Cyprinid fishes of the genus *Neolissochilus* in Peninsular Malaysia

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Abstract

Meristic, morphometric and distributional patterns of cyprinid fishes of the genus *Neolissochilus* found in Peninsular Malaysia are presented. Based on the current concept of *Neolissochilus*, only two species are present: *N. soroides* and *N. hendersoni*. *Neolissochilus hendersoni* differs from *N. soroides* by having lower scale and gill raker counts. *Neolissochilus soroides* has three mouth types (normal with a rounded snout, snout with a truncate edge, and lobe with a comparatively thick lower lip). A PCA of log-transformed measurements did not reveal significant differences between *N. hendersoni* and *N. soroides*, or between any of the morphotypes of *N. soroides*; however, a CVA of log-transformed measurements successfully classified 87.1% of all specimens. Removing body size by running a CVA on all of the principal components except PC1 (which was correlated with length) only slightly decreased the successful classification rate to 86.1%. Differences in morphometrics were as great between the three morphotypes of *N. soroides* as between any of the morphotypes and *N. hendersoni* suggesting that the morphotypes should be examined in greater detail with genetic tools. The PCA of morphometrics revealed separate clouds for *N. hendersoni* and *N. soroides*, but no differences between the *N. soroides* morphotypes. This study revealed that *N. hendersoni* is recorded for the first time in the mainland area of Peninsular Malaysia. Other nominal species of *Neolissochilus* reported to occur in the river systems of Peninsular Malaysia are discussed. *Lissochilus tweediei* Herre in Herre & Myers 1937 and *Tor soro* Bishop 1973 are synonyms of *Neolissochilus soroides*.

Key words: *Neolissochilus*, taxonomy, Peninsular Malaysia, Teleostei

Introduction

The cyprinid fishes of the genus *Neolissochilus* are widely distributed in freshwater habitats throughout tropical and subtropical areas of the southern and southeastern Asia (Rainboth 1991). Species of *Neolissochilus* have had a convoluted taxonomic history, and they have been placed under various genera, such as *Barbus* (M’Clelland 1839, 1845; Day 1869, 1870, 1871, 1873, 1878; Bouleneger 1893; Duncker 1904, Pellegrin & Fang 1940), *Labeobarbus* (Weber & de Beaufort 1916), *Lissochilus* (Weber & de Beaufort 1916; Ahl 1933; Fowler 1934; Herre 1940), *Crossochilus* (Pellegrin & Chevey 1936; Herre & Myers 1937), *Puntius* (Smith 1945), and *Acrossocheilus* (Smith 1945).

Myers (1941) commented that the generic name *Lissochilus* described by Weber & de Beaufort (1916) is a junior homonym to the fossil gastropod genus *Lissochilus* (Pethő in Zittel 1881). Based on a single shared morphological character (a sharp, horny sheath covering of the lower jaw), Myers suggested placement of the fishes into *Acrossocheilus* (Oshima 1919). Rainboth (1985) reassessed this group of fishes and recognized the close relationship between them and *Tor* Gray as had also been suggested by several authors previously (Hora 1940, 1941; Hora & Misra 1941). Rainboth also commented that the sharp, horny sheath covering the lower jaw used to group fishes in *Acrossocheilus* is ecophenotypically variable as was found in other barbins, and therefore this character cannot serve as a primary distinguishing character. Based on several characters, such as the absence of the fleshy lobes on the lower lips, the development of a horny sheath on the lower jaw, low number of gill rakers on the lower arm, blunt, broad and longer snout, shallow and terete trunk, and shorter and more massive pharyngeal arch, Rainboth (1985) erected a new genus, *Neolissochilus*. 
Due to the lack of morphological variation among the species, the taxonomy of this new genus has proven to be complex. Currently, there are 24 nominal species of *Neolissochilus* with sixteen of them described from Southeast Asian drainages (Rainboth 1985), including a recently described species from Thailand, *Neolissochilus subterraneus* Vidthayanon & Kottelat (2003).

In Peninsular Malaysia, *Neolissochilus* is locally known as ‘ikan tengas’ or ‘copper mahseer’ and is found in good quality, clear and rapid streams (Zakaria-Ismail & Fatimah 2002). The distribution of *Neolissochilus* in Peninsular Malaysia has been well documented (Duncker 1904; Weber & de Beaufort 1916; Herre & Myers 1937; Herre 1940; Ogilvie 1953; Menon 1954; Alfred 1963a, 1963b; Johnson 1967; Bishop 1973; Cramphorn 1983; Mohsin & Ambak 1983; Rainboth 1991; Zakaria-Ismail 1984, 1993; Zakaria-Ismail & Sabariah 1994; Zakaria-Ismail & Lim 1995; Doi 1997; Lim & Tan 2002; Zakaria-Ismail & Fatimah 2005; Ahmad & Lim 2006; Ambak & Jalal 2006; Esa et al. 2006). However, various names that have been used, and the number of species reported is variable. Doi (1997) reported six species, i.e. *Neolissochilus dukai*, *N. hendersoni*, *N. paucisquamatus*, *N. soroides*, *N. sumatranus* and *N. tweediei* in the Malay Peninsula but he did not specify which species occurred in Peninsular Malaysia. Ambak & Jalal (2006) and Esa et al. (2006) reported the occurrence of *N. hexagonolepis* and *N. stracheyi* in river systems of Peninsular Malaysia. Recently, Roberts & Khaironizam (2008) recognized polymorphism in *N. soroides* from Sungai Gombak of Selangor and described three morphotypes: 1) normal, which is rounded edge of lower jaw, 2) truncate, which is truncated edge with trenchant cutting edge, and 3) lobe, which is lower lip developed into mantel lobe.

The objective of this paper is to study the variation of fishes of the genus *Neolissochilus* in Peninsular Malaysia to determine which species are valid and whether or not the morphotypes of *N. soroides* can be differentiated morphometrically or meristically. The distributional pattern of *Neolissochilus* in Peninsular Malaysia is also provided.

### Material and methods

The majority of the specimens used in this study were from the Zoological Museum of the Institute of Biological Sciences, Faculty of Sciences, University of Malaya (UMKL). Under material examined, the following data were given: institutional acronym and reference number, number of specimens examined, standard length or range of standard length, locality of the collection, date of collection and collector (s). For comparative purposes, some of the Malaysian and South Asian material from the California Academy of Sciences, formerly the Stanford University Collection (CAS-SU); National Museum of Natural History, Washington DC (USNM); and Zoological Reference Collection of the Raffles Museum of Biodiversity Research, National University of Singapore (ZRC), were examined. The abbreviation ‘Sg.’ is for ‘Sungai’ [= River] and ‘SL’ refers to standard length.

