Figure 9 (type locality: Kachin, Myanmar).

Barilius infrafasciatus Fowler, 1934: 141-142, Figure 114-115 (type locality: Maetaeng River, 35 miles north of Chiengmai, Chiangmai Province, northern Thailand).

Barilius caudiocellatus Chu, 1984: 98-102 (type locality: Mengding (23° 33' N, 99° 5' E) belonging to Salween drainage, Yunnan, China).

Danio monshiensis Yang and Hwang, 1964: 587-589 (type locality: Yunnan, China).

Diagnosis. A *Barilius* species reaching around 120 mm SL that is distinguished from all other congeners by having 37-43 scales on the lateral line (rarely 36), predorsal scales 17-23 (rarely 16), circumpeduncle scales 16 or less (rarely 15-16), head depth not less than 16.82%SL, dark pigment on dorsal fin not concentrate on the middle of intermembrane nor forming strong submarginal band but concentrating at edge of branched dorsal fin rays, generally short and thin rostral and maxillary barbels if present, small dentary tubercles, and at least 38 total vertebrae or more.

Description. (based on 197 specimens, 31.75-121.35 mm SL) Meristic and morphometric measurements are shown in Table 19-20, respectively.

Branched dorsal fin rays 7-9, branched anal fin rays 9-12, pectoral fin rays 11-15, pelvic fin rays 7-10, 36-43 scales in lateral line scale row to the end of hypural plate, 1-4 scales more to the end of caudal base. 6-8 scale rows above lateral line (predorsal scale row not included), 1.5-4 rows below. 16-23 scales in predorsal scale row. Scales in Circumpeduncle scale row 11-16. Axillary process at the anterior base

of pectoral fin and axillary scale at the anterior base of pelvic fin well developed.

Body oblong, deep (depth 20.88-34.47%SL) and compressed (width 8.82-16.37%SL) with ventral profile more convex than dorsal profile. Head deep (depth 16.82-23.92%SL) and compressed, snout slightly blunt to acute. Caudal peduncle long (length 11.86-23.11%SL) and narrow (depth 8.13-12.36%SL) near caudal base. Mouth large (upper jaw length 8.96-13.66%SL), oblique, terminal, with maxilla extends to the range from vertical from the anterior margin of eye to vertical from the posterior edge of pupil. In some specimens the snout projects beyond lower jaw, and in few specimens lower jaw projects beyond upper jaw. Lower jaw with no notch to slight notch with corresponding emargination in the upper jaw. Barbels 2 pairs (often missing on either side), both rostral and maxillary barbels generally short and tiny, often only rudimentary, with rostral barbel length generally far shorter than 50% distance between the origin of rostral barbels and the corner of the mouth (figure 36). Rostral barbels often under rostral grooves. Eye large (eye diameter 5.5-10.78%SL) but eye size generally decreases with body length, from diameter longer than snout length in small specimens to slightly shorter than snout length in large specimens. Infraorbital bones large. Total vertebrae (N=141) 38-43, abdominal vertebrae (N=135) 18-23, caudal vertevrae (N=135) 18-21. Presumed alpha male with greatly enlarged chest (figure 29B, 30A, 31B, 32B, and 33B-C).

Dorsal fin origin behind and near the posterior half of the body (not including caudal fin), straight to slightly concave in most specimens, convex with middle and posterior branched rays lengthened in presumed alpha male, the posterior tip often surpasses the vertical from the posterior base of anal fin in presumed Presumed alpha male (figure 29B, 30A, 31B, 32B, and 33B-C). Anal fin origin at the vertical from 2nd branched rays to slightly behind last branched dorsal fin rays, the first 3-4 branched rays elongated creating concave margin, in presumed alpha male the margin is less concave or straight. Lower lobe of caudal fin longer or equal to upper lobe. Pectoral fin large, often reaches the anterior base of pelvic fin. Pelvic fin origin far in front of dorsal fin origin, anterior tip not reaching the anterior origin of anal fin, posterior tip generally not reach the anterior origin of anal fin but often reach the anterior origin of

anal fin in presumed alpha male.

Tuberculation. In highly tuberculated male numerous small tubercles cover the whole body, head and parts of fins (figure 29B, 30A, 31B, and 32B). Dentary tubercles on highly tuberculated male generally up to around 5 incomplete rows in large specimens, anterior ones larger than posterior ones, and more distinct on the outer and inner edges of dentary (figure 36). Small tubercles on side of snout, end of maxilla, front of eye, top of eye, all area below eye, opercle and branchiostegal region. Larger tubercles on the whole side of the body, generally up to around 4 tubercles per scale in large specimens. Small and large tubercles on snout, dorsum, and dorsal region. Tubercles also cover the outer surface of pectoral and pelvic fins, part of dorsal and anal fins, and the upper lobe of caudal fin. In most other specimens tubercles restrict mainly to snout and dentary, and not as numerous nor as large as on highly tuberculated male.

Color. In life and fresh specimens: dorsum greenish to grayish, side silvery to greenish or bluish depending on light angle, belly silvery in most specimens but some with slightly reddish orange to bronze belly (figure 29A-B, 30A,C). Presumed alpha male often with slightly reddish orange to bronze belly that exclude lower jaw region (figure 29B, 30A). Body side with 6-17 blue vertical bars (not including the caudal spot), each bar generally 1-2 scale wide, most bars in front of anal fin generally reach or cross lateral line, but in some specimens these bars do not reach lateral line and appear as spots or disappear, but reappears after a while in preservation. These bars are often broken up into double bars both vertically and horizontally, and often the number of bars on either side of the body is unequal. Marking on caudal base varies greatly between specimens from different drainages. The caudal spot, if present, does not extend far into the anterior region of caudal fin in specimens from Salween, Maetaeng, Ataran and Ayeyarwaddy drainages. Specimens from Maeklong and Pegu drainages have a large caudal blotch at caudal base extending into the anterior region of caudal fin. All bars may become indistinct depending on light reflection and mood of the fish, and sometimes hard to distinguish. Pectoral and pelvic fins clear to yellowish or orange. Pelvic fins sometimes with bright whitish anterior and posterior

margin in specimens from Ayeyarwaddy and Pegu drainages. Anal fin clear to yellow to orange, with bright whitish. anterior tip in specimens from Ayeyarwaddy and Pegu drainages, clear to faint whitish anterior tip in specimens from other drainages. Caudal fin with dark margins on principal rays, outer parts of branched rays, and the whole branched rays in the middle of the fin, sometimes forming dark outer frame; caudal fin membrane clear to yellowish. Ayeyarwaddy and Pegu specimens have light caudal fin margin. Dorsal fin clear to pinkish with dark pigment on rays and membrane, concentrating at the edge at the side of dorsal fin rays forming one indistinct horizontal stripe halfway on the anterior part of dorsal fin. In most specimens dark pigment on the first 3-5 branched dorsal rays do not reach the tip of the fin leaving clear to white anterior dorsal fin tip (figure 35), but in presumed alpha male dark pigment expands toward the anterior dorsal fin tip.

In preserved specimens: silvery, red and green coloration usually disappear. Dorsum dark brown, lighter below. All dark pigment in fins, body bars and caudal blotch turn dark brown to black. A dark and thin horizontal stripe sometimes appears along the middle of the body side from behind the opercle down to the caudal base.

Distribution. *Barilius ornatus* is a widespread species that is found both in streams and rivers of the Ayeyarwaddy, Salween, Ataran, Pegu, and Maeklong drainages. It is also found in the Maetaeng River, which is the tributary of the Ping River which is the western tributary of the Chao Phraya River, and some tributaries of the Mekong basin (figure 38).

Habitat. *Barilius ornatus* are found in running waters of various types from small, slow streams to fast rivers with mud, sand to gravel substrates (figure37).

Remarks. Sauvage described *Barilius ornatus* from specimens obtained from Dr. Harmand (Sauvage, 1883). Their locality was reported as Menam, Siam. Although it is presumed that “Menam” at the collecting time is the Chao Phraya River as reported by Smith, (1945) and Kaewpaitoon (1979), the word “Menam” means “River” in Thai and it can actually be any river in Siam (Thailand) at that time. Even if “Menam” is

the Chao Phraya River it is not known what part of the long river with 4 main northern tributaries these specimens are from. No *Barilius* species other than *B. koratensis* and *Raiamas guttatus* has been found in the Chao Phraya River mainstream from Nakorn Sawan Province down to the delta since the original description of *B. ornatus*, however (Smith, 1945). It is notable that life or very fresh color of the type specimens of *B. ornatus* was recorded as silver with blue bars, since these blue color quickly turns dark or fade after dead for a short while.

In 1984 Kottelat examined the type specimens of *B. ornatus* and designated the two specimens as lectotype and paralectotype. From his examination he finds several errors on the original description. The type specimens of *B. ornatus* have small maxillary barbels and 41 scales on the lateral line scales row as opposed to no barbel and 45 scales in the original description. He compares *B. ornatus* with *Barilius* specimens from Nam Yuan (tributary of Salween) that he designated as *B. barnoides* and concludes that they are different species based on smaller eye (diameter 5.3-6.5%SL vs. 7.4-7.6%SL), longer caudal peduncle (17-19%SL vs. 14-16%SL), prepelvic length (47-48%SL vs. 52-53%SL), and shorter preanal length (64-68%SL vs. 69-72%SL). In the present study the range of eye diameter (5.5-10.08%SL), caudal peduncle length (14.17-23.11%SL), prepelvic length (45.79-54.96%SL), and preanal length (64.42-75.15%SL) of *Barilius* in this study overlappes Kottelat's measurements of both *B. ornatus* and *B. barnoides* though. Mr. Chaivut Grudpan examined the type specimens of *B. ornatus* in 2008 and, according to his examination, eye diameter of the lectotype and paralectotype of *B. ornatus* is 7.75 and 6.7%SL, caudal peduncle length is 14.73 and 11.86%SL, and prepelvic length is 51.27and.51.59%SL respectively. Kottelat reports that the lectotype and paralectotype of *B. ornatus* have 16 and 14 predorsal scales respectively, while data provided by Grudpan in this study have 17 and 16 respectively. Apart from the predorsal scale count of paralectotype of *B. ornatus* (16) all other measurements of type specimens of *B. ornatus* seem to fit in the measurements of specimens examined in this study.

The morphometric and meristic characters of syntype of *B. barnoides* and

holotype of *B. infrafasciatus* also fall within range of specimens examined in this study as well, with no caudal spot and one small caudal spot respectively, dorsal fin pigment align at the edge of dorsal fin rays, anal fin origin opposite 6th and 4th branched dorsal fin ray respectively, and small dentary tubercles (table 11-15). Fowler differentiated *B. ornatus* from *B. infrafasciatus* based on Sauvage's error on number of scales on the lateral line on the original description of *B. ornatus* (45), anal fin origin further back, slightly shorter head, and the absent of barbel in *B. ornatus*. He did not compare *B. infrafasciatus* with *B. barnoides*. The position of dorsal and anal fin and head length of *Barilius* can vary slightly, and tiny barbels can be absent in some specimens of the same species and population. Thus *B. barnoides* and *B. infrafasciatus* are regarded as junior synonyms of *B. ornatus* in this study. *Danio monshiensis* Yang and Hwang from Ayeyarwaddy drainage in Yunnan was regarded as synonym of *Barilius barnoides* by Chu (1984) (as *B. barila*) and Kottelat (1984). From its proportion, meristics counts, and color pattern from original description and the figure accompanying the description (table 13-15 and figure 34B) it is within range of *B. ornatus*. Morphometric and meristic characters of *B. caudiocellatus* syntypes is within range of *B. ornatus* (table 13-15), the same dorsal fin color pattern as *B. ornatus*, and the small caudal spot of *B. caudiocellatus* is also the same as *B. ornatus* (figure 37A). Thus *Danio monshiensis* and *B. caudiocellatus* are junior synonym of *B. ornatus* in this study.

In the description of *B. caudiocellatus* Chu stated that *Danio monshiensis* is a junior synonym of *B. barila* based on Mukerji's study in 1934 that synonymized *B. barnoides* with *B. barila*. Mukerji based his statement on the presence of both rostral and maxillary barbels on paratype [syntype?] of *B. barnoides* and Day's specimen of *B. barila*, and that the shape of the infraorbital bones of both species, previously used by Day as differentiating character, are actually varied. Many species of *Barilius* have both pairs of barbels, however. Since it is not known whether or not the body length measured by Day is the standard length or the total length, from the measurement of Hamilton and Day's figures of *Barilius barila* (figure 34C-D) their heads are relatively narrow at around 15-16.5%SL which is narrower than all *Barilius*

from mainland Indochina in this study (except *B. koratensis*) whose head depth are at least 16.82%SL. One 70.4 mm SL specimen of *Barilius* from Gowahati, Assam, India identified as *B. barila* in this study has extremely narrow head at 14.77%SL (figure 34E). *B. barila* can be differentiated from *B. koratensis* by having more scales on the lateral line (43-46 scales vs. 31-36 in *B. koratensis*), and from *B. vagra* from India by the length of rostral barbels, which is very short in *B. barila* but only shorter than eye diameter in *B. vagra* (Talwar and Jhingran, 1991).