External morphology of each individual was observed and noted. Procedures for the 20 meristics and 36 morphometrics taken followed the standard procedures outlined by Hubbs & Lagler (1964) and Kottelat et al. (1993) or are self-explanatory. A total of 1459 specimens of *N. soroides* and 102 specimens of *N. hendersoni*, were examined from 75 localities of the 14 major drainages throughout Peninsular Malaysia (Fig. 1). Of those, 287 specimens had a full series of meristics and morphometrics (213 of *N. soroides* and 74 *N. hendersoni*), and the remainder were partially measured for their meristic and morphometric characters or identified based on their individual features. Other specimens labeled as *Barbus soroides* (1 specimen—Sg. Batang Padang in Perak, Peninsular Malaysia), *Lissochilus tweediei* (10 specimens—Sg. Yum in Perak, Peninsular Malaysia), *Lissochilus dukai* (1 specimen—Darjeeling, Himalayas, India), *Acrossocheilus hexagonolepis* (10 specimens—Chitawan Valley, Nepal) and *Lissochilus hendersoni* (10 specimens—Penang, Peninsular Malaysia) were used as comparative material.

The measurements were taken to the nearest 0.1 mm by using calipers and expressed as percentages of standard length (SL). Raw measurements were log-transformed in Excel and analyzed in JMP v. 11.0.0 (SAS Institute, 2013). A principal components analysis (PCA) and a canonical variates analysis (CVA) were performed on the log-transformed measurements. For the CVA, species and morphotype were used as the classification variable. The first three principal components and the three canonical variates were plotted against SL, and an ANOVA performed to determine whether or not they were correlated with overall size. Because CV1 was correlated with size, a second CVA for PC2-PC37 was performed. The resultant canonical variates were also tested.
against SL. Meristics were examined in a separate PCA; 95% confidence intervals were calculated for each PC and CV plot.

In addition, morphometrics were plotted against SL to determine if there appeared to be any biologically significant differences between species or morphotypes. Two characters, Lower Jaw Length and Lower Jaw Width
appeared to show significant differences between morphotypes of *N. soroides*, and were plotted against one another. An ANCOVA was performed in JMP using the “Fit Model” command and Standard Least Squares. Log-transformed Lower Jaw Length was chosen as the variable and log-transformed Lower Jaw Width and Species/Morphotype chosen as the Model Effects. A Tukey HSD posthoc test was employed to evaluate pairwise differences between species.

**FIGURE 2.** Results of morphometric analyses. A) PCA: PC2 was most strongly influenced positively by Upper Lips Thickness, Lower Jaw Width, and Snout Length, and negatively by Body Depth, Anal-fin Base Length, and Dorsal-fin Base Length; PC3 was most strongly influenced positively by Lower Jaw Length, Head Width, and Orbital Length, and negatively by Upper Lips Thickness, Depressed Dorsal-fin Length, and Dorsal-fin Base Length. B) CVA of all log-transformed morphometric data: CV1 was most strongly influenced positively by Post-pectoral-fin Length, Head Length, and Dorsal-fin Height, and negatively by Standard Length, Pre-anal Length, and Body Depth; CV2 was most strongly influenced positively by Post-dorsal-fin Length, Pre-dorsal Length, and Pre-nostril Length. C) CVA on principal components, excluding PC1.
TABLE 1. Meristic and morphometric features of three mouth types of *N. soroides* in Peninsular Malaysia.

<table>
<thead>
<tr>
<th>Characters</th>
<th>Normal mouth type (n=108, 38.2-153.2 mm SL)</th>
<th>Truncate mouth type (n=90, 40.6-144.4 mm SL)</th>
<th>Lobe mouth type (n=15, 63.3-120.0 mm SL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meristic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dorsal-fin spines and rays</td>
<td>iv, 9</td>
<td>iv, 9</td>
<td>iv, 9</td>
</tr>
<tr>
<td>Anal-fin spines and rays</td>
<td>iii, 5</td>
<td>iii, 5</td>
<td>i, 5</td>
</tr>
<tr>
<td>Pectoral-fin spines and rays</td>
<td>i, 14-15 (14.5±0.5)</td>
<td>i, 14-15 (14.5±0.5)</td>
<td>i, 14-15 (14.3±0.5)</td>
</tr>
<tr>
<td>Pelvic-fin spines and rays</td>
<td>i, 8</td>
<td>i, 8</td>
<td>i, 8</td>
</tr>
<tr>
<td>Lateral-line scales</td>
<td>20-24 (22.4±0.8)</td>
<td>21-24 (22.3±0.6)</td>
<td>21-24 (22.1±0.6)</td>
</tr>
<tr>
<td>Scales in lateral line on hypural plates</td>
<td>2-3 (2.8±0.4)</td>
<td>2-3 (2.8±0.4)</td>
<td>3</td>
</tr>
<tr>
<td>Scales above lateral line</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Scales below lateral line</td>
<td>2.5-3.5 (2.7±0.4)</td>
<td>2.5-3.5 (2.8±0.4)</td>
<td>2.5-3.5 (2.8±0.4)</td>
</tr>
<tr>
<td>Circumpeduncular scale rows</td>
<td>16-18 (17.0±0.9)</td>
<td>16-18 (16.9±0.9)</td>
<td>16-18 (17.5±0.9)</td>
</tr>
<tr>
<td>Predorsal scales</td>
<td>8-10 (8.4±0.5)</td>
<td>8-10 (8.5±0.6)</td>
<td>8-10 (8.4±0.6)</td>
</tr>
<tr>
<td>Scales at dorsal-fin base</td>
<td>7-10 (8.4±0.7)</td>
<td>7-9 (8.3±0.5)</td>
<td>8-9 (8.4±0.5)</td>
</tr>
<tr>
<td>Scales from end of dorsal-fin base to origin of caudal-fin base</td>
<td>12-15 (13.5±0.8)</td>
<td>12-15 (13.4±0.5)</td>
<td>12-14 (13.0±0.7)</td>
</tr>
<tr>
<td>Scales from isthmus to pelvic-fin base</td>
<td>12-14 (13.3±0.5)</td>
<td>12-14 (13.2±0.4)</td>
<td>13-14 (13.2±0.4)</td>
</tr>
<tr>
<td>Scales from end of pelvic-fin base to origin of anal-fin base</td>
<td>5-6 (5.6±0.5)</td>
<td>5-6 (5.7±0.5)</td>
<td>5-6 (5.8±0.4)</td>
</tr>
<tr>
<td>Scales at anal-fin base</td>
<td>4-6 (4.9±0.4)</td>
<td>4-6 (4.8±0.5)</td>
<td>5</td>
</tr>
<tr>
<td>Scales from end of anal-fin base to origin of caudal-fin base</td>
<td>6-8 (6.7±0.5)</td>
<td>6-8 (6.6±0.5)</td>
<td>6-7 (6.9±0.4)</td>
</tr>
<tr>
<td>Total gill rakers</td>
<td>14-17 (16.0±0.8)</td>
<td>15-17 (16.3±0.7)</td>
<td>15-17 (16.2±0.9)</td>
</tr>
<tr>
<td>Gill rakers on lower arm</td>
<td>10-12 (10.7±0.7)</td>
<td>10-12 (10.7±0.6)</td>
<td>10-12 (10.9±0.7)</td>
</tr>
<tr>
<td>Gill rakers on upper arm</td>
<td>4-5 (4.4±0.5)</td>
<td>4-5 (4.5±0.5)</td>
<td>4-5 (4.3±0.5)</td>
</tr>
<tr>
<td>Morphometric (in % SL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body depth</td>
<td>26.2-35.5 (30.4±1.7)</td>
<td>26.2-35.9 (31.0±2.2)</td>
<td>26.8-33.4 (30.1±1.9)</td>
</tr>
<tr>
<td>Head length</td>
<td>26.8-32.2 (29.4±1.2)</td>
<td>26.9-33.1 (29.3±1.5)</td>
<td>27.9-31.6 (29.5±1.1)</td>
</tr>
<tr>
<td>Head depth</td>
<td>17.8-25.5 (22.6±1.2)</td>
<td>19.8-24.6 (22.7±1.0)</td>
<td>20.9-24.3 (23.1±0.9)</td>
</tr>
<tr>
<td>Head width</td>
<td>14.9-24.0 (18.4±1.9)</td>
<td>14.4-23.0 (18.3±1.8)</td>
<td>17.3-21.2 (18.8±1.1)</td>
</tr>
</tbody>
</table>

...Continue on next page
### TABLE 1 (continued). Comparative meristic and morphometric features between three mouth types of *N. soroides* from Peninsular Malaysia.

<table>
<thead>
<tr>
<th>Characters</th>
<th>Normal mouth type</th>
<th>Truncate mouth type</th>
<th>Lobe mouth type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=108, 38.2-153.2 mm SL)</td>
<td>(n=90, 40.6-144.4 mm SL)</td>
<td>(n=15, 63.3-120.0 mm SL)</td>
</tr>
<tr>
<td>Snout length</td>
<td>6.6-12.1 (10.3±0.9)</td>
<td>8.6-12.7 (10.5±1.0)</td>
<td>9.8-11.6 (10.7±0.5)</td>
</tr>
<tr>
<td>Pre-nostril length</td>
<td>7.2-9.7 (8.5±0.6)</td>
<td>7.0-10.9 (8.9±0.9)</td>
<td>7.8-9.7 (8.9±0.5)</td>
</tr>
<tr>
<td>Eye diameter/length</td>
<td>5.0-8.7 (6.8±0.6)</td>
<td>5.3-8.7 (6.9±0.7)</td>
<td>5.8-8.4 (6.8±0.7)</td>
</tr>
<tr>
<td>Pre-occipital length</td>
<td>20.2-26.3 (23.0±1.2)</td>
<td>18.9-28.1 (23.4±1.6)</td>
<td>21.3-24.6 (23.1±0.9)</td>
</tr>
<tr>
<td>Pre-operculum length</td>
<td>18.3-24.0 (21.2±1.1)</td>
<td>17.6-25.1 (21.3±1.5)</td>
<td>20.2-21.7 (20.9±0.5)</td>
</tr>
<tr>
<td>Caudal-peduncle length</td>
<td>13.9-18.9 (16.5±1.0)</td>
<td>12.8-19.1 (16.3±1.2)</td>
<td>15.7-18.7 (17.2±0.7)</td>
</tr>
<tr>
<td>Caudal-peduncle depth</td>
<td>10.8-13.6 (12.0±0.6)</td>
<td>10.3-13.8 (12.1±0.7)</td>
<td>10.8-13.1 (11.8±0.7)</td>
</tr>
<tr>
<td>Dorsal-fin base length</td>
<td>14.6-19.8 (16.6±1.0)</td>
<td>15.3-18.9 (16.8±0.9)</td>
<td>14.7-17.8 (16.1±1.0)</td>
</tr>
<tr>
<td>Dorsal-fin depressed length</td>
<td>25.6-33.4 (29.1±1.6)</td>
<td>25.6-33.7 (29.9±1.6)</td>
<td>26.4-31.8 (29.3±1.6)</td>
</tr>
<tr>
<td>Dorsal-fin height</td>
<td>19.7-27.4 (23.4±1.4)</td>
<td>20.3-28.3 (23.6±1.5)</td>
<td>21.0-25.6 (23.7±1.5)</td>
</tr>
<tr>
<td>Anal-fin base length</td>
<td>6.5-9.0 (7.9±0.5)</td>
<td>6.4-9.3 (7.8±0.5)</td>
<td>7.0-8.4 (7.6±0.4)</td>
</tr>
<tr>
<td>Anal-fin depressed length</td>
<td>18.0-25.0 (20.8±1.3)</td>
<td>18.0-24.7 (21.1±1.3)</td>
<td>19.8-23.2 (21.7±1.0)</td>
</tr>
<tr>
<td>Anal-fin height</td>
<td>15.7-23.2 (18.8±1.5)</td>
<td>15.2-22.7 (19.2±1.2)</td>
<td>17.6-20.6 (19.4±0.9)</td>
</tr>
<tr>
<td>Pectoral-fin length</td>
<td>19.9-26.7 (23.7±1.4)</td>
<td>21.2-27.6 (24.4±1.4)</td>
<td>22.8-26.4 (24.8±1.1)</td>
</tr>
<tr>
<td>Pelvic-fin length</td>
<td>17.8-23.8 (21.0±0.8)</td>
<td>18.2-23.9 (21.0±1.3)</td>
<td>18.9-22.6 (21.0±1.2)</td>
</tr>
<tr>
<td>Pre-dorsal length</td>
<td>47.5-55.5 (51.6±1.2)</td>
<td>48.2-57.0 (51.8±1.8)</td>
<td>49.7-54.4 (51.9±1.4)</td>
</tr>
<tr>
<td>Post-dorsal length</td>
<td>51.1-60.4 (54.4±2.1)</td>
<td>51.1-59.7 (55.1±2.2)</td>
<td>51.1-55.6 (53.2±1.5)</td>
</tr>
<tr>
<td>Pre-pectoral length</td>
<td>25.6-33.2 (29.2±1.8)</td>
<td>23.8-33.1 (29.2±1.8)</td>
<td>26.4-32.3 (29.3±1.6)</td>
</tr>
<tr>
<td>Post-pectoral length</td>
<td>62.3-79.9 (74.5±2.3)</td>
<td>69.5-79.8 (74.5±2.4)</td>
<td>69.8-76.1 (73.9±2.0)</td>
</tr>
<tr>
<td>Pre-anal length</td>
<td>75.9-82.1 (78.3±1.6)</td>
<td>74.1-84.3 (78.7±1.9)</td>
<td>74.9-82.3 (77.6±1.8)</td>
</tr>
<tr>
<td>Post-anal length</td>
<td>21.3-27.4 (24.3±1.3)</td>
<td>19.8-27.1 (23.9±1.4)</td>
<td>23.4-26.2 (24.3±0.9)</td>
</tr>
<tr>
<td>Pre-pelvic length</td>
<td>50.7-57.9 (54.3±1.7)</td>
<td>49.3-59.7 (54.5±2.1)</td>
<td>51.3-56.0 (53.7±1.3)</td>
</tr>
<tr>
<td>Post-pelvic length</td>
<td>46.0-55.9 (50.0±1.7)</td>
<td>45.6-54.2 (49.5±1.9)</td>
<td>47.6-51.8 (49.7±1.4)</td>
</tr>
<tr>
<td>Length from dorsal-fin base to pectoral-fin base</td>
<td>21.4-39.1 (33.0±2.3)</td>
<td>20.7-39.4 (33.0±2.5)</td>
<td>29.5-35.4 (32.9±2.1)</td>
</tr>
<tr>
<td>Length from dorsal-fin base to anal-fin base</td>
<td>33.7-43.1 (39.2±1.7)</td>
<td>36.2-43.1 (39.5±1.6)</td>
<td>35.6-40.3 (38.1±1.5)</td>
</tr>
<tr>
<td>Length from pelvic-fin base to anal-fin base</td>
<td>23.2-29.1 (25.8±1.2)</td>
<td>23.1-29.5 (25.7±1.2)</td>
<td>22.9-27.2 (25.0±1.3)</td>
</tr>
<tr>
<td>Length from pectoral-fin base to pelvic-fin base</td>
<td>23.1-30.4 (26.5±1.3)</td>
<td>22.3-29.7 (26.7±1.3)</td>
<td>23.7-28.5 (26.0±1.3)</td>
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<tr>
<td>Length from pectoral-fin base to anal-fin base</td>
<td>47.4-56.9 (51.5±1.8)</td>
<td>47.0-55.5 (51.3±1.7)</td>
<td>46.3-53.8 (50.2±1.9)</td>
</tr>
<tr>
<td>Lower jaw length</td>
<td>5.6-11.5 (8.6±1.3)</td>
<td>4.5-11.1 (6.8±1.3)</td>
<td>5.7-15.7 (9.4±2.2)</td>
</tr>
<tr>
<td>Lower jaw width</td>
<td>6.0-11.5 (8.2±1.2)</td>
<td>6.0-12.3 (9.1±1.1)</td>
<td>6.8-11.0 (8.7±1.1)</td>
</tr>
<tr>
<td>Upper lip thickness</td>
<td>1.5-2.2 (1.8±0.2)</td>
<td>1.0-2.4 (1.8±0.3)</td>
<td>1.6-2.1 (1.8±0.2)</td>
</tr>
<tr>
<td>Lower lip thickness</td>
<td>1.1-2.5 (1.8±0.3)</td>
<td>1.2-2.4 (1.7±0.3)</td>
<td>1.4-2.4 (2.0±0.3)</td>
</tr>
</tbody>
</table>
Results