The majority of morphometric and meristic characters of *Barilius barna* from Northern India (Talwar and Jhingran, 1991) overlaps with *B. ornatus*. *Barilius barna* has 15-16 predorsal scales while most of *B. ornatus* has 17-23 predorsal scales (only the paralectotype has 16 scales). In life the body color of *B. barna* is said to be silvery shot with gold, while the body color of *B. ornatus* is silvery to greenish or bluish. According to Talwar and Jhingran (1991) and Selim and Vishwanath (2002) most of the other Indian *Barilius* species with 36-43 lateral line scales (*B. canarensis*, *B. evezardi*, *B. gatensis*, *B. chatricensis*, and *B. modestus*) has 14-15 predorsal scales as well. *B. bakeri* has 16 predorsal scales but has 10 branched dorsal fin rays and 14 branched anal fin rays (Talwar and Jhingran, 1991), while *B. ornatus* has 7-9 branched dorsal fin rays and 9-12 branched anal fin rays. *Barilius bendelisis* has comparable number of lateral line scales and predorsal scales but has only 7-8 branched anal fin rays (Talwar and Jhingran, 1991) and adult with a black spot on each scale on the side at its base (Day, 1878). *Barilius borneensis* has fewer branched anal fin rays (7 vs. 9-12) than *B. ornatus* (Roberts, 1989). *B. mesopotamicus* has well developed rostral barbels longer than 50% distance between the origin of rostral barbels and the corner of the mouth (vs. much shorter than 50% in *B.ornatus*), brilliant silvery color with golden-yellow glimmer (vs. silvery to greenish in *B. ornatus*), and generally has more lateral line scales (42-58 vs. 36-43 in *B. ornatus*) (Coad, 2010). According to Vishwanath and Manojkumar (2002) all 41 type specimens of *B. ngawa* has 16-17 circumpeduncle scales while almost all *B. ornatus* in this study (197 specimens) generally have 11-15 circumpeduncle scale, with 13 specimens having 15 circumpeduncle scales, and only 2 specimens have 16 circumpeduncle scales. *B. lairokensis* has more lateral line scale than *B. ornatus* (44

vs. 36-43) and has two black spots in the back of caudal peduncle (Arunkumar and Singh, 2000). *Barilius shacra*, *B. shacra naseeri*, *B. tileo*, *B. radiolatus*, and *B. dimorphicus* have 46 lateral line scales or more, while *B. ornatus* has 43 lateral line scale or less (Talwar and Jhingran, 1991; Mirza, Rafiq, and Awan, 1986; Tilak and Husain, 1990).

From characters of examined specimens and photographs of life and fresh specimens it is possible that *Barilius ornatus* are composed of several different morphological groups. *Barilius ornatus* from the Ayeyarwaddy and Pegu drainages often has one more scale rows above lateral line (7-8 vs. 6-7) and slightly more lateraline scales (37-43 vs. 36-41) than *B. ornatus* from Salween and Ataran drainages (table 24). Photo of life and fresh Ayeyarwaddy and Pegu specimens also show bright light inner margin on caudal fin, and on anterior tip of pelvic and anal fins (figure 29C, 30A-B) while life and fresh specimens from Salween, Ataran, and the Maetaeng drainages have pale to clear inner margin on caudal fin (figure 29A-B), but it is not known whether or not most or all specimens have this feature. Individuals from the Maeklong Drainage have 8 scale rows above the lateral line like the majority of the Ayeyarwaddy specimens, but Maeklong specimens have large caudal blotch (which is absent or only small caudal spot present in Ayeyarwaddy and Salween specimens) without bright white caudal fin margin (figure 30C), and their anal fin origin is opposite 2^{nd} – 4^{th} branched dorsal fin rays as opposed to 4^{th} to slightly behind 7^{th} branched dorsal fin rays in Ayeyarwaddy and Salween-Ataran populations. Individuals from Pegu Drainage also have large caudal blotch (figure 30B), but both Pegu and Ayeyarwaddy specimens share bright light markings in life and fresh conditions (figure 29C, 30A-B). Pegu specimens also have their anal fin origin opposing 5^{th} – 7^{th} branched dorsal fin rays. Nevertheless other characters of specimens from all drainages are similar to each other and it is better to identify them as *Barilius ornatus* in this study.

Material examined. MNHN A-5074 (lectotype), 90.3 mm SL, Menam, Thailand, 1882, Harmand, examined by Grudpan, C.; MNHN B-2981 (paralectotype), 91.1 mm SL, Same data, examined by Grudpan, C.; BMNH 1893.2.16.40 (syntype) (1), 98.6

mm SL, Kakhien Hills, upper Myanmar, 16 February 1893, L. Fea; ANSP 58940 *Barilius infrafasciatus* (holotype), 74.4 mm SL, Maetaeng River, tributary of Ping River, 35 miles N of Chiengmai, northern Thailand, 18 January 1933, deSchuensee, R.M., examined by Sabaj, M.; ANSP 58941 *Barilius infrafasciatus* (paratypes) (3), 47.9-68.38 mm SL, Same data; KIZ 748230-748235, 748237-748240, 197400916-197400917 *Barilius caudiocellatus* (syntypes) (12), 61.45-77.8 mm SL, Mengding (23° 33' N, 99° 5' E) belonging to Salween drainage, Yunnan, China, 1974.

RLIKU 1355 (2) 83.6-86.65 mm SL, Panglung River, border between Mandalay and Shan States, Myanmar, August 1995, Musikasinthorn, P.; RLIKU 1356 (4) 50.65-60 mm SL, Pagan Market, Pagan, Myanmar, 14 August 1995, Musikasinthorn P.; RLIKU 1384 (6) 44.9-66.08 mm SL, Huai Pa, Maetaeng River, Chiengmai Province, Thailand, 9 May 2003; RLIKU 1357 (3) 63.5-86.7 mm SL, Pai River, Maehongson Province, Thailand, 3 February 1993, Musikasinthorn, P. *et al*.; RLIKU 1358 (4) 57.15-75.65 mm SL, Pai River, Maehongson Province, Thailand, 3 February 1993, Musikasinthorn, P. *et al*.; RLIKU 1383 (3) 55.75-57.7 mm SL, Huai Nam Ping Noi, Pai district, Maehongson Province, Thailand, 16 February 2005; RLIKU 1382 (4) 68.55-97.6 mm SL, Huai Maelamao, Tak Province, Thailand, 13 February 2004; RLIKU 1385 (1) 71.5 mm SL, Lang River, tributary of Pai River, Pangmapha district, Maehongson Province, Thailand; 17 February 2005; RLIKU 1359 (2) 50.8-83.9 mm SL, N,want stream at Luho bridge, 27 miles from Wai Maw, Wai Maw township, Myitkyina district, Kachin state, Myanmar, 24 August 2008, Musikasinthorn, P. *et al*.; RLIKU 1360 (1) 121.35 mm SL, Setapu market (morning), Myitkyina township, Myitkyina division, Kachin state, Myanmar, 23 August 2008, Musikasinthorn, P. *et al*.; RLIKU 1361 (1) 93.3 mm SL, Wai Maw market, Wai Maw township, Myitkyina district, Kachin state, Myanmar, 25 August 2008, Musikasinthorn, P. *et al*.; RLIKU 1362 (4) 76.4-92.55 mm SL, Setapu Market, Holaw village, Myitkyina district, Kachin state, Myanmar, 23 August 2008, Musikasinthorn, P. *et al*.; RLIKU 1365 (6) 38.15-75.95 mm SL Nan Khwin stream at Nan Khwin bridge, Five Miles village, Mo Pin township, Moenyin district, Kachin state, Myanmar, 18 March 2009, Musikasinthorn, P. *et al*.; RLIKU 1364 (3) 78.3-87.25 mm SL Setapu market (morning), Myitkyina township, Myitkyina division, Kachin state,

Myanmar, 23 August 2008, Musikasinthorn, P. *et al*.; RLIKU 1363 (3) 67.25-115.7 mm SL Setapu Market, Holaw village, Myitkyina district, Kachin state, Myanmar, 26 August 2008, Musikasinthorn, P. *et al*.; RLIKU 1371. 45.13-53.25 mm SL. Payalay stream, Pegu (17° 30' N, 96° 32' E) Myanmar, 12 August 1995, Musikasinthorn, P.; NRM 27091 *Barilius barila* (20) 44.75-64.63 mm SL, Mu-se, Ayeyarwaddy drainage, Shan State, Myanmar, 31 December 1993, R.M. Fang Fang; NRM 40920 *Barilius* (6) 31.75-63.6 mm SL, Nan Hto Chaung, ca. 1 mile from 48th regiment close to rice mill in Putao, Ayeyarwaddy River drainage, Myanmar, Kullander, SO and Britz, R.; NRM 31903 *Barilius* (4) 31.75-61 mm SL, Ayeyarwaddy River, Myitkyina, Kachin State, Myanmar, 7 August 1934, Malaise, R.; BMNH 1972.7.26 12-13 *Barilius barna* (1) (specimen without tag) 80.15 mm SL, Upper Myanmar, 26 July, 1972 (but collected in 1939 according to BMNH online data), Kaulback, R.; MJUFM cat # 1141 (5) 62.2-90.55 mm SL, St. 1, Ban Chang, Chiengmai Province, Thailand, 17 October 2000; MJUFM cat # 1147 (8) 47.15-55.25 mm SL, St. 1, guest house, Chiengmai Province, Thailand, 6 April 2002; NRM 18775 (2) 77.8-77.93 mm SL, Nu Jiang or Langang Jiang (Salween or Mekong) close to Myanmar border, Yunnan, China; End of March to September 1934, Malaise, R.; NRM 10503 (5) 55-69.3 mm SL, Kawkareik River, Kayin State, Myanmar, October 1934, Malaise, R.; THNHM UNCAT (3) 62.35-83.6 mm SL, Mountain stream flowing from Thailand into Salween (midway between Mae Sam Leap and Palek), Salween basin, Thailand, 20 April 1989, Tyson, R.; KIZ 2006003977 and 2006003986 (2) 80.75-105.7 mm SL, Longchuan River at Mengyue Township, Longchaun County, Yunnan, China. 2006; UNMF 00564 (6) 44.9-83.7 mm SL, Huai Pa, Maetaeng River, Chiengmai Province, Thailand, 20 March 2003; UNMF 00565 (10) 51.85-100.38 mm SL, Huai Nam Ping Noi, Pai district, Maehongson Province, Thailand, 9 May 2003; UNMF 00567 (2) 67.6-68.25 mm SL, Huai Maelamao, Tak Province, Thailand, 13 February 2004; UNMF 00579 (1) 68.45 mm SL, Lang River, tributary of Pai River, Pangmapha district, Maehongson Province, Thailand, 17 February 2005; UNMF 00568 (3) 83.63-94.1 mm SL, Maehongson Province, Thailand, 2004; UNMF 00569 (8) 64.75-98.9 mm SL, Kasa River, the border between Sangklaburi district, Kanchanaburi Province, Thailand and Myanmar, Myanmar, October 2002; UNMF 00570 (2) 103.6-106.6 mm SL, same locality. October 2002; UNMF 00571 (1) 88.85 mm SL, Suriya River,

Jakae, Laivo, Sangklaburi district, Kanchanaburi Province, Thailand, April 2006, specimen collected by fishermen; UNMF 00566 (3) 65.28-73.75 mm SL. Bridge across Pai river in Pai district, Maehongson Province, Thailand; UNMF 00575 (11) 43.75-96.95 mm SL, Sangklaburi District, Maeklong basin, Kanchanaburi Province, Thailand, 1 April 2004; RLIKU 1372 (1) 88.45 mm SL, same locality, 11 April 2003, Panitvong, N.; UNMF 0035 (7) 62.95-74.8 mm SL, Krung-Krai, Srisawat District, Maeklong basin, Kanchanaburi Province, Thailand, Grudpan, C. *et al.*; THNHM F.00531 (3) 37.1-78.5 mm SL, Huai Maelamung, Umpang District, Maeklong basin, Tak Province, Thailand, 24-26 July 2002, Vilasri, Y.; THNHM UNCAT (5) 71.8-92.2 mm SL, Huai Mae La Mun, Dan Ta Chalab, Srisawat District, Kanchanaburi, Thailand, 20 July 1999, Tanya Chan-Arb; THNHM UNCAT (4) 54.2-69.1 mm SL, Hai Sai Khao at Klong Kor (Huai Kae Kaeng), Maeklong basin, Thailand, 16 January 1999, Tyson Roberts *et al.*.

Barilius barila: RLIKU 1391 (1) 70.4 mm SL, Gowahati, Assam, India, 8 April 1998, Prachya Musikasinthorn.

Table 19 Morphometric measurements (in %SL) of *Barilius ornatus*. Data of *B. ornatus* lectotype by Grudpan, C..

Measurements (%SL)	*Barilius ornatus* (lectotype)	*Barilius ornatus* (N=197)		
		range	mean	SD
Standard length (mm)	90.3	31.75-121.35	-	-
Body depth	30.79	20.88-34.47	27.77	2.62
Pelvic-dorsal depth	31.78	22.35-36.59	29.13	2.71
Caudal peduncle depth	11.3	8.13-12.36	10.43	0.74
Caudal peduncle length	14.73	11.86-23.11	18.19	1.58
Preanal length	68.66	62.80-75.15	68.88	1.93
Predorsal length	56.81	51.43-63.29	58.56	1.77
Prepelvic length	51.27	45.79-54.96	50.99	1.56
Pelvic-anal fin length	18.72	15.15-22.97	19.05	1.48
Dorsal fin base length	14.51	11-17.3	13.72	1.27
Anal fin base length	15.61	13.14-21.69	17.18	1.66
Lateral head length	25.25	22.86-30.03	26.34	1.3
Dorsal head length	19.16	16.12-23.32	19.76	1.26
Head depth	19.71	16.82-23.92	19.86	1.46
Head width	12.07	8.82-16.37	11.48	1.27
Snout length	6.87	6.29-11.13	7.85	0.78
Preorbital head depth	12.07	8.56-16.18	11.63	1.38
Postorbital head depth	16.61	12.2-21.73	17.38	1.57
Postorbital length	10.63	9.61-17.59	13.13	0.99
Interorbital width	8.31	6.36-10.13	8.56	0.69
Eye diameter	7.75	5.5-10.78	7.72	0.85
Upper jaw length	11.96	8.96-13.66	11.01	0.91
Head depth (%lhl)	78.07	65.16-85.44	75.4	4.26
Snout length (%lhl)	27.19	23.46-40.51	29.72	2.35
Postorbital length (%lhl)	42.11	38.36-68.86	49.9	3.37
Interorbital width (%lhl)	32.89	22.61-42.97	32.64	2.84
Eye diameter (%lhl)	30.70	21.9-38.86	29.36	3.05
Upper jaw length (%lhl)	47.37	24.5-49.76	41.62	3.17

Table 20 Meristic counts and other characteristics of *Barilius ornatus*. Data of *B. ornatus* lectotype by Grudpan, C..