Observations on 213 specimens of *Neolissochilus soroides* revealed 108 with the normal mouth type, 90 specimens with the truncate mouth type, and 15 with the lobe mouth type. Table 1 shows the meristic and morphometric data on the three morphotypes. Comparative meristic and morphometric characters of *N. hendersoni* and *N. soroides* are in Table 2. PCA of measurements (Fig. 2A) failed to demonstrate any major differences between species or between morphotypes, but there is a slight trend towards lower PC3 scores in the truncate morphotype compared to those in the normal and lobe morphotypes. PC1 was found to be significantly correlated with size, but PC2 and PC3 were not (Table 3A). PCA on meristics (Fig. 3) yielded significant differences between *Neolissochilus hendersoni* and *N. soroides*, but there were no differences between the morphotypes of *N. soroides*.

![FIGURE 3. Principal Components Analysis of meristic data. Neolissochilus hendersoni and N. soroides separated only along PC1, which was most strongly influenced positively by Total Gill Rakers, Scales from Isthmus to Pelvic-fin base, and Gill Rakers on Lower Arm, and negatively by Scales at Anal-fin Base.](image)

CVA on log-transformed data was remarkably successful in correctly predicting group identity (87.1% of specimens correctly classified to species or morphotype; Fig. 2B: Table 4A); however, CV1 was significantly correlated with size (Table 3B), and was one of the most strongly loaded variables on CVA. Given that the size range of each species/morphotype was roughly equivalent, this is not likely to be a major factor; however, a second CVA on the PC scores excluding PC1 (Fig. 2C) was similar to the original CVA with just a slight reduction in percent of specimens correctly classified to species or morphotype (86.1% of specimens correctly classified to species or morphotype; Table 4B). None of the CV’s on PC scores were correlated with size (Table 3C).

Analysis of Lower Jaw Length vs. Lower Jaw Width (Fig. 4) showed differences between at least the normal plus lobe morphotypes and the truncate morphotype. ANCOVA revealed significant differences between the truncate and the normal and lobe morphotypes (p<0.0001), and each of the *N. soroides* morphotypes was significantly different from *N. hendersoni* (vs. normal p<0.01, vs. truncate p=0.0009, vs. lobe p=0.0012). Only the normal and lobe morphotypes were not significantly different (p=0.992) from one another.
Meristic and morphometric data on Neolissochilus revealed that only two species occur in the river systems of Peninsular Malaysia: *N. hendersoni* and *N. soroides*. Although both species have similar morphology and numbers of fin rays, the numbers of scales and gill rakers are smaller in *N. hendersoni*. Although there is some overlap in meristics, the PCA of meristics showed complete separation between *N. hendersoni* and *N. soroides.

**TABLE 2.** Comparison of meristic and morphometric features of *N. hendersoni* and *N. soroides* from Peninsular Malaysia.

<table>
<thead>
<tr>
<th>Characters</th>
<th><em>N. hendersoni</em> (n=74, 44.6-122.7 mm SL)</th>
<th><em>N. soroides</em> (n=213, 38.2-153.2 mm SL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dorsal-fin spines and rays</td>
<td>iv, 9</td>
<td>iv, 9</td>
</tr>
<tr>
<td>Anal-fin spines and rays</td>
<td>iii, 5</td>
<td>iii, 5</td>
</tr>
<tr>
<td>Pectoral-fin spines and rays</td>
<td>i, 14-15 (14.3±0.5)</td>
<td>i, 14-15 (14.5±0.5)</td>
</tr>
<tr>
<td>Pelvic-fin spines and rays</td>
<td>i, 7-8 (8.0±0.2)</td>
<td>i, 7-8 (8.0±0.1)</td>
</tr>
<tr>
<td>Lateral-line scales</td>
<td>18-22 (20.0±0.8)</td>
<td>20-24 (22.3±0.7)</td>
</tr>
<tr>
<td>Scales in lateral line on hypural plates</td>
<td>2-3 (2.0±0.2)</td>
<td>2-3 (2.8±0.4)</td>
</tr>
<tr>
<td>Scales above lateral line</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Scales below lateral line</td>
<td>2.0-3.0 (2.0±0.2)</td>
<td>2.5-3.5 (2.8±0.4)</td>
</tr>
<tr>
<td>Circumferential scale rows</td>
<td>16-18 (16.4±0.7)</td>
<td>16-18 (17.0±0.9)</td>
</tr>
<tr>
<td>Circumpeduncular scale rows</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Pre-dorsal scales</td>
<td>6-8 (7.7±0.5)</td>
<td>8-10 (8.5±0.6)</td>
</tr>
<tr>
<td>Scales at dorsal-fin base</td>
<td>7-9 (8.1±0.6)</td>
<td>7-10 (8.3±0.6)</td>
</tr>
<tr>
<td>Scales from end of dorsal-fin base to origin of caudal fin</td>
<td>10-13 (12.2±0.8)</td>
<td>12-15 (13.4±0.7)</td>
</tr>
<tr>
<td>Scales from isthmus to pelvic-fin base</td>
<td>10-12 (10.7±0.8)</td>
<td>12-14 (13.2±0.5)</td>
</tr>
<tr>
<td>Scales from end of pelvic-fin base to origin of anal-fin base</td>
<td>4-6 (5.3±0.5)</td>
<td>5-6 (5.6±0.5)</td>
</tr>
<tr>
<td>Scales at anal fin base</td>
<td>3-5 (4.1±0.3)</td>
<td>4-6 (4.9±0.4)</td>
</tr>
<tr>
<td>Scales from end of anal-fin base to origin of caudal fin</td>
<td>5-6 (5.9±0.3)</td>
<td>6-8 (6.6±0.5)</td>
</tr>
<tr>
<td>Total gill rakers</td>
<td>12-14 (13.8±0.5)</td>
<td>14-17 (16.1±0.8)</td>
</tr>
<tr>
<td>Gill rakers on the lower arms</td>
<td>9-10 (9.3±0.5)</td>
<td>10-12 (10.7±0.8)</td>
</tr>
<tr>
<td>Gill rakers on the upper arms</td>
<td>3-4 (3.5±0.5)</td>
<td>4-5 (4.5±0.5)</td>
</tr>
<tr>
<td><strong>Morphometric (in % SL)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Body depth</td>
<td>27.6-35.6 (31.1±1.6)</td>
<td>26.2-35.9 (30.7±2.0)</td>
</tr>
<tr>
<td>Head length</td>
<td>26.4-31.3 (28.9±1.2)</td>
<td>26.8-33.1 (29.4±1.3)</td>
</tr>
<tr>
<td>Head depth</td>
<td>19.8-25.5 (23.0±1.2)</td>
<td>17.8-25.5 (22.7±1.1)</td>
</tr>
<tr>
<td>Head width</td>
<td>15.4-19.6 (17.7±1.0)</td>
<td>14.4-24.0 (18.4±1.8)</td>
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<tr>
<td>Snout length</td>
<td>8.6-11.6 (10.2±0.7)</td>
<td>6.6-12.7 (10.4±0.9)</td>
</tr>
<tr>
<td>Pre-nostril length</td>
<td>7.0-9.6 (8.3±0.6)</td>
<td>7.0-10.9 (8.7±0.7)</td>
</tr>
<tr>
<td>Eye diameter/length</td>
<td>5.9-8.7 (7.3±0.6)</td>
<td>5.0-8.7 (6.8±0.7)</td>
</tr>
</tbody>
</table>
TABLE 2 (continued). Comparison of meristic and morphometric features of *N. hendersoni* and *N. soroides* from Peninsular Malaysia.

<table>
<thead>
<tr>
<th>Characters</th>
<th><em>N. hendersoni</em> (n=74, 44.6-122.7 mm SL)</th>
<th><em>N. soroides</em> (n=213, 38.2-153.2 mm SL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre occipital length</td>
<td>20.9-26.0 (23.4±1.1)</td>
<td>18.9-28.1 (23.2±1.4)</td>
</tr>
<tr>
<td>Pre operculum length</td>
<td>19.2-22.9 (21.1±0.9)</td>
<td>17.6-25.1 (21.2±1.2)</td>
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<tr>
<td>Caudal-peduncle length</td>
<td>13.8-19.4 (16.4±1.1)</td>
<td>12.8-19.1 (16.5±1.1)</td>
</tr>
<tr>
<td>Caudal-peduncle depth</td>
<td>10.9-13.8 (12.5±0.6)</td>
<td>10.3-13.8 (12.0±0.6)</td>
</tr>
<tr>
<td>Dorsal-fin base length</td>
<td>14.8-19.1 (16.9±0.9)</td>
<td>14.6-19.8 (16.6±1.0)</td>
</tr>
<tr>
<td>Dorsal-fin depressed length</td>
<td>25.9-33.1 (29.8±1.4)</td>
<td>25.6-33.7 (29.4±1.7)</td>
</tr>
<tr>
<td>Dorsal-fin height</td>
<td>19.5-25.3 (22.2±1.2)</td>
<td>19.7-28.3 (23.5±1.5)</td>
</tr>
<tr>
<td>Anal-fin base length</td>
<td>6.7-9.2 (7.8±0.5)</td>
<td>6.4-9.3 (7.8±0.5)</td>
</tr>
<tr>
<td>Anal-fin depressed length</td>
<td>17.3-23.6 (20.4±1.3)</td>
<td>18.0-25.0 (21.0±1.3)</td>
</tr>
<tr>
<td>Anal-fin height</td>
<td>15.1-21.0 (17.9±1.4)</td>
<td>15.2-23.2 (19.0±1.4)</td>
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<tr>
<td>Pectoral-fin length</td>
<td>21.2-26.7 (23.6±1.4)</td>
<td>19.9-27.6 (24.1±1.4)</td>
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<tr>
<td>Pelvic-fin length</td>
<td>18.1-22.8 (20.4±1.1)</td>
<td>17.8-23.9 (21.1±1.1)</td>
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<tr>
<td>Pre-dorsal length</td>
<td>47.2-53.7 (51.2±1.3)</td>
<td>47.5-57.0 (51.7±1.5)</td>
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<tr>
<td>Post-dorsal length</td>
<td>48.0-59.3 (53.2±2.3)</td>
<td>51.1-60.4 (54.6±2.2)</td>
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<tr>
<td>Pre-pectoral length</td>
<td>24.8-34.5 (28.5±2.1)</td>
<td>23.8-33.2 (29.2±1.8)</td>
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<tr>
<td>Post-pectoral length</td>
<td>71.2-80.2 (74.6±2.0)</td>
<td>62.3-79.9 (74.4±2.3)</td>
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<td>Pre-anal length</td>
<td>72.2-83.5 (78.9±2.0)</td>
<td>74.1-84.3 (78.4±1.7)</td>
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<tr>
<td>Post-anal length</td>
<td>20.1-26.2 (23.2±1.2)</td>
<td>19.8-27.4 (24.1±1.3)</td>
</tr>
<tr>
<td>Pre-pelvic length</td>
<td>50.6-58.7 (54.4±2.0)</td>
<td>49.3-59.7 (54.4±1.9)</td>
</tr>
<tr>
<td>Post-pelvic length</td>
<td>46.5-52.9 (49.7±1.4)</td>
<td>45.6-55.9 (49.8±1.8)</td>
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<tr>
<td>Length from dorsal-fin base to pectoral-fin base</td>
<td>30.4-37.0 (33.3±1.5)</td>
<td>20.7-39.4 (33.0±1.9)</td>
</tr>
<tr>
<td>Length from dorsal-fin base to anal-fin base</td>
<td>36.5-44.4 (40.1±1.6)</td>
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<tr>
<td>Length from pelvic-fin base to anal-fin base</td>
<td>23.3-31.4 (26.3±1.5)</td>
<td>22.9-29.5 (25.7±1.2)</td>
</tr>
<tr>
<td>Length from pectoral-fin base to pelvic-fin base</td>
<td>24.3-30.0 (27.4±1.2)</td>
<td>22.3-30.4 (26.5±1.3)</td>
</tr>
<tr>
<td>Length from pectoral-fin base to anal-fin base</td>
<td>48.8-56.4 (52.9±1.7)</td>
<td>46.3-56.9 (51.4±1.8)</td>
</tr>
<tr>
<td>Lower jaw length</td>
<td>4.6-10.5 (7.3±1.2)</td>
<td>4.5-15.7 (7.9±1.6)</td>
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<tr>
<td>Lower jaw width</td>
<td>5.3-9.8 (8.3±1.1)</td>
<td>6.0-12.3 (8.6±1.2)</td>
</tr>
<tr>
<td>Upper lip thickness</td>
<td>1.1-2.6 (1.7±0.3)</td>
<td>1.0-2.4 (1.8±0.2)</td>
</tr>
<tr>
<td>Lower lip thickness</td>
<td>1.2-2.2 (1.7±0.2)</td>
<td>1.1-1.8 (1.5±0.2)</td>
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</table>
TABLE 3. Linear correlations with standard length for A) PCA log-transformed morphometric data, B) CVA of log-transformed morphometric data, and C) CVA of CVA of principal components scores excluding PC1. A quadratic equation better fit PC1 with $r^2=0.94822$ and $p<0.0001$.