Counts	*Barilius ornatus* (lectotype)	*Barilius ornatus* (N=197)		
		range	mean	SD
Origin of anal fin opposite branched dorsal fin rays	6th	2nd (1), 3th (13), 4th (26), 5th (38), 6th (53), 7th (59), about 1 ray width after 7th ray (7)	5.70	1.32
Pectoral fin rays	14	11 (1), 12 (60), 13 (96), 14 (34), 15 (6)	12.92	0.78
Pelvic fin rays	9	7 (6), 8 (105), 9 (83), 10 (2)	8.41	0.57
Branched dorsal fin rays	7-8	7 (179), 8 (17), 9 (1)	7.1	0.31
Branched anal fin rays	11	9 (26), 10 (132), 11 (38), 12 (1)	10.07	0.58
Lateral line scales	39	[36 (9), 37 (37), 38 (46), 39 (47), 40 (27), 41 (23), 42 (6), 43 (2)] + (1-4)	38.73	1.57
Scale rows above lateral line	7	6 (12), 7 (98), 8 (87)	7.38	0.6
Scale rows below lateral line	3	1.5 (1), 2 (8), 2.5 (35), 3 (95), 3.5 (50), 4 (8)	3.03	0.45
Predorsal scales (N=196)	17	16 (1), 17 (7), 18 (23), 19 (38), 20 (72), 21 (448), 22 (7), 23 (4)	19.8	1.26
Circumpeduncle scales	14	11 (1), 12 (34), 13 (42), 14 (105), 15 (13), 16 (2)	13.51	0.91
Total vertebrae (N=141)	-	38 (8), 39 (43), 40 (43), 41 (32), 42 (14), 43 (1)	40.03	1.08
Abdominal vertebrae (N=135)	-	18 (2), 19 (22), 20 (50), 21 (39), 22 (20), 23 (2)	20.44	1.03
Caudal vertebrae (N=135)	-	18 (2), 19 (62), 20 (62), 21 (9)	19.58	0.64

Table 21 Morphometric measurements (in %SL) of nominal species of *Barilius* synonymized with *Barilius ornatus*. Data of *B. infrafasciatus* holotype by Sabaj, M., * = data from figure from the original description.

Measurements (%SL)	***B. barnoides*** **(BMNH syntype)**	***B. infrafasciatus*** **(holotype)**	***D. monshiensis*** **(original description)**	***B. caudiocellatus*** **(syntypes) N = 12**
Standard length (mm)	98.6	74.4	67-103	61.45-77.8
Body depth	25.25	26.61	25-27.03	24.88-30.53
Pelvic-dorsal depth	26.06	27.15	30.22 *	27.67-32.98
Caudal peduncle depth	10.04	10.08	10-11.11	9.81-11.19
Caudal peduncle length	16.84	18.95	16.66-20	17.8-20.96
Preanal length	67.04	66.4	72.53 *	66.87-71.09
Predorsal length	56.44	59.27	56.04 *	56.23-63.29
Prepelvic length	51.67	50.27	49.45 *	48.42-53.75
Pelvic-anal fin length	18.36	17.2	23.08 *	18.39-22.08
Dorsal fin base length	13.79	13.44	15.38 *	11.73-14.04
Anal fin base length	18.91	18.01	17.58 *	14.59-17.22
Lateral head length	24.65	26.48	22.22-25	24.14-26.58
Dorsal head length	17.04	18.95	15.93 *	17.78-19.67
Head depth	17.75	20.3	18.13 *	17.48-19.6
Head width	9.43	12.5	-	8.97-11.5

Table 21 (Continued)

Measurements (%SL)	***B. barnoides*** **(BMNH syntype)**	***B. infrafasciatus*** **(holotype)**	***D. monshiensis*** **(original description)**	***B. caudiocellatus*** **(syntypes) N = 12**
Snout length	6.29	7.53	6.54-8.33	6.84-7.81
Preorbital head depth	10.14	12.23	12.09 *	9.57-11.64
Postorbital head depth	16.18	18.28	17.03 *	14.44-17.82
Postorbital length	12.98	11.96	13.19 *	12.36-14.25
Interorbital width	7.96	8.6	6.73-8.93	6.77-7.98
Eye diameter	6.19	7.26	4.83-5.95	5.5-7.97
Upper jaw length	9.84	11.29	9.34 *	9.51-11.26
Head depth (%lhl)	72.02	76.65	75 *	65.95-78.1
Snout length (%lhl)	25.51	28.43	29.41-33.33	27.59-29.82
Postorbital length (%lhl)	52.67	45.18	50 *	50-56.48
Interorbital width (%lhl)	32.3	32.49	30.3-35.7	26.55-31.91
Eye diameter (%lhl)	25.1	27.41	21.74-23.81	21.9-31.15
Upper jaw length (%lhl)	39.92	42.64	38.64 *	36.9-45.01

Table 22 Meristic counts and other characteristics of nominal species of *Barilius* synonymized with *Barilius ornatus*. Data of *B. infrafasciatus* holotype by Sabaj, M., * = data from figure from the original description.

Counts	*B. barnoides* (BMNH syntype)	*B. infrafasciatus* (holotype)	*D. monshiensis* (original description)	*B. caudiocellatus* (syntypes) N = 12
Origin of anal fin opposite branched dorsal fin rays	6th	4th	7th *	5th-6th
Pectoral fin rays	13	14	12	12-14
Pelvic fin rays	9	9	9	8-9
Branched dorsal fin rays	7	7-8	7	7
Branched anal fin rays	11	10	10-11	10-11
Lateral line scales	41	41	42-44	38-40
Scale rows above lateral line	7	7	8	7-8
Scale rows below lateral line	3	3	2	2.5-3
Predorsal scales	21	18	18-19	20-23
Circumpeduncle scales	14	12	14-15	12-15

Table 23 Selected characters of nominal species of *Barilius* synonymized with *Barilius ornatus*.

Characters	***B. ornatus*** **(lectotype)**	***B. barnoides*** **(BMNH syntype)**	***B. infrafasciatus*** **(holotype)**	***D. monshiensis*** **(original description and figure from original description)**	***B. caudiocellatus*** **(syntypes)**	**specimens examined (N = 197)**
Lateral line scales	39	41	41	42-44	38-40	36-43
Anal fin origin opposing branched dorsal fin rays	6^{th}	6^{th}	4^{th}	7^{th}	5^{th}-6^{th}	2^{nd}-very slightly behind 7^{th}
Predorsal length (%SL)	56.81	56.44	59.27	57.27	56.23-63.29	51.43-63.29
Head depth (%SL)	19.71	17.75	20.3	18.8	17.48-19.6	16.82-23.92
Dorsal fin color pattern	-	Pigment at edge of rays	Pigment at edge of rays	Pigment at edge of rays	Pigment at edge of rays	Pigment at edge of rays
Caudal mark	no	one small caudal spot at caudal base	one small caudal spot at caudal base	no	no or one small caudal spot at caudal base	no or one small caudal spot at caudal base, or one large caudal blotch

Table 24 Comparision of the number of lateral line scales, scale rows above lateral line and the order of branched dorsal fin ray that overlaps the origin of anal fin between *Barilius ornatus* from different drainages.

Lateral line scales	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**mean**	**SD**
Salween (N=86)	6	21	26	24	7	2			38.13	1.16
Ayeyarwaddy (N=56)		1	4	10	16	21	3	1	40.11	1.12
Pegu (N=5)		1	1	2	1				38.6	1.14
Maeklong (N=31)	4	13	11	3					37.42	0.85
Scale rows above lateral line		**6**			**7**			**8**	**mean**	**SD**
Salween (N=86)		12			74				6.86	0.35
Ayeyarwaddy (N=56)					9			47	7.84	0.37
Pegu (N=5)					3			2	7.4	0.55
Maeklong (N=31)								31	8	0
Anal fin origin	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**Not overlapped**		**mean**	**SD**
Salween (N=86)			9	31	30	15	1		5.63	0.93
Ayeyarwaddy (N=56)				4	13	34	5		6.71	0.73
Pegu (N=5)					1	4			6.8	0.45
Maeklong (N=31)	1	13	17						3.52	0.57

Figure 29 A) *Barilius ornatus* ca. 80 mm SL. Stream flowing into Salween River, Maesamlab district, Maehongson Province, Thailand. Not preserved. B) *B. ornatus* ca. 85 mm SL. Same location. Presumed alpha male. Not preserved. C) *B. ornatus* RLIKU 1359. 83.9 mm SL. N,want stream at Luho bridge, 27 miles from Wai Maw, Wai Maw township, Myitkyina district, Kachin state, Myanmar. Photograph by Sakda Arbsuwan.

Figure 30 A) *Barilius ornatus* ca. 100 mm SL. Ayeyarwaddy drainage, Ruili, Yunnan, China. Male. KIZ photograph. B) *B. ornatus* RLIKU 1371. ca 50 mm SL. Payalay stream, Pegu (17° 30' N, 96° 32' E), Myanmar. Photograph by Prachya Musikasinthorn. C) *B. ornatus* ca. 80 mm SL. Sangklaburi District, Maeklong drainage, Kanchanaburi Province, Thailand. Not preserved.

Figure 31 A) *B. ornatus* RLIKU 1383. 57.7 mm SL. Huai Nam Ping Noi, Pai district, Maehongson Province, Thailand. B) *B. ornatus* RLIKU 1385. 71.5 mm SL. Lang River, tributary of Pai River,Pangmapha district, Maehongson Province, Thailand. Presumed alpha male. C) *B. ornatus* RLIKU 1361. 93.3 mm SL. Wai Maw market, Wai Maw township, Ayeyarwaddy drainage, Myitkyina district, Kachin state, Myanmar.

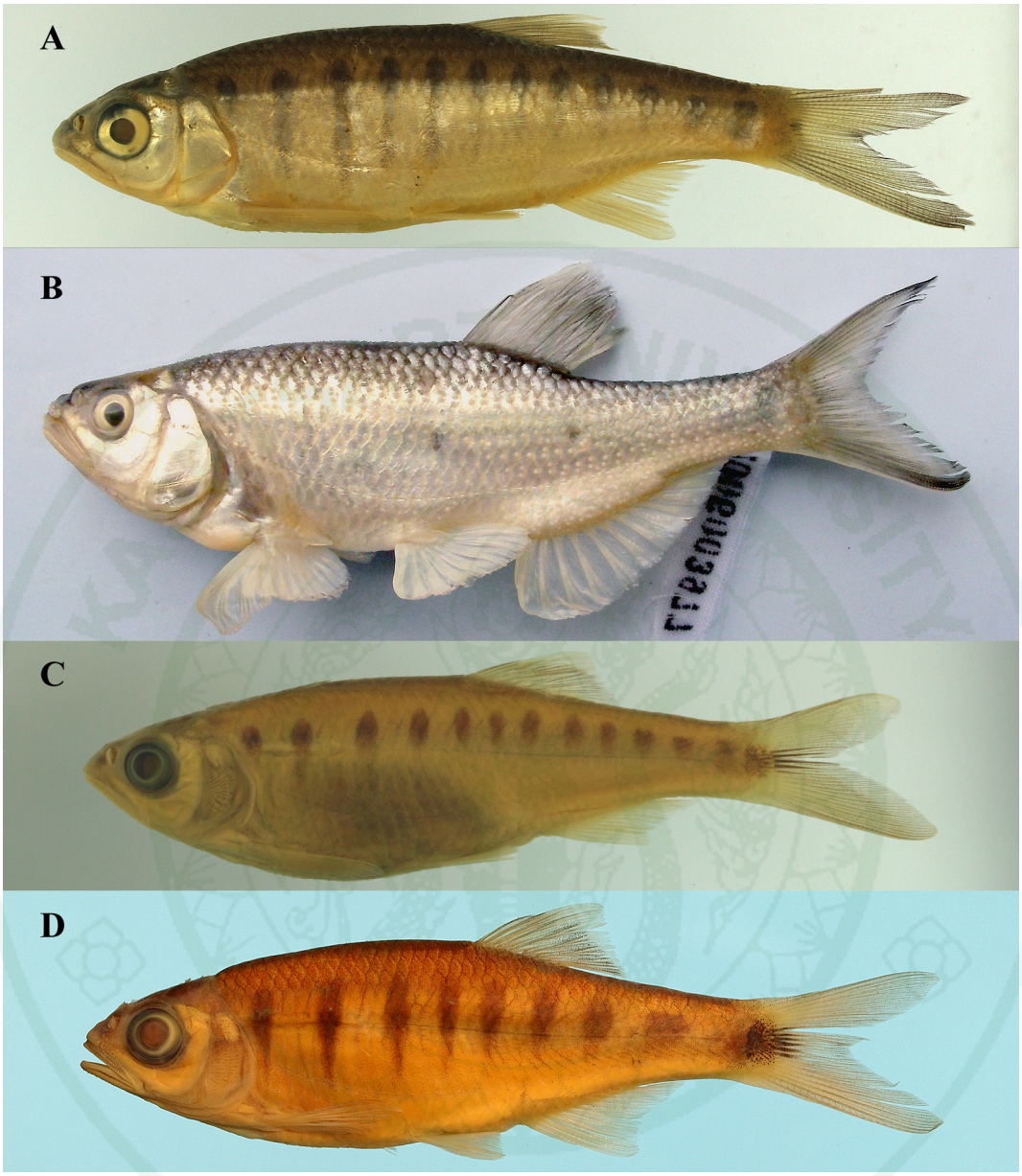

Figure 32 A) *Barilius ornatus* NRM 40920. 63.6 mm SL. Nan Hto Chaung, ca. 1 mile from 48th regiment close to rice mill in Putao, Ayeyarwaddy drainage, Myanmar. B) *B. ornatus* KIZ 2006003977. 105.7 mm SL. Longchuan River at Mengyue Township, Longchaun County, Yunnan, China. Presumed alpha male. C) *B. ornatus* RLIKU 1371. 53.25 mm SL. Payalay stream, Pegu (17° 30' N, 96° 32' E) Myanmar. D) *B. ornatus* UNMF 00575. 43.75 mm SL. Sangklaburi District, Maeklong basin, Kanchanaburi Province, Thailand.