<table>
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<tr>
<th></th>
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<th>PC2</th>
<th>PC3</th>
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<tr>
<td>$r^2$</td>
<td>0.963922</td>
<td>0.000583</td>
<td>0.0005581</td>
</tr>
<tr>
<td>$p$</td>
<td>&lt;0.0001</td>
<td>0.6837</td>
<td>0.8997</td>
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<table>
<thead>
<tr>
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<th>CV1</th>
<th>CV2</th>
<th>CV3</th>
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<tbody>
<tr>
<td>$r^2$</td>
<td>0.151506</td>
<td>0.000139</td>
<td>0.008466</td>
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<tr>
<td>$p$</td>
<td>&lt;0.0001</td>
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<tr>
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<th>CV2</th>
<th>CV3</th>
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</thead>
<tbody>
<tr>
<td>$r^2$</td>
<td>0.000282</td>
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<td>$p$</td>
<td>0.7769</td>
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A)  

<table>
<thead>
<tr>
<th>Actual Identification</th>
<th>Predicted Identification</th>
<th>N. soroides</th>
<th>N. hendersoni</th>
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</thead>
<tbody>
<tr>
<td>N. soroides normal</td>
<td>normal</td>
<td>92</td>
<td>2</td>
</tr>
<tr>
<td>N. soroides lobe</td>
<td>lobe</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>N. soroides truncate</td>
<td>truncate</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>N. hendersoni</td>
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<td>1</td>
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</table>

B)  

<table>
<thead>
<tr>
<th>Actual Identification</th>
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<th>N. soroides</th>
<th>N. hendersoni</th>
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</thead>
<tbody>
<tr>
<td>N. soroides normal</td>
<td>normal</td>
<td>91</td>
<td>3</td>
</tr>
<tr>
<td>N. soroides lobe</td>
<td>lobe</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>N. soroides truncate</td>
<td>truncate</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>N. hendersoni</td>
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</table>

Although PCA failed to show any distinct differences in morphometry between the morphotypes of *N. soroides*, CVA was successful in classifying specimens into morphotypes as well as in separating *N. hendersoni* (Fig. 2). The morphotypes are sympatric and reportedly consume the same food resources (Khaironizam, 2010). We support Roberts & Khaironizam (2008) that the differences in the lower part of the mouth in *N. soroides* are due to polymorphisms, but given the trends in morphometric differences indicated by CVA and the analysis of Lower Jaw Length vs. Lower Jaw Width, we suggest that the question of the identity of the morphotypes be further examined with genetic techniques.

Zakaria-Ismail (1994) and Lim & Tan (2002) reported that *N. hendersoni* was endemic to Penang. Recently, Ahmad & Lim (2006) reported the occurrence of this species in Langkawi. Both localities are islands at the northwestern part of Peninsular Malaysia. Our specimens from Merbok and Muda drainage in Kedah and Golok drainage in Kelantan appeared to be the first record of the species on the mainland. Until now, the distribution of this species is only known from Peninsular Malaysia and there have been no reports on the occurrence of the species in other localities in Southeast Asia.

*Neolissochilus hendersoni* in Penang and Langkawi is critically vulnerable because it is limited to certain
areas. This is due to the rapid development in these islands and the occurrence of pollution in the river systems such as several streams in Batu Feringgi, Teluk Bahang and Balik Pulau of Penang (pers. obs.). We believe that further environmental alterations will definitely endanger this species in Peninsular Malaysia.

It is not surprising to find *N. hendersoni* in other localities in the Malay Peninsula, especially in southern Thailand as they can be found in the northern most part of Peninsular Malaysia. Although *N. hutchinsoni* (Fowler, 1938) and *N. paucisquamatus* (Smith, 1945) were described from southern Thailand, they appear similar to *N. hendersoni*. For the time being, we consider those species as valid.

**FIGURE 4.** Lower Jaw Length vs. Lower Jaw Width. Significant differences were found between all pairs of species/morphotypes except Normal and Lobe *N. soroides*.

Duncker (1904) indicated that the type locality of *N. soroides* was a stream in the Pahang drainage near Sangka Dua Pass. There is no such place as Sangka Dua Pass in Pahang; however, there is a place called Sangka Dua along the way from Kuala Kubu Baru to Freser’s Hill, and two small streams, Sg. Chiling and Sg. Gamut, pass through Sangka Dua. We believe the type specimens were collected from these streams. Thus the type locality should be Sangka Dua of the Selangor drainage instead of the Pahang drainage.

Herre in Herre & Myers (1937) described *N. tweediei* (as *Lissochilus tweediei*) from the Sg. Yum of the Perak drainage, based on the distinct characters of the lower jaw, which is the truncate morphotype. Roberts & Khaironizam (2008) reported that the flat-edge of the lower jaw and the thickness of the lower lips are only a trophic polymorphism or ecophenotype as observed in other cyprinid fishes. Ismail (1989) compared the meristics and the morphometrics of several specimens of *N. soroides* and *N. tweediei* and also found no significant difference between the two species other than the differences in the lower jaw.

Data from the type specimens of *N. tweediei* and from specimens from the same or nearby the type locality shows no evidence to suggest that *N. tweediei* differs from *N. soroides*. We consider *N. tweediei* to a junior
synonym to *N. soroides*. We agree with Roberts & Khaironizam (2008) that characters of the truncated edge of the lower jaw used by Herre in Herre & Myers (1937) to distinguish *N. tweediei* are the result of trophic polymorphisms.

Ogilvie (1953), Menon (1954), Cramphorn (1983), Mohsin & Ambak (1983), Ambak & Jalal (2006) and Esa et al. (2006) reported the occurrence of *N. hexagonolepis* and *N. stracheyi* in Peninsular Malaysia. We have examined specimens from the same localities or the streams near to these localities and found them not to agree with the descriptions of *N. hexagonolepis* and *N. stracheyi*. *Neolissochilus hexagonolepis* has 26–32 scales in the lateral line (M’Clelland 1839; Hora 1940; Jayaram 1981), while *N. stracheyi* has a distinct black lateral stripe running parallel from the end of the operculum to the caudal-fin base (Rainboth 1985, 1996). Therefore, the occurrence of those species in Peninsular Malaysia is doubtful.

Doi (1997) reported the occurrence of *N. dukai*, *N. paucisquamatus* and *N. sumatranus* in the Malay Peninsula. *Neolissochilus dukai* was described by Day (1878) from Darjeeling, India, and we suggest that it be compared with *N. hexagonolepis*, as they seem to share a lot of similarities. *Neolissochilus sumatranus* (Weber & de Beaufort, 1916) seems to be similar to our specimens of *N. soroides*. Roberts & Khaironizam (2008) examined specimens in ZRC and also found them to be similar to *N. soroides* and tentatively concluded that *N. sumatranus* is a junior synonym of *N. soroides*. *Neolissochilus paucisquamatus*, a small fish (45–55 mm length), probably does not occur in Peninsular Malaysia as it was originally reported from northern Thailand and the mountane areas of Nakhon Si Tammarat in Peninsular Thailand (Smith, 1945). This species seems to be similar to *N. hendersoni*.

Ismail (1989) reported the occurrence of *Neolissochilus* sp. with all scales on the body covered with tubercles, a rarity for any Malaysian cyprinid. He recorded it from Sg. Ayer Lanas of the Golok drainage, which is the same drainage in which *N. hendersoni* is found. After close examination of specimens examined by Ismail (UMKL 108), we conclude that they are *N. soroides*. The tubercles are not true tubercles as defined by Roberts (1982), but rather appear to be a manifestation of a fungal infection.

The occurrence of *Tor soro* as reported by Bishop (1973) and Mohsin & Ambak (1983) in Peninsular Malaysia is also questionable. Roberts (1993), in his comments on Bleeker’s (1863) description of the Indonesian *Labeobarbus* (*Tor*) *soro*, showed that *T. soro* is similar to *Neolissochilus*, but the holotype of *Labeobarbus soro* has not been located and probably is lost. We examined 61 specimens labeled as *Tor soro* and collected by Bishop in 1969 and 1970 from Sg. Gombak of Selangor (UMKL 5388, 5393, 5403, 5421, 5425, 5426), and the results showed them to be *N. soroides*. We believe that the description of *Tor soro* by Bishop (1973) and Mohsin & Ambak (1983) is based on *N. soroides*.

### Taxonomy

*Neolissochilus* Rainboth 1985


**Description.** Body elongate, relatively deep, broad anteriorly and compressed posteriorly. Trunk slightly arced predorsally, ventral profile straight to convex. Head broad, snout blunt with mouth placement varying from oblique and nearly terminal to horizontal and inferior. Mouth smoothly rounded when lower jaw edge is blunt to nearly truncate when lower jaw edge is sharp; cheek with numerous tubercles, occasionally many anterior to rostral barbel, but never across tip of snout. Lower lip always present medially, with post-labial groove complete or incompletely interrupted. Lips thick, but not hypertrophied. Dorsal fin iv, 9 (rarely iv, 8), with last unbranched ray never serrated on its posterior edge. Pelvic fin i, 8 (rarely i, 7), pointed, first ray longest and unbranched; anal fin iii, 5 pointed with third ray longest and unbranched. Scales large, lateral-line scales 20–29 plus 2–3 on base of caudal fin, circumpeduncular scales always 12. Gill rakers long, slender, each with basal frenulum and mediadly directed; 2–6 rakers on upper arm and 7–12 rakers on lower arm of anterior side of first arch. Rainboth (1985) provided a detailed description of this genus.

*Neolissochilus hendersoni* (Herre 1940) (Fig. 5)

*Lissochilus hendersoni* Herre 1940: 10 (Penang); Tweedie 1940: 73 (Penang); Menon & Yazdani 1963: 113 (Penang); Alfred 1971: 71 (Penang)
**Acrossocheilus hendersoni**: Alfred 1963a: 146 (Sg. Batu Feringgi, Sg. Teluk Bahang, Sg. Balik Pulau and Sg. Pinang of Penang); Johnson 1967: 724 (Penang)

**Neolissochilus hendersoni**: Rainboth 1985: 31 (Penang); Ahmad & Lim 2006: 109 (waterfall stream at Durian Perangin, Sg. Korok, Sg. Temah Kecil of Langkawi)


**Diagnosis.** In Peninsular Malaysia, *N. hendersoni* is distinguished from *N. soroides* by the following unique
combination of characters: lateral-line scales 18–22, usually 20 (vs. 20–24, usually 22); transverse scales 3.5/1/2 (vs. 3.5/1/3); predorsal scales 6–8 (vs. 8–10), scales from end of dorsal-fin base to origin of caudal-fin base 10–13, usually 12 (vs. 12–15, usually 14); scales from isthmus to pelvic-fin base 10–12, usually 11 (vs. 12–14, usually 13); scales at anal-fin base 3–5, usually 4 (vs. 4–6, usually 5); total gill rakers 12–14, usually 14 (vs. 14–17, usually, 16); gill rakers on lower arm 9–10, usually 9 (vs. 10–12, usually 11).

**Description.** General body shape and appearance are shown in Figure 5A. Mouth with smoothly rounded or 'normal' type of lower jaw (Fig. 5B), sub-terminal or inferior. Lower lip present medially, varies, as thick as but never thicker than upper lip, always interrupted by post-labial groove; lips never developed into fleshy lobes. Anal fin when depressed usually reaching origin of caudal-fin base.

**Distribution and habitat.** Four specimens of *N. hendersoni* were found in runs with rapid flow and crystal clear water in Sg. Air Putih, a stream near Penang Hill Railway Station in Penang. This species was also found in the fast flowing and crystal clear streams of Sg. Batu Pahat and Sg. Tupah, Sg. Karangan and Sg. Sedim, tributaries of the Merbok and Muda drainages in Kedah. Its occurrence in Sg. Telaga Bijih, Sg. Lata Perahu and Sg. Sator of the Golok drainage in Tanah Merah, Kelantan were previously unrecorded (Fig. 1).

**Remarks.** Scale counts in *N. hendersoni* are lower than those of *N. soroides*, but other characteristics, including body coloration, are similar to those of *N. soroides* as discussed below.

![Fish Images](image-url)

**FIGURE 6.** A) *Neolissochilus soroides* from Sg. Gombak of Selangor (UMKL 6098, 112.2 mm SL); B) normal mouth type of *N. soroides* from Sg. Chiling of Selangor (UMKL 3315, 98.4 mm SL); C) truncated mouth type of *N. soroides* from Sg. Batang Padang of Perak (UMKL 5411, 58.0 mm SL); D) lobe mouth type of *N. soroides* from Sg. Gombak of Selangor, Peninsular Malaysia (UMKL 6077, 91.8 mm SL).
Neolissochilus soroides (Duncker 1904) (Fig. 6)

Barbus soroides Duncker 1904:178 (montane stream at east slope of Sangka Dua Pass, Pahang drainage, Pahang)

Lissochilus dukai: Weber & de Beaufort 1916:168 (Peninsular Malaysia); Fowler 1938:66 (montane stream of Pahang drainage, Pahang)

Lissochilus tweediei Herre in Herre & Myers 1937:61 (Sg. Yum of the Perak drainage, Perak); Tweedie 1940:73 (stream in Cameron Highland in Pahang and west of Genting Simpah and west of Bukit Telaga in Selangor); Myers 1941:43 (Perak drainage, Perak). Lissochilus tweediei Herre in Herre & Myers is herein considered to be synonym of Neolissochilus soroides (Duncker)