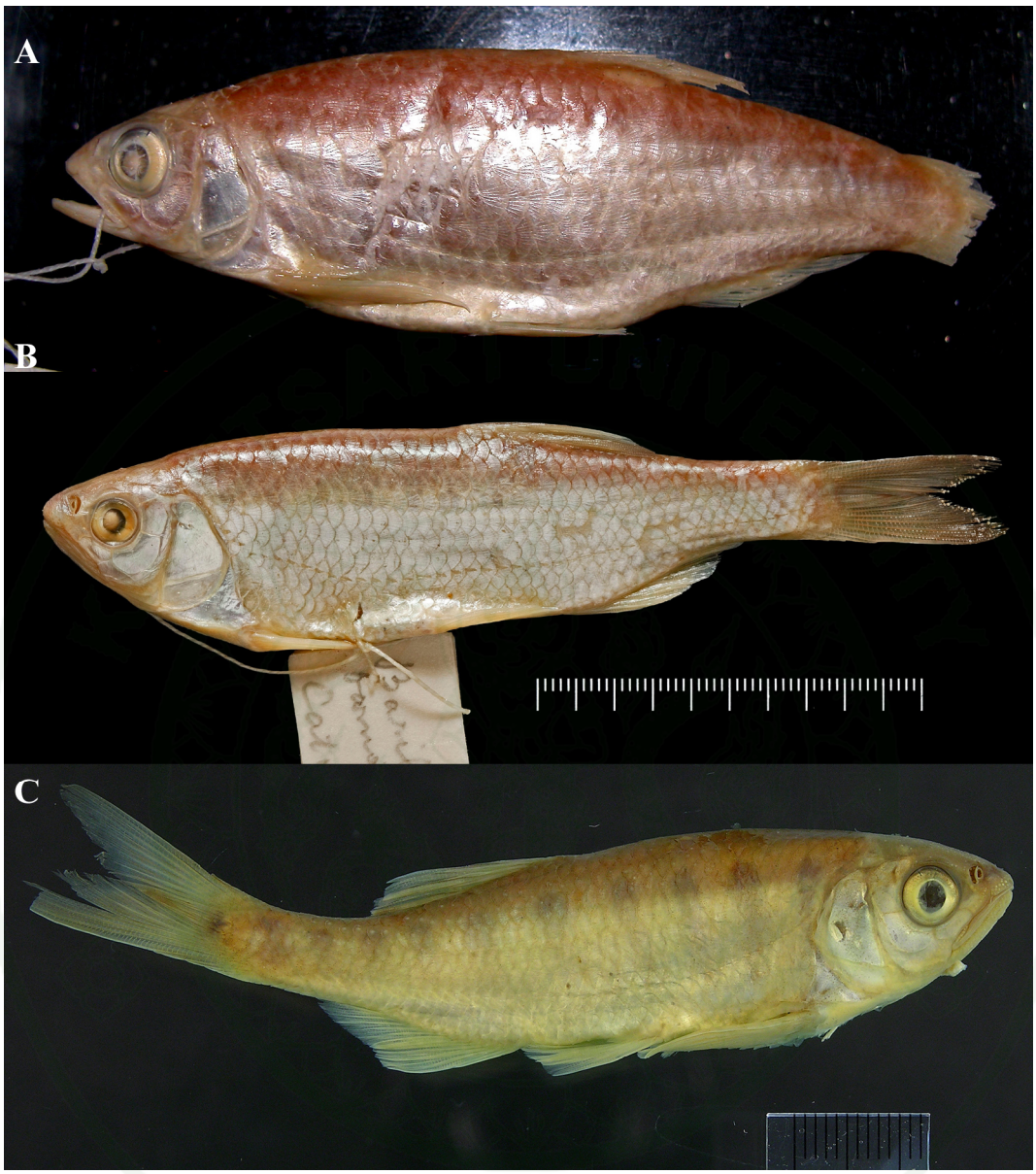

Figure 33 A) *Barilius ornatus* MNHN A-5074. Lectotype. 90.3 mm SL. Thailand. Photograph by Chaiwut Grudpan. B) *B. ornatus* BMNH 1893.2.16.40. One of syntype of *B. barnoides*. 98.6 mm SL. Kachin, Myanmar. Presumed male. BMNH photograph. C) *B. ornatus* ANSP 58940. Holotype of *B. infrafasciatus*. 74.4 mm SL. Maetaeng River, tributary of Ping River, 35 miles N of Chiengmai, northern Thailand. Presumed male. ANSP photograph.

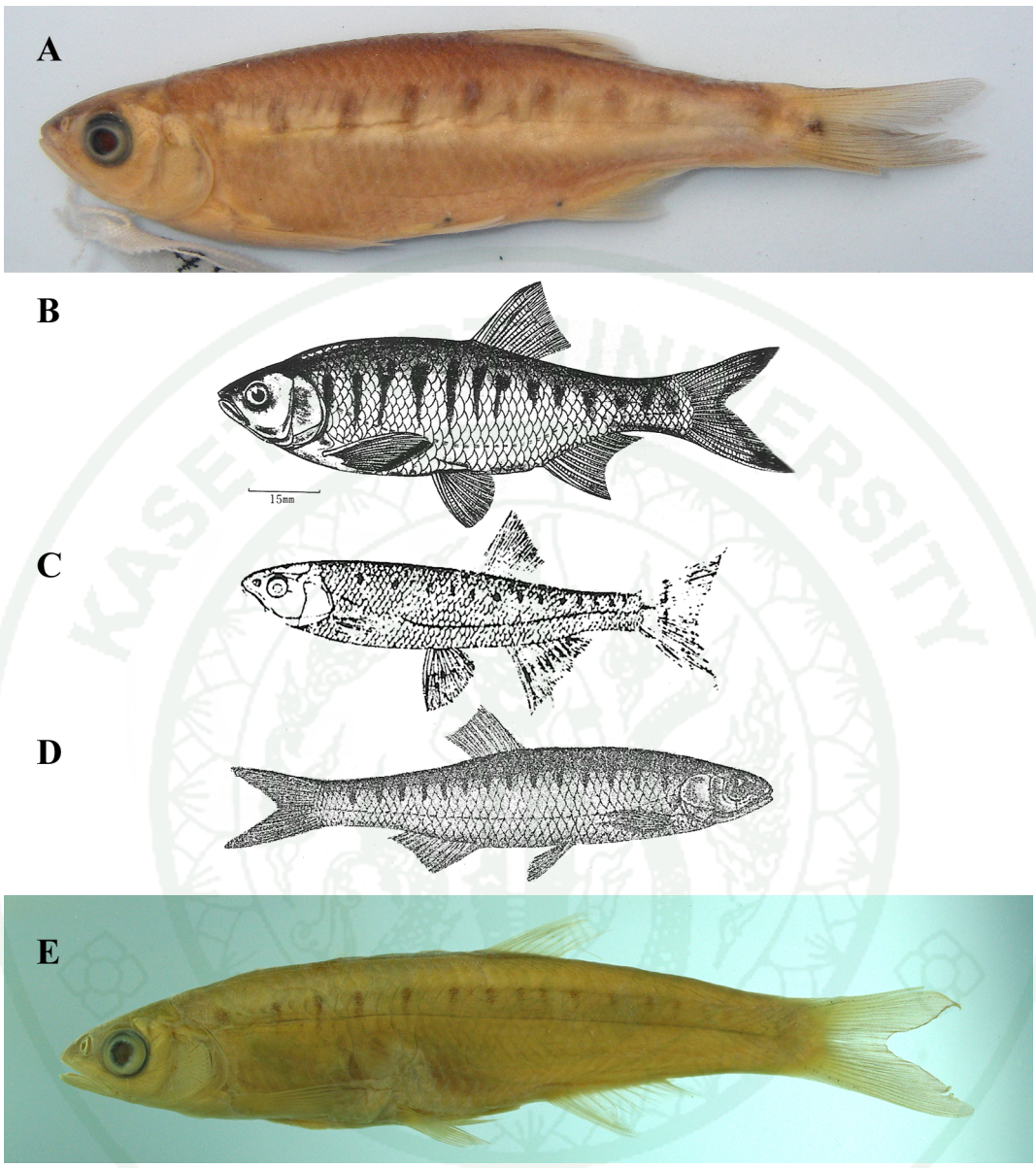

Figure 34 A) *B. ornatus* KIZ 748240. One of syntypes of *B. caudiocellatus*. 70.15 mm SL. Mengding (23° 33' N, 99° 5' E) belonging to Salween drainage, Yunnan, China. B) *Danio monshiensis* Figure from the original description. C) *Barilius barila* Hamilton's figure from Mcclelland (1839) as *Opsarius anisocheilus*. D) *B. barila* Figure from Day (1878). E) *B. barila* RLIKU 1391. 70.4 mm SL. Gowahati, Assam, India

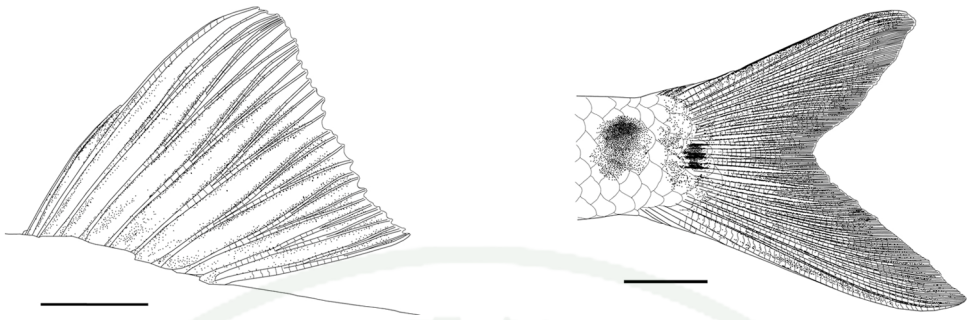

Figure 35 Diagram of dorsal fin (UNMF 00567, 68.25 mm SL) and caudal region of *Barilius ornatus*. (UNMF 00567, 68.25 mm SL) Scale bar = 5 mm.

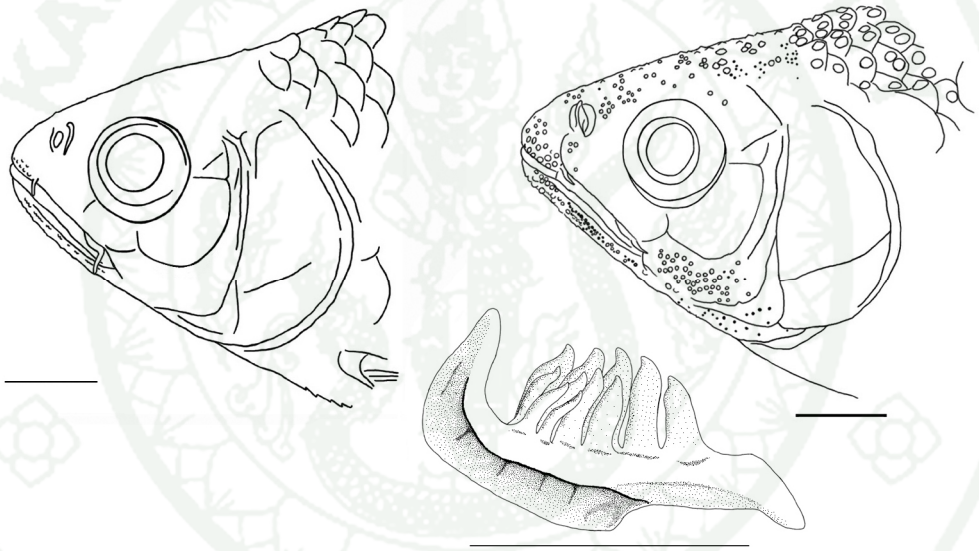

Figure 36 Diagram of right pharyngeal teeth (ventro-mesial view) (UNMF 00569, 78.4 mm SL) and head of normal (left = UNMF 00567, 57.7 mm SL) and presumed alpha male (right = RLIKU 1385, 71.5 mm SL) of *B. ornatus*.

Figure 37 *B. ornatus* habitat: Huai Pa, tributaries of Maetaeng River, Chiengmai Province, Thailand (above), Salween mainstream at Maesamlab district, Maehongson Province, Thailand (below).

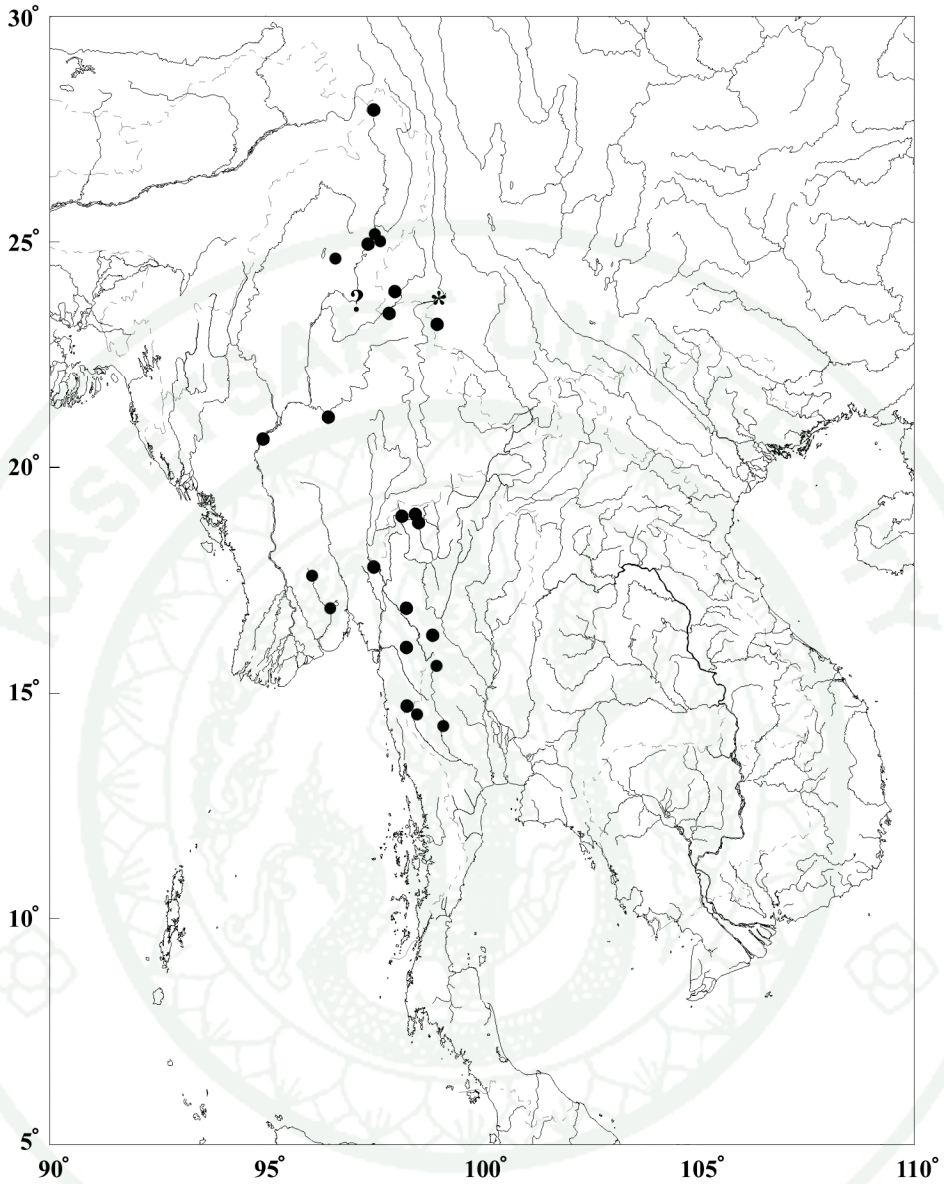

Figure 38 The locality of *B. ornatus* specimens examined in this study. ? = speculated type locality of *B. barnoides*. * = possible locality of NRM 18775.

***Barilius pulchellus* Smith, 1931**

(fig. 39-44)

Barilius pulchellus Smith, 1931: 17-18, Figure 8 (type locality: Maeklang at Pang Chao, Chiangmai Province, Northern Thailand).

Barilius buddhae Fowler, 1934: 142-144, Figure 16 (type locality: Foot of Chieng Dao, Chiangmai Province, Northern Thailand).

Barilius pellegrini Fang, 1938: 587-589 (type locality: Szemao, Yunnan, China).

Paradaniops macropterus Hao & Hoa, 1969: 10-11 (type locality: Sinh Ho, Lai Chau Province, Vietnam).

Daniops nammuensis Hao & Hoa, 1969: 11 (type locality: Nam Mu, Phong Tho, Lai Chau Province, Vietnam).

Diagnosis. A *Barilius* species reaching around 80 mm SL that is distinguished from all other congeners by the combination of the dark pigment on dorsal fin concentrated at the middle of intermembrane forming blotch, total vertebrae 38-41, lateral line scales 36-40, predorsal scales 19-26, branched anal fin rays 10-14, large dentary tubercles, absence of large caudal spot, upper jaw length 9.91-14.15 %SL, and dorsal fin position far backwards whose the origin of anal fin overlapped the dorsal fin at the range from simple rays to 4th branched ray.

Description. (based on 75 specimens, 27.55-77.85 mm SL) Meristic and morphometric measurements are shown in Table 25-26, respectively.

Branched dorsal fin rays 7-8, branched anal fin rays 10-14, pectoral fin rays 11-14, pelvic fin rays 7-10. 36-40 scales in lateral line scale row to the end of hypural plate, 1-4 scales more to the end of caudal base. 7-8 scale rows above lateral line (predorsal scale row not included), 3-4.5 rows below. 19-26 scales in predorsal scale row. Scales in Circumpeduncle scale row 11-14. Axillary process at the anterior base of pectoral fin and axillary scale at the anterior base of pelvic fin well developed.

Body oblong, deep (depth 21.41-33.37 %SL) and compressed with ventral profile more convex than dorsal profile. Head deep (depth 17.55-25.33 %SL) and compressed (width 8.47-13.03 %SL), snout slightly blunt to acute. Caudal peduncle long and narrow near caudal base. Mouth large (upper jaw length 9.91-14.15 %SL), oblique, terminal, with maxilla extends to the range from vertical from the anterior margin of eye to vertical from the middle of the eye. In some specimens lower jaw projects beyond upper jaw. Lower jaw with none to slight notch with corresponding slight emargination in the upper jaw. Barbels 2 pairs (often missing on either side), both rostral and maxillary barbels generally short and tiny with rostral barbel length generally shorter than (but sometimes as long as) 50% distance between the origin of rostral barbels and the corner of the mouth. Rostral barbels often under rostral grooves. Eye large (eye diameter 6.42-10.34 %SL) but eye size generally decreases with body length, from diameter longer than snout length in small specimens to slightly shorter than snout length in large specimens. Infraorbital bones large. Total vertebrae (N=57) 38-41, abdominal vertebrae (N=48) 18-21, caudal vertebrae (N=48) 19-22. Presumed alpha male with greatly enlarged chest (figure 39B, 40, 41, and 42B).

Dorsal fin origin behind and near the posterior half of the body (not including caudal fin); with narrow base, straight to slightly concave in most specimens, convex with middle and posterior branched rays lengthened in presumed alpha male, the posterior tip often surpasses the vertical from the posterior base of anal fin in presumed alpha male. Anal fin origin at the vertical from simple rays to 4th branched dorsal fin rays, the first 3-4 branched rays elongated creating concave margin, these rays enlarged and thickened in presumed alpha male, and with expanding posterior soft rays reducing its concavity. Lower lobe of caudal fin longer or equal to upper lobe. Pectoral fin large and often reaches the anterior base of pelvic fin. Pelvic fin origin far in front of dorsal fin origin, anterior tip not reaching the anterior origin of anal fin, posterior tip generally not reach the anterior origin of anal fin but often reach the anterior origin of anal fin in presumed alpha male.

Tuberculation. In tuberculated male rather large tubercles cover the posterior half of body, head and parts of fins. Numerous tiny tubercles sometimes scatter over lower jaw region. Dentary tubercles on presumed alpha male larger than all other Indochinese *Barilius* and generally up to around 2-4 rows in large specimens, anterior ones larger than posterior ones, and more distinct on the outer and inner edges of dentary. Large tubercles on side of snout, end of maxilla, front of eye, top of eye, all area below eye, opercle and branchiostegal region (figure 44). Tubercles also on the posterior side of the body, generally only a few tubercles per scale in large specimens however. Smallest tubercles on head dorsum. Tubercles also cover the outer surface of pectoral and pelvic fins, part of dorsal and anal fins, and the upper lobe of caudal fin. In most other specimens tubercles restrict mainly to snout and dentary, and not as numerous nor as large as on presumed alpha male (figure 44), but still fairy large and can be seen in the field even on small life specimens.

Color. In life and fresh specimens: dorsum greenish to brownish to grayish, side mainly greenish-gold but sometimes bluish to silvery depending on light angle, belly white to silvery in most specimens (figure 39A). Presumed alpha male in good condition often with orange to slightly reddish orange belly that include lower jaw region (figure 39B). Body side with 7-10 blue vertical bars; each bar generally 1-2 scale wide, most bars in front of anal fin generally reach or cross lateral line. The number of bars on either side of the body is not always equal. The caudal spot, if present, is small and does not extend far into the anterior region of caudal fin. All bars may become indistinct depending on light reflection and mood of the fish, but generally the bars remain deep blue and strongly visible. Pectoral and pelvic fins clear to yellowish or orange. Pelvic fins with white, pink or orange margin. Anal fin clear yellow to orange, sometimes with orange to red margin, juveniles with light or white anterior tip that disappears with increasing size. Caudal fin clear yellow with dark margins on principal rays, outer parts of branched rays, and the whole branched rays in the middle of the fin. Dorsal fin clear to red with dark pigment on rays and membrane, concentrating at the middle of intermembrane. In most specimens dark pigment on the first 3-5 branched dorsal rays do not reach the tip of the fin leaving clear anterior dorsal fin tip (figure 43), but in presumed alpha male dark pigment

expands toward the anterior dorsal fin tip. Many presumed male specimens with a dark vertical bar across the eye through the pupil.

In preserved specimens: usually the red, blue and green color and reflectivity would disappear after preservation. Dorsum dark brown, lighter below. All dark pigment in fins, body bars and caudal blotch turn dark brown to black. Pelvic fin margin generally disappears or becomes indistinct in preserved specimens. The vertical stripe across the eye often disappears in preserved specimens too.

Distribution. *Barilius pulchellus* is found in streams at the tributaries of the Chao Phraya basin, Mekong basin in northern region and northern area of northeastern region in Thailand, southern China, eastern Myanmar, Laos (Kottelat, 2001b), Cambodia (Rainboth, 1996), and the Da (Black) River tributaries in Lai Chou Province in Vietnam (Kottelat, 2001a). In the Chao Phraya basin it is found in headwaters of the Ping, Wang and Nan River, while in the Mekong basin it is found in streams in Yunnan (Chu and Chen, 1989) to at least the Middle Mekong.

Habitat. *Barilius pulchellus* are found in mainly in running waters from small slow streams to fast rivers with mud, sand to gravel substrates, but it prefers clear running waters with gravel bottoms with rocks (figure 45). It seems to live mainly in mountain streams.

Remarks. In the original description of *Barilius buddhae* and *B. pellegrini* the combination of high number of predorsal scales (21-23 in *B. buddhae* and 24 in *B. pellegrini*), the far back dorsal fin position (shown in figure for *B. buddhae*), large and few rows of dentary tubercles (3-4 rows in *B. buddhae* and *B. pellegrini*), 8 branched dorsal fin rays, and the unique dorsal fin color pattern described for both species point straight towards the characters described in the original description of *B. pulchellus* (Smith, 1931) that was shown in the accompanying figure (figure 45A). All these characters are also found in the holotype (figure 44) (by data and ANSP photograph provided by Mark Sabaj) and paratypes of *B. buddhae* (by the author). Thus earlier decision by Smith (1945), Chu (1984), and Kottelat (1984) to include both species

within *B. pulchellus* is correct.

According to Kottelat (2001a) *Paradaniops macropterus* and *Daniops nammunensis* are synonym of *B. pulchellus*. From English translation of Mai's redescription (1978) of both species available in Kottelat (2001a) stated that both have yellowish belly and vertical bars on the body, and figure of *D. nammunensis* from [Identification of the freshwater fishes of northern Vietnam] and the figure of *Paradaniops macropterus* from republished original figure (figure 42B-C) showed the backward position of dorsal fin that greatly overlapped anal fin that is found in *B. pulchellus*. The republished figure of *P. macropterus* also shows enlarged dentary tubercles and intermembrane-based dark dorsal fin pigment characteristic of *B. pulchellus*. Both also have 12-13 branched anal fin rays (Hao, 2007a) that are more than the average on other *Barilius* species in Indochina except *B. pulchellus*. From Hao and Hao (2007a) the original description of both species has 2 rows of pharyngeal teeth (3-5) while *B. pulchellus* has 3 rows. The tooth on the front row of the pharyngeal jaw of *Barilius* is, however, often small and can be easily dislodged while removing flesh to prepare the pharyngeal jaw for study. Without additional data and photograph of specimens the author would follow Kottelat (2001a) in his decision to include both species into *B. pulchellus*.

B. pulchellus, although highly distinctive, is often confused with the Salween and Maetaeng populations of *B. ornatus* in numerous literatures such as Kaewpaitoon (1979). Salween and Maetaeng populations of *B. ornatus* distribution includes Maetaeng River that is one of the tributaries of the Ping River and some nearby streams, while *B. pulchellus* is found in other tributaries of the Ping River. They are not found together yet. In earlier publications the sexual dimorphism of *Barilius* species were not well documented, and the characteristic of presumed alpha male of Salween and Maetaeng populations of *B. ornatus* was not described. Since presumed alpha male of Salween and Maetaeng populations of *B. ornatus*, as with most other species of Indochinese *Barilius*, also have greatly enlarged chest, pelvic, dorsal and anal fins with numerous tubercles it is possible to confuse it with *B. pulchellus* whose male's figure was shown in Fowler's description of *B. buddhae*. However *B.*

pulchellus has much larger dentary tubercles, more intense body bars, red-based dorsal fin with black blotchs concentrating between fin rays, and dorsal fin placement far towards the tail whose anal fin overlapped the dorsal fin from simple rays to 3rd branched dorsal fin rays (rarely to 4th), while Salween and Maetaeng populations of *B. ornatus* has smaller dentary tubercles, lighter and less permanent body bars, dorsal fin with black pigment on fin rays edge, and dorsal fin placement less towards the tail whose anal fin overlapped the dorsal fin from 4th-7th branched dorsal fin rays. Presumed alpha male of *B. pulchellus* also has bright red dorsal fin, bright yellowish-green to greenish-gold body, and yellow to orange belly, chest and lower jaw, while Salween and Maetaeng populations of *B. ornatus* has greenish body, with orange to bronze belly and chest that does not extend to lower jaw.

With blotch on intermembrane region of branched dorsal fin rays, dorsal fin placement far back with anal fin overlapped the dorsal fin from simple rays to 3rd branched dorsal fin rays (rarely to 4th), 19-26 predorsal scales, and 36-40 lateral line scales *Barilius pulchellus* is distinct from all Indian *Barilius* species. *Barilius barila*, *B. dimorphicus*, *B. lairokensis*, *B. ngawa*, *B. radiolatus*, *B. shacra*, *B. shacra naseeri*, and *B. tileo* have more than 41 lateral line scales which is more than *B. pulchellus* (Talwar and Jhingran, 1991; Vishwanath and Manojkumar, 2002; Mirza, Rafiq, and Awan, 1986; Arunkumar and Singh, 2000; Tilak and Husain, 1990). Most Indian *Barilius* species with lateral line scales 40 or less (*B. bakeri*, *B. barna*, *B. canarensis*, *B. chatricensis*, *B. evezardi*, and *B. gatensis*) have less predorsal scales than *B. pulchellus* (16 or less vs. 19 or more) (Talwar and Jhingran, 1991; Selim and Vishwanath, 2002). *Barilius bendelisis* and *B. vagra* have comparable number of lateral line and predorsal scales, but *B. vagra* has its anal fin origin opposing 6th branched dorsal fin ray (vs. simple rays – 4th in *B. pulchellus*), while *B. bendelisis* has its dorsal fin placement entirely in front of anal fin, and 7-8 branched anal fin rays while *B. pulchellus* has 10-14 branched anal fin rays (Talwar and Jhingran, 1991). *B. mesopotamicus* has more lateral line scales (42-54) than *B. pulchellus* (36-40) (Coad, 2010), and *B. borneensis* has only 7 branched anal fin rays while *B. pulchellus* has 10-14 branched rays (Roberts, 1989).