Barbus (Lissochilus) hexagonolepis: Ogilvie 1953:10 (Sg. Tahan of the Pahang drainage, Pahang)

Barbus dukai: Alfred 1963b:165 (eastern slope of Sangka Dua Pass, Pahang drainage, Pahang)

Acrossocheilus dukai: Menon 1954:11 (Kuala Terla, Cameron Highland of Pahang and west of Gunung Simpah of Selangor); Mohsin & Ambak 1983:77 (streams in Langkawi, Cameron Highland, Fraser’s Hill and Kota Tinggi); Zakaria-Ismail 1984:24 (Pahang drainage in Taman Negara, Pahang)

Barbus (Barbodes) soroides: Ladiges et al. 1958:158 (Pahang drainage in Cameron Highland of Pahang)


Diagnosis. In Peninsular Malaysia, Neolissochilus soroides is distinguished from N. hendersoni by the
following unique combination of characters: lateral-line scales 20–24, rarely 20 (vs. 18–21, rarely 22); transverse scale 3.5/1/3 (vs. 3.5/1/2); predorsal scales 8–10, usually 9 (vs. 6–8, usually 7), scales from end of dorsal-fin base to origin of caudal-fin base 12–15, usually 14 (vs. 10–13, usually 12); scales from isthmus to pelvic-fin base 12–14, usually 13 (vs. 10–12, usually 11); scales at anal-fin base 4–6, usually 5 (vs. 3–5, usually 4); total gill rakers 14–17, usually 16 (vs. 12–14, usually 14); gill rakers on lower arms 10–12, usually 11 (vs. 9–10, usually 9).

Description. Body elongate, abdomen rounded and peduncle smoothly tapered. Trunk slightly arced predorsally, ventral profile varies from straight to convex. Head relatively broad, snout relatively short and rounded. Eyes moderate in size, located in lateral and upper half position of head and not visible from below ventral surface. Dorsal fin concave, it first simple ray short and embedded into the skin, last simple rays not strongly ossified, never serrated and when depressed, the end tips of last simple rays reaching the end tips of the last unbranched rays. Anal fin truncate, it first and second simple rays short and usually attached to the third and the longest simple rays, when depressed, it not reaching the caudal fin base. Pectoral and pelvic fins pointed and their first simple rays long. Caudal fins deeply forked with convex distal margin of each lobe. Scales large, covering the trunks except on the head, pre occipital areas and areas between the mandibles. Mouth sub-terminal with three morphotypes of lower jaw; first smoothly rounded or blunt edge or normal type (Fig. 6B), second nearly truncate edge or truncate type (Fig. 6C) and third rounded lower jaw edge but with mental lobe or lobe type (Fig. 6D). Lower jaw of normal morphotype always covered by lower lips; lower lips present medially, thickness varies, with or without notches; without fleshy lobes; post labial groves always interrupted. Lower jaws of truncated morphotype always exposed with trenchant cutting edge covering the horny sheath; lower lips present medially, thickness at the posterior parts always as thick as upper lips and with or without notches, post labial grooves always interrupted; fleshy lobes never occurred. Lower jaw of the lobe type is similar to the normal one but their lower lips developed into fleshy lobes; post labial groves always uninterrupted.

Coloration. In live specimens, dorsum and upper half of flanks on lateral side varies from light brown to dark greenish-emerald, lateral and operculum coloration light brown to brownish copper, lower half of the flanks and ventrum silvery-white; dorsal-fin base varies from dark greenish-emerald to reddish brown and translucent at tip; caudal-fin base varies from light brown to dark greenish-emerald; pectoral, pelvic and anal fins varies from yellowish-orange to reddish on first simple rays and translucent on other unbranched rays. On preserved specimens, body and fins yellowish brown.

Distribution and habitat. All morphotypes of Neolissochilus soroides inhabited the rapid flow and crystal clear waters of the montane streams throughout Peninsular Malaysia (Fig. 1). The normal and the truncated mouth morphs of N. soroides are common in the locality most studied, but the lobed type is rare and only recorded from Sg. Gombak (UMKL 3230, 3412, 5418, 6095 and 6098; ZRC 50988 and 50989), Sg. Kerling (UMKL 5117), Sg. Bil (UMKL 4111) of Selangor, Sg. Relong (UMKL 2547) and Sg. Terim (UMKL 2948) of Pahang, Sg. Kenas (UMKL 6093) and Sg. Rui (UMKL 5400 and 5406) of Perak, Sg. Awit (UMKL 6099) of Kelantan and Sg. Peres of Terengganu (UMKL 6085). Recently, this species has adapted itself to reservoirs as well as large rivers flowing into them, such as in Tasik Bukit Merah (UMKL 109) and Tasik Temengor (Zakaria-Ismail & Lim 1995; Ambak & Jalal 2006) in Perak, Selangor dam (UMKL 5154) in Selangor, and Tasik Kenyir (UMKL, 6112, 6113, 6114; Ambak & Jalal 2006) in Terengganu. This species has also been reported in Thailand (Rainboth 1996), Java and Sumatra (Kottelat et al. 1993), Anambas Island in South China Sea (Tan & Lim 2004).

Key to species of Neolissochilus in Peninsular Malaysia

1a. Total gill rakers 14–17; predorsal scales 8–10, usually 9; lateral-line scales 20–24, usually 22; scales on hypural plate usually 3, scales from isthmus to pelvic-fin base 12–14, usually 13. N. soroides
1b. Total gill rakers 12–14; predorsal scales 6–8, usually 7; lateral-line scales 18–22, usually 20; scales on hypural plate usually 2, scales from isthmus to pelvic-fin base 10–12 usually 11. N. hendersoni

Comparative materials

Neolissochilus dukai: CAS-SU 34594 (labeled as Lissocilus dukai), 1 ex., 102.0 mm SL; India: Himalayas: Darjeeling; coll. A.W. Herre, 11 Apr.1937. N. hendersoni: Holotype—CAS-SU 32632 (labeled as Lissocilus
NEOLISSOCHILUS IN PENINSULAR MALAYSIA

hendersoni), 1 ex., 68.1 mm SL; Peninsular Malaysia: Penang; coll. A.W. Herre; 24 Mar.1937. Paratypes—CAS-SU 68360 (labeled as Lissochilus hendersoni), 9 ex., 58.5–62.7 mm SL; same data as holotype. N. hexagonolepis: CAS-SU 50201 (labeled as Acrossocheilus hexagonolepis), 10 ex., 41.6–115.0 mm SL; Nepal: Chitawan Valley; coll. T.R. Roberts, 29 Apr.1975. Paratypes—CAS-SU 68360 (labeled as Lissochilus hendersoni), 9 ex., 58.5–62.7 mm SL; same data as holotype.

N. hexagonolepis: CAS-SU 50201 (labeled as Acrossocheilus hexagonolepis), 10 ex., 41.6–115.0 mm SL; Nepal: Chitawan Valley; coll. T.R. Roberts, 29 Apr.1975. Paratypes—CAS-SU 68360 (labeled as Lissochilus hendersoni), 9 ex., 58.5–62.7 mm SL; same data as holotype.

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