Material examined. ANSP 58912 *Barilius buddhae* (holotype) 78.6 mm SL, Foot of Chieng Dao, North Siam, 50 miles north of Chiang Mai, 23 January 1939, R.M. deSchuensee. examined by Sabaj, M.; ANSP 58913 *Barilius buddhae* (paratypes) (6) 53.2-72.25 mm SL, same data.

RLIKU 1373 (10) 39.65-64.8 mm SL, Tributary of Ping River, Doi Saket District, Chiangmai Province, Thailand, 21 March 2003; RLIKU 393 (5) 45.9-65.3 mm SL, Tributary of Nan River, Ban Na Ku, Khun Nan County, Chaloem Phra Kiat District, Nan Province, Thailand, Lauthongkham, A.; RLIKU 395 (4) 47.6-67 mm SL, Ban Khun Nan, Bor Kluea District, Nan Province, Thailand, Lauthongkham, A.; RLIKU 1374 (5) 48.15-54.9 mm SL, Tributary of Maelao River, Wiang Pa Pao District, Chiangrai Province, Thailand, 19 March 2003; RLIKU 1375 (1) 75.88 mm SL, Below the reservoir at Mae Suai District, Chiang Rai Province, Thailand, 10 December 2004; RLIKU 1351 (10) 47-77.85 mm SL, Kengtung, Myanmar, January 1993, Musiksinthorn, P.; MJUFM cat no. 1144 (4) st.7, Doi Mae Mae area near Chiang Dao, Chiang Mai Province, Thailand; UNMF 00551 (2) 38.85-56.4 mm SL, Same Locality, 11 December 2004; UNMF 00552 (8) 27.55-65.8 mm SL, Tributary of Wang River, Wang Nuea District, Lampang Province, Thailand. 10 May 2003; UNMF 00553 (5) 41.2-55.65 mm SL, Tributary of Maelao River, Wiang Pa Pao District, Chiangrai Province, Thailand, 19 March 2003; UNMF 00579 (2) 47.4-50.15 mm SL, Nan Lei River, Meng Lian, Yunnan Province, China, 15 July 2006, Zhou, H..; THNHM UNCAT (6) 37.65-45.79 mm SL, Mekong mainstream east of Chiang Khan, Loei Province, Thailand, 11-12 March 1990, Tyson Roberts; IOZCAS 39022, IOZCAS 39041, IOZCAS 39047 (as *Barilius barna*) (3) 45.13-49.95 mm SL, Gan Lan County, Yunnan Province, China, IOZCAS 43933-43936 (4) 51.55-55.26 mm SL, Jing Hong (Capital of Xi-Shang Ban Na District/County, Yunnan Province, China.

Table 25 Morphometric measurements (in %SL) of *Barilius pulchellus*. * = data from figure in the original description (Smith, 1931).

Measurements (%SL)	*Barilius pulchellus* (original description and data of types from Kaewpaitoon, 1979) (N=5)	*Barilius pulchellus* (N=75)		
		range	mean	SD
Standard length (mm)	43-50	27.55-77.85	-	-
Body depth	27.9-32.3	21.41-33.37	27.01	2.07
Pelvic-dorsal depth	32.79 *	24.33-35.58	29.09	2.04
Caudal peduncle depth	10.66 *	7.87-11.25	9.75	0.78
Caudal peduncle length	19.67 *	14.89-21.15	18.24	1.32
Preanal length	67.21 *	60.03- 69.48	65.29	2.17
Predorsal length	59.02 *	58.96-66.33	62.32	1.6
Prepelvic length	49.18 *	45.19-54.55	49.72	1.84
Pelvic-anal fin length	18.85 *	14.01-25.03	16.99	1.83
Dorsal fin base length	16.39 *	12.48-18.89	14.63	1.31
Anal fin base length	19.67 *	15.56-22.45	19.04	1.47
Lateral head length	27.9-29.6	23.65-30.95	27.1	1.57
Dorsal head length	19.67 *	17.59-25.05	20.21	1.16
Head depth	22.95 *	17.55- 25.33	20.59	1.57
Head width	-	8.47-13.03	10.92	1.16
Snout length	6.56 *	6.65-10.04	8.02	0.69
Preorbital head depth	14.75 *	8.96-14.85	12.19	1.31
Postorbital head depth	19.67 *	13.77-20.7	17.97	1.36
Postorbital length	13.11 *	10.84-17.42	13.48	1.36
Interorbital width	-	6.91-10.49	8.39	0.72
Eye diameter	7.38 *	6.42-10.34	8.24	0.73
Upper jaw length	13.11 *	9.91-14.15	12.41	0.91
Head depth (%lhl)	87.5 *	67.94-87.47	75.99	4.13
Snout length (%lhl)	20-27.5	25.2-38.06	29.63	2.31
Postorbital length (%lhl)	40-50	38.75-59.02	49.73	4.01
Interorbital width (%lhl)	33.7-41.6	26.74-41.02	31	2.47
Eye diameter (%lhl)	30.4-34.4	25-36.7	30.52	2.49
Upper jaw length (%lhl)	50 *	35.67-52.63	45.82	3

Table 26 Meristic counts and other characteristics of *Barilius pulchellus*. * = data from figure in the original description (Smith, 1931).

Counts	*Barilius pulchellus* (original description and data of types from Kaewpaitoon, 1979) (N=5)	*Barilius pulchellus* (N=75)		
		range	mean	SD
Origin of anal fin opposite branched dorsal fin rays	1st *	Simple rays (15), 1st (9), 2nd (35), 3rd (15), 4th (1)	1.71	1.05
Pectoral fin rays	10-13	11 (5), 12 (45), 13 (23), 14 (2)	12.29	0.63
Pelvic fin rays	7-8	7 (21), 8 (44), 9 (9), 10 (1)	7.87	0.66
Branched dorsal fin rays	8	7 (11), 8 (63), 9 (1)	7.87	0.38
Branched anal fin rays	11	10 (7), 11 (44), 12 (16), 13 (4), 14 (4)	11.39	0.93
Lateral line scales	(39-40) + (2-3)	[36 (16), 37 (18), 38 (26), 39 (10), 40 (5)] + (2-4)	37.6	1.16
Scale rows above lateral line	7	7 (46), 8 (29)	7.39	0.49
Scale rows below lateral line	2.5	3 (64), 3.5 (2), 4 (8), 4.5 (1)	3.14	0.35
Predorsal scales	21-23	19 (5), 20 (10), 21 (24), 22 (21), 23 (8), 24 (4), 25 (2), 26 (1)	21.56	1.44
Circumpeduncle scales	12	11 (6), 12 (35), 13 (14), 14 (20)	12.64	0.97
Total vertebrae (N = 57)	-	38 (1), 39 (18), 40 (34), 41 (4)	39.72	0.62
Abdominal vertebrae (N=48)	-	18 (2), 19 (35), 20 (10), 21 (1)	19.21	0.54
Caudal vertebrae (N=48)	-	19 (1), 20 (18), 21 (28), 22 (1)	20.6	0.58

Table 27 Selected characters of nominal species of *Barilius* synonymized with *Barilius pulchellus*.

Characters	***B. pulchellus***	***B. buddhae***	***B. pellegrini***	***P. macropterus***	***D. nammunensis***	**specimens examined (N = 75)**
Anal fin origin opposing branched dorsal fin rays	1st	1st-3rd	1st	Simple rays	1st	Simple rays-4th
Branched dorsal fin rays	8	8	8	8	7	7-9
Branched anal fin rays	11	11-12	13	13	12	10-14
Predorsal scales	21-23	21-24	24	-	-	19-26
Dorsal fin color pattern	Dark pigment on intermembrane	Dark pigment on intermembrane	Dark pigment on intermembrane	Dark pigment on intermembrane	-	Dark pigment on intermembrane
Caudal mark	no	no	no	no	no	no
Dentary tubercles	large	large	large	large	-	large

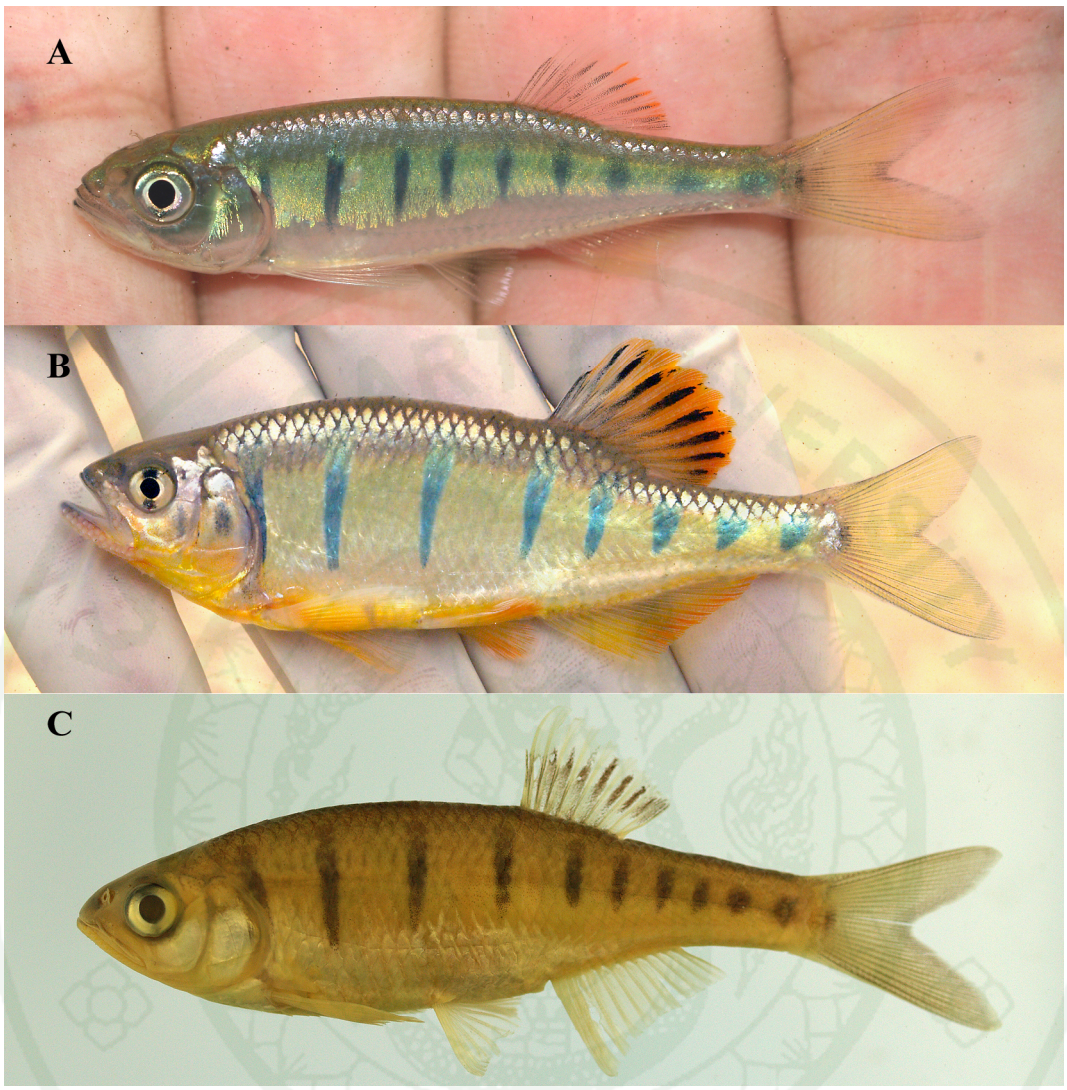

Figure 39 *B. pulchellus*. A) ca. 45 mm SL. Tributary of Maelao River, Mae Kon County, Mae Lao District, Chiang Rai Province, Thailand. Not preserved. Note the presence of light margin on pelvic fin that often disappears in preserved specimens, B) ca. 75 mm SL. Tributary of Maelao River, Wiang Pa Pao District, Chiang Rai Province, Thailand. Presumed alpha male in full coloration. Not preserved, C) RLIKU 1374. 51.25 mm SL. Tributary of Maelao River, Wiang Pa Pao District, Chiang Rai Province, Thailand.

Figure 40 *B. pulchellus* RLIKU 393. 67 mm SL. Ban Khun Nan, Bor Kluea District, Nan Province, Thailand. Amornchai Lauthongkham. Presumed alpha male.

Figure 41 *B pulchellus* ANSP 58912. Holotype of *Barilius buddhae*. 78.6 mm SL. Male. ANSP Photograph.

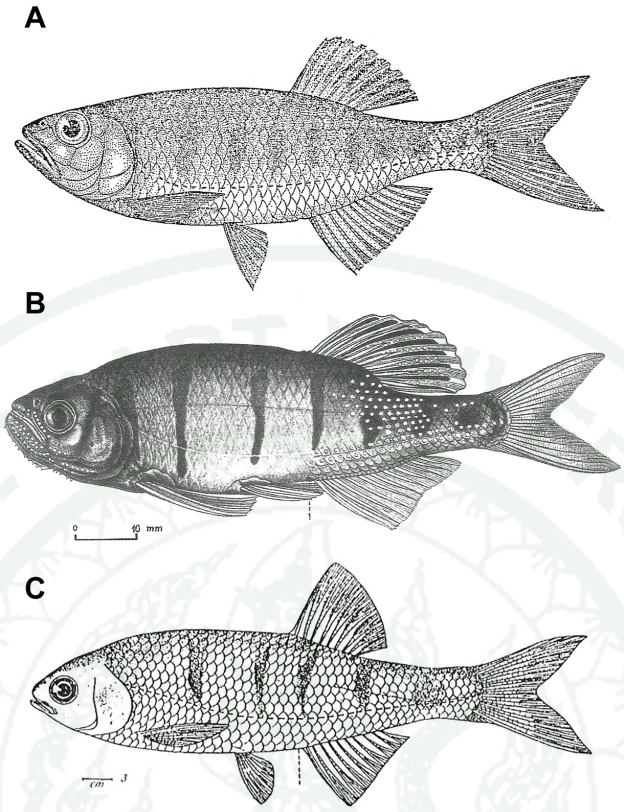

Figure 42 A) Figure of *B. pulchellus* from the original description (Smith, 1931), B) *Paradaniops macropterus* Figure from reprint of original figure (Hao, 2007b), C) *Daniops nammunensis* Figure from [Identification of the freshwater fishes of northern Vietnam] (Mai, 1978).

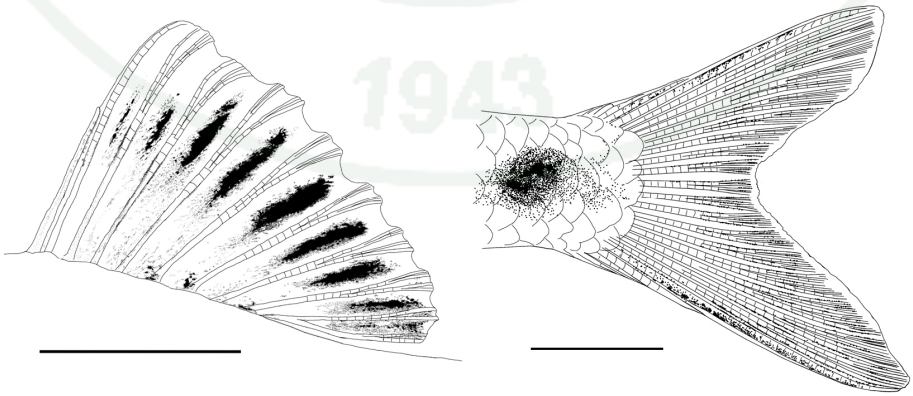

Figure 43 Diagram of dorsal fin (UNMF 00552, 46.7 mm SL) and caudal region (RLIKU 1351, 60.3 mm SL) of *B. pulchellus*. Scale bar = 5 mm.

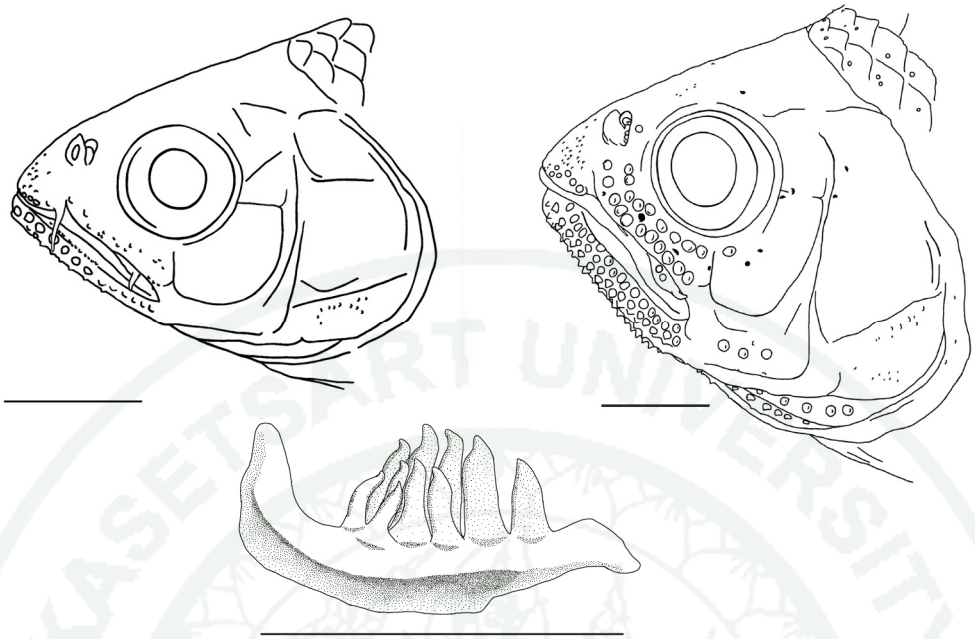

Figure 44 Diagram of right pharyngeal teeth (ventro-mesial view) (UNMF 00553, 52.7 mm SL) and head of normal (left = RLIKU 1374, 51.25 mm SL) and presumed alpha male (right = RLIKU 395, 67 mm SL) of *B. pulchellus*. Scale bar = 5 mm.

Figure 45 Tributary of Maelao River, Mae Kon County, Mae Lao District, Chiang Rai Province, Thailand.

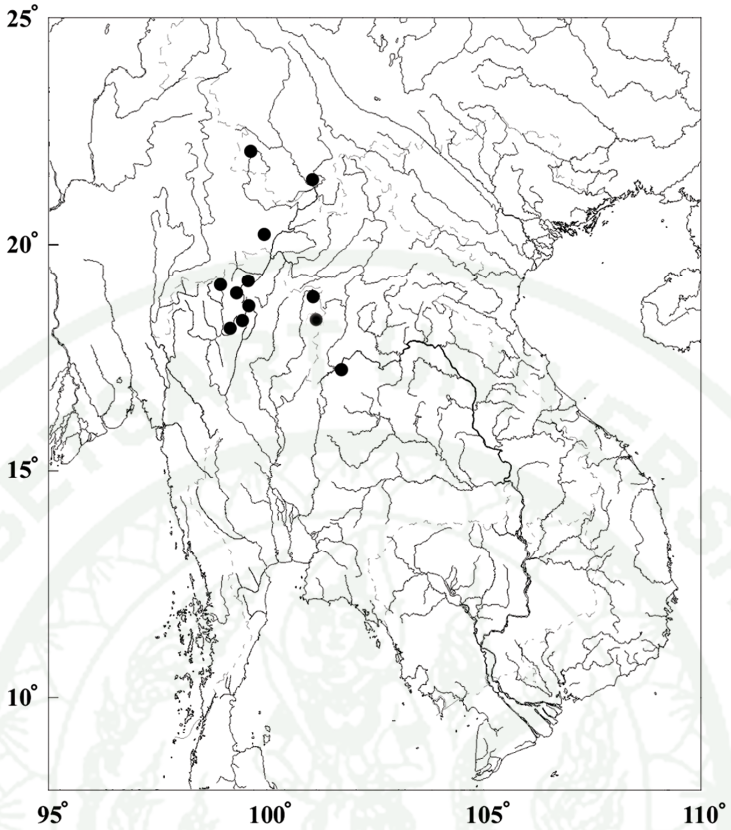

Figure 46 The locality of *B. pulchellus* examined in this study.

***Barilius* sp.**

(fig. 47-49)

Diagnosis. A *Barilius* species reaching around 70 mm SL that is distinguished from all other *Barilius* species by the combination of the dark pigment on dorsal fin from 3rd branched ray backwards concentrated into blotch mainly at the middle of intermembrane region to adjacent to the anterior side of the branched dorsal fin ray, total vertebrae less than 35, absence of large caudal blotch, head depth 21.82-25.49 %SL, short rostral barbels that are far shorter than 50% distance between its origin and the end of maxilla, and less than 33 lateral line scales to the end of hypural plate.

Description. (based on 21 specimens, 42.1-70.9 mm SL) Meristic and morphometric measurements are shown in Table 28 and 29, respectively.

Branched dorsal fin rays 7, branched anal fin rays 8-9, pectoral fin rays 11-13, pelvic fin rays 8-10, 30-32 scales in lateral line scale row to the end of hypural plate, 2-4 scales more to the end of caudal base. 7 scale rows above lateral line (predorsal scale row not included), 2-3 rows below. 14-17 scales in predorsal scale row. Scales in Circumpeduncle scale row 11-12. Axillary process at the anterior base of pectoral fin and axillary scale at the anterior base of pelvic fin well developed.

Body oblong, deep (depth 32.09-37.12 %SL) and compressed with ventral profile more convex than dorsal profile. Head deep (depth 21.82-25.49 %SL) and compressed (width 11.96-14.18 %SL), snout slightly blunt to acute. Caudal peduncle long (length 15.3-18.74 %SL) and narrow (depth 10.69-12.84 %SL) near caudal base. Mouth large (upper jaw length 10.07-11.73 %SL), oblique, terminal, with maxilla extends to the range from slightly in front of the vertical from the anterior margin of eye or slightly beyond. Lower jaw without notch or emargination in the upper jaw. Barbels 2 pairs, both rostral and maxillary barbels short and tiny with length far shorter than 50% distance between the origin of rostral barbels and the corner of the mouth. Rostral barbels often under rostral folds. Eye large (eye diameter 8.37-10.95

%SL). Infraorbital bones large. Total vertebrae 33-34 (N=20), abdominal vertebrae (N=19) 17-18, caudal vertebrae (N=19) 15-17. Presumed alpha male with enlarged chest (figure 47C).

Dorsal fin origin behind and near the posterior half of the body (not including caudal fin) with narrow base, straight to slightly concave in normal specimens, convex with middle and posterior branched rays lengthened in presumably nuptial male, the posterior tip often surpasses the vertical from the posterior base of anal fin in presumably nuptial male (figure 47C). Anal fin origin at the vertical from between 5^{th}-7^{th} branched dorsal fin rays, the first 3-4 branched rays elongated creating concave margin, posterior branched rays lengthened in presumably nuptial male reducing its concavity. Lower lobe of caudal fin longer or equal to upper lobe. Pectoral fin large and often reaches the anterior base of pelvic fin. Pelvic fin origin far in front of dorsal fin origin, anterior tip not reaching the anterior origin of anal fin, posterior tip generally not reach the anterior origin of anal fin but often reach the anterior origin of anal fin in presumed alpha male.

Tuberculation. In presumed alpha male numerous tubercles cover the whole body, head and parts of fins. Dentary tubercles on presumably nuptial male moderate size, up to 4-5 rows in large specimens, anterior ones larger than posterior ones. Large tubercles on snout, side of snout, end of maxilla, front of eye, below eye, and branchiostegal region. Smaller tubercles on dorsum, the whole upper part and posterior lower part of the body. Tubercles also cover the outer surface of pectoral fins, part of dorsal and anal fins. Although the other specimens lack numerous tubercles on the body and fins, they have more or less similar number and size of dentary and head tubercles as presumed alpha male.

Color. In one specimen after preservation for a few days (figure 47A): dorsum brown, upper flank yellowish green, lower flank silvery. Base of pectoral, pelvic, anal, and caudal fin orange. Body side with 8-9 faint bluish bars about 1-1.5 exposed scales wide, the first few bars reach or cross lateral line. Pectoral fins, pelvic fins, and anal fin clear with orange patches between fin rays. Caudal fin with dark margins on

principal rays, outer parts of branched rays, and the whole branched rays in the middle of the fin; orange on rays of anterior part of caudal fin, caudal fin membrane clear,. Dorsal fin clear with dark pigment on rays, edge of rays and membrane, from 3rd branched ray backwards concentrating mainly on the area adjacent to the anterior side of the branched dorsal fin ray, clear red color on the membrane on the area near dorsal fin base, but not on ray.

In preserved specimens: dorsum dark brown, side brown. Body side with 7-10 dark bars, each bar generally 1-2 scale wide, bars in front of anal fin sometimes reach or cross lateral line. Pectoral fins, pelvic fins, and anal fin clear, but in one specimen 2nd – 4th branched anal fin ray tips with dark pigments at edge of rays. Caudal fin with dark margins on principal rays, outer parts of branched rays, and the whole branched rays in the middle of the fin; caudal fin membrane clear, spreading or closing the fin creates the illusion of 2-3 indistinct dark caudal stripes and margin. Dorsal fin clear with dark pigment on rays, edge of rays and membrane, from 3rd branched ray backwards concentrating mainly at the middle of intermembrane region or align backwards to the area adjacent to the anterior side of the branched dorsal fin ray (figure 48).

Distribution. At the present all specimens in this study were collected from Kamyit Chaung and the Kyien Tali River basin in Thandway District, Rakhine State, Myanmar (figure 51). It has the smallest distributional range of all Indochinese *Barilius* in this study.

Habitat. The stream and small river where *Barilius* sp. Rakhine was collected has sandy bottoms with rocks (figure 50).

Remarks. Apart of the distinctive dorsal fin color pattern along the line of *B. pulchellus* the other aspect of preserved coloration of *B.* sp. is quite similar to most Indochinese *Barilius* species, without distinctive color pattern. Color of specimen after a short while in preservation is quite similar in general to *B. bernatziki* and *B. ornatus*. The overall shape of *B.* sp. is most similar to more compact version of *B.*

bernatziki without large caudal blotch. With less than 33 lateral line scales *B.* sp. is distinct from *B. bakeri*, *B. barila*, *B. barna*, *B. bendelisis*, *B. canarensis*, *B. evezardi*, *B. gatensis*, *B. modestus*, *B. radiolatus*, *B. shacra*, *B. tileo*, *B. vagra*, *B. shacra naseeri*, *B. dimorphicus*, *B. lairokensis*, *B. ngawa*, *B. chatricensis*, *B. mesopotamicus*, and *B. borneensis* which have 37 lateral line scales or more according to Talwar and Jhingran (1991), Vishwanath and Manojkumar (2002), Mirza, Rafiq, and Awan (1986), Arunkumar and Singh (2000), Tilak and Husain (1990), Selim and Vishwanath (2002), Coad (2010), and Roberts (1989).

Barilius sp. is probably endemic to western Rakhine States. According to Kullander and Fang (2004) there are many endemic fishes found together with *B.* sp. at Kamyit Chaung such as *Danio* sp., *Batasio elongatus*, *Puntius binduchitra*, *Garra propulvinus*, and *G. flavatra*. *B.* sp. seems to be yet another species that illustrate the high degree of endemism in the Rakhine States.

Material examined. RLIKU 1368 (12) 46.2-65.15 mm SL, Kyein Tali River at Kya Awo Maak, Thandway District, Rakhine State, Myanmar. 4 March 2009. Musikasinthorn, P. and Arbsuwan, S.. RLIKU 1369 (1) 69.9 mm SL, Khayin Chaung Village, Kyein Tali River at the village, Thandway District, Rakhine State, Myanmar. 5 March 2009. Musikasinthorn, P. and Arbsuwan, S.. RLIKU 1370 (4) 58.5-70.9 mm SL, Kyien Tali River at Khayin Chuang, Thandway District, Rakhine State, Myanmar. 6 March 2009. Musikasinthorn, P. and Arbsuwan, S.. NRM 40800 (3) 54.65-61.0 mm SL, Kamyit Chaung near Paukdu village, Thandwe District, Rakhine State, Myanmar. 19 March 1998. Kullander, SO and Britz, R.

Table 28 Morphometric measurements (in %SL) of *Barilius* sp..

Measurements (%SL)	*Barilius* sp. (N=21)		
	range	mean	SD
Standard length (mm)	42.1 - 70.9	-	-
Body depth	32.09 - 37.72	34.43	1.18
Pelvic - dorsal depth	33.95 - 38.59	35.84	1.06
Caudal peduncle depth	10.69 - 12.84	11.71	0.52
Caudal peduncle length	15.3 – 18.74	16.8	0.92
Preanal length	68.69 – 74.57	71.78	1.35
Predorsal length	59.29 – 64.19	61.57	1.37
Prepelvic length	51.71- 55.52	53.51	1.11
Pelvic - anal fin length	16.48 – 21.09	19.78	1.21
Dorsal fin base length	13.58 - 17.21	14.74	0.9
Anal fin base length	15.63 - 18.3	16.87	0.77
Lateral head length	24.6 – 29.45	27.48	1.25
Dorsal head length	19.57 – 23.27	21.23	1.01
Head depth	21.82 - 25.49	22.95	0.79
Head width	11.96 - 14.18	13.1	0.72
Snout length	6.95 – 9.01	7.93	0.52
Preorbital head depth	10.67- 14.34	12.17	0.97
Postorbital head depth	18.99 - 22.13	20.6	0.77
Postorbital length	11.26 - 14.1	12.21	0.63
Interorbital width	9.59 – 11.3	10.49	0.47
Eye diameter	8.37 - 10.95	9.95	0.69
Upper jaw length	10.07 - 11.73	10.84	0.46
Head depth (%lhl)	77.42 – 89.94	83.62	3.19
Snout length (%lhl)	25.19 – 31.98	28.88	1.91
Postorbital length (%lhl)	40.32 – 48.86	44.45	2.12
Interorbital width (%lhl)	33.24 – 43.6	38.26	2.54
Eye diameter (%lhl)	31.71 – 41.7	36.26	2.63
Upper jaw length (%lhl)	36.08 – 43.14	39.48	1.72

Table 29 Meristic counts and other characteristics of *Barilius* sp..

Counts	*Barilius* sp.(N=21)		
	range	mean	SD
Origin of anal fin opposite branched dorsal fin rays	5^{th} (9), 6^{th} (9), 7^{th} (3)	5.71	0.62
Pectoral fin rays	11 (11), 12 (8), 13 (1)	11.48	0.6
Pelvic fin rays	8 (5), 9 (14), 10 (1)	8.81	0.51
Branched dorsal fin rays	7	7	0
Branched anal fin rays	8 (1), 9 (20)	8.95	0.22
Lateral line scales	[30 (4), 31 (11), 32 (6)] + (2-4)	31.1	0.7
Scale rows above lateral line	7	7	0
Scale rows below lateral line	2 (2), 3 (19)	2.9	0.3
Predorsal scales	14 (2), 15 (6), 16 (11), 17 (2)	15.62	0.8
Circumpeduncle scales	11 (1), 12 (20)	11.95	0.22
Total vertebrae (N=20)	33 (2), 34 (18)	33.9	0.31
Abdominal vertebrate (N=19)	17 (8), 18 (11)	17.58	0.51
Caudal vertebrate (N=19)	15 (1), 16 (10), 17 (8)	16.37	0.6

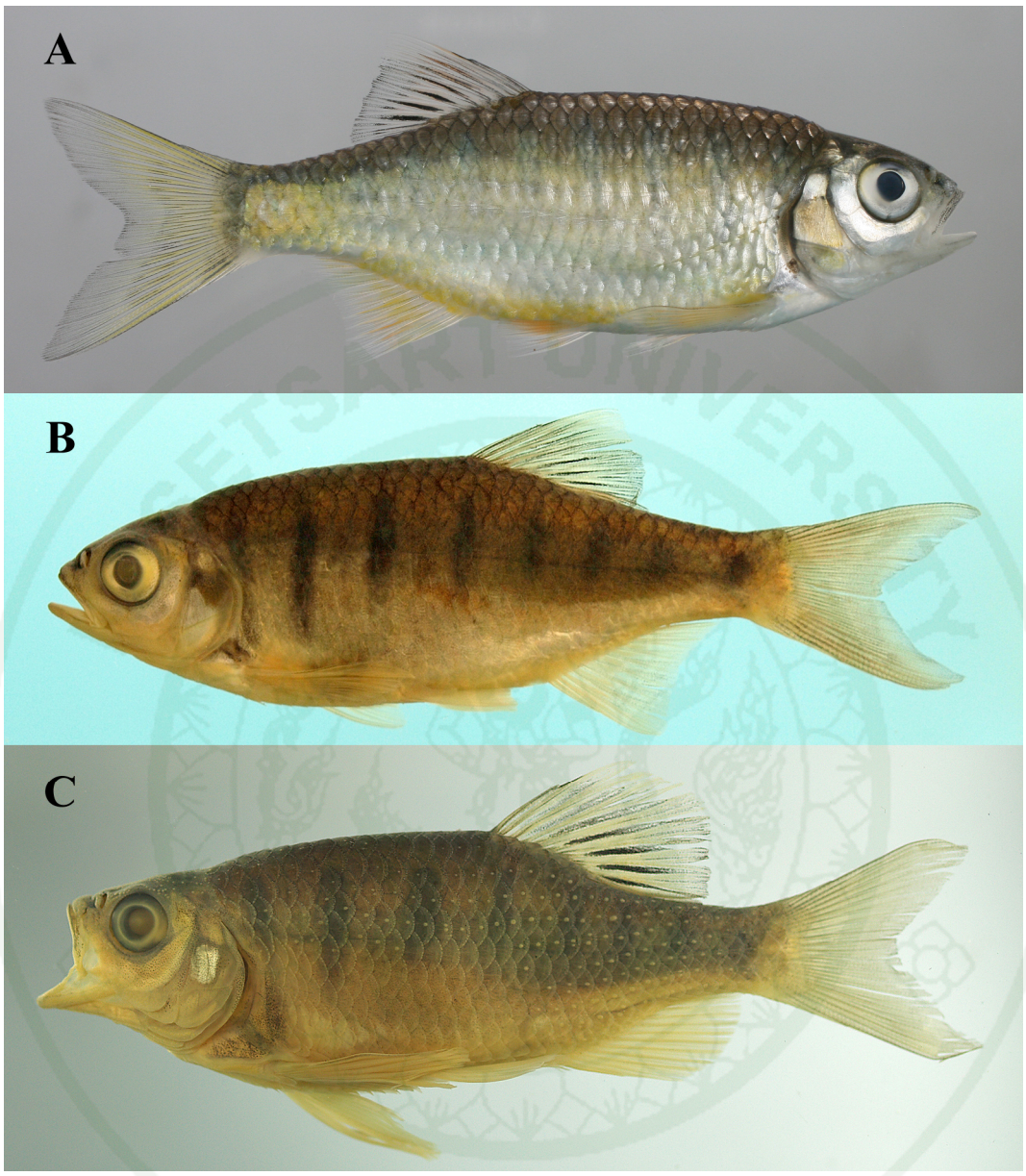

Figure 47 *Barilius* sp. A) freshly preserved specimens from Kyein Tali River at Kya Awo Maak, Thandway District, Rakhine State, Myanmar. B) RLIKU 1368 60.6 mm SL. Kyein Tali River at Kya Awo Maak, Thandway District, Rakhine State, Myanmar. C) NRM 40800 61.0 mm SL Kamyit Chaung near Paukdu village, Thandwe District, Rakhine State, Myanmar. Presumed alpha male.

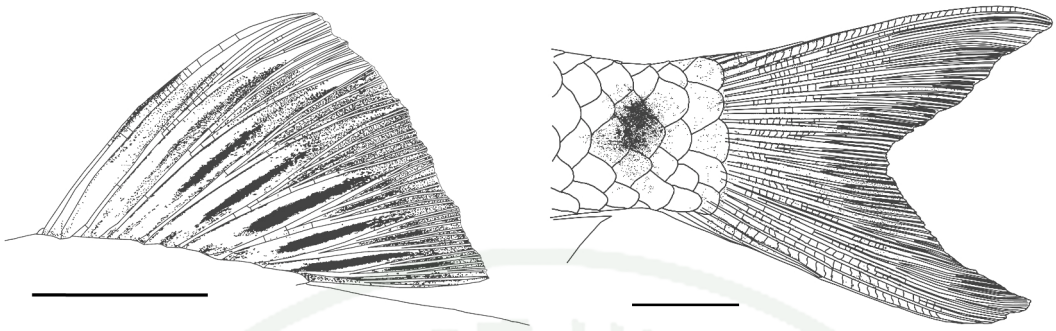

Figure 48 Diagram of dorsal fin (RLIKU 1368, 53.5 mm SL) and caudal region (RLIKU 1368, 60.6 mm SL) of *Barilius* sp.. Scale bar = 5 mm.

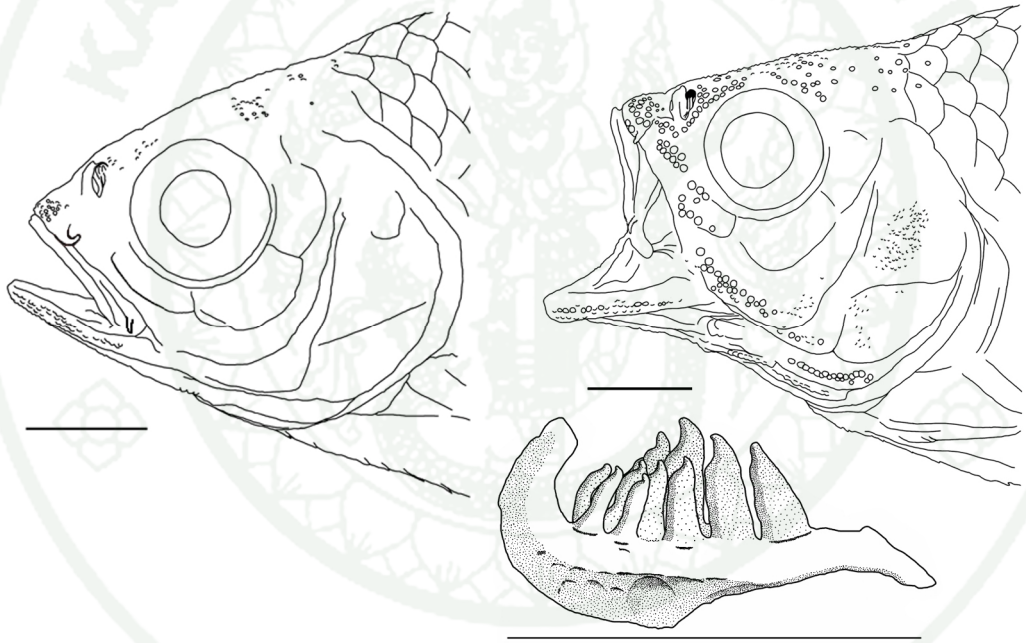

Figure 49 Diagram of head of normal (left = RLIKU 1368, 60.6 mm SL), presumed alpha male (right = NRM 40800, 61 mm SL), and pharyngeal teeth (ventro-mesial view) (RLIKU 1368, 49.55 mm SL) of *Barilius* sp.. Scale bar = 5 mm.

Figure 50 The Kyein Tali River, Thandway District, Rakhine State, Myanmar. Photograph by Prachaya Musikasinthorn.

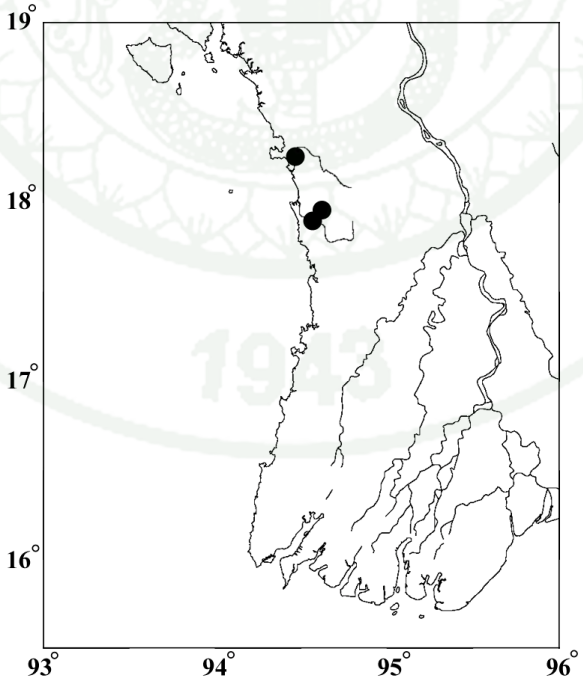

Figure 51 The locality of *B.* sp. specimens examined in this study.

CONCLUSION

In a taxonomic review of *Barilius* species in Indochina based on 511 specimens by using morphological character including 21 morphometric, 11 meristic characters and color pattern 6 species, *Barilius bernatziki*, *B. dogarsinghi*, *B. koratensis*, *B. ornatus*, *B. pulchellus* and *B.* sp. (an undescribed species) are recognized. *B. pulchellus* was distributed in tributaries of the Chao Phraya basin, the middle Mekong, and the Da basin and *B.* sp. from streams in western Rakhine States, Myanmar. *B. dogarsinghi* was distributed in the Ayeyarwaddy basin. *B. ornatus* was widespread in the Ayeyarwaddy, Salween and Ataran basins and some tributaries of the Chao Phraya, Maeklong, and Mekong. *B. bernatziki* was distributed in Ranong Province, southwestern Thailand up to Tavoy in Myanmar. *B. koratensis* was widespread in the Chao Phraya and Maeklong basin, middle and lower Mekong, Bangpakong, Tapi and Dong Nai Rivers. *Barilius huahinensis*, *B. nanensis*, and *Danio ponticulus* were treated as junior synonym of *Barilius koratensis*. *Barilius barnoides*, *B. infrafasciatus*, *Danio monshiensis*, and *B. caudiocellatus* were treated as junior synonym of *Barilius ornatus*. *Barilius buddhae*, *B. pellegrini*, *Paradaniops macropterus* and *Daniops nammuensis* were treated as junior synonym of *Bariliius pulchellus*.

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