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# DISTRIBUTION, THREATS AND CONSERVATION STATUS OF THE WAYANAD MAHSEER, *NEOLISSOCHILUS WYNAADENSIS* (DAY, 1873) (TELEOSTEI: CYPRINIDAE): AN ENDEMIC LARGE BARB OF THE WESTERN GHATS, INDIA

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**Abstract:** The Wayanad Mahseer *Neolissochilus wynaadensis* (Day, 1873) is an endemic cyprinid fish that occurs in the upland streams and rivers of the southern region of the Western Ghats. This species has been listed as 'Critically Endangered' on the IUCN Red List of Threatened Species due to its restricted distribution and heavy declines in populations. Like many large cyprinids of the Western Ghats, *N. wynaadensis* is poorly known and documented, with very few verified records and voucher specimens. Based on specimens recently collected from Wayanad, Kerala, the type locality, as well as two additional locations in the Kodagu District of Karnataka; we provide information on the current distribution, phylogenetic position, threats and conservation. An updated conservation assessment of this species following the IUCN Red List categories and criteria is also provided.

**Keywords:** *Barbodes*, Coorg, freshwater fish, Vulnerable.

**Abbreviations:** BMNH - Natural History Museum, London; CRG-SAC - Conservation Research Group, St. Albert's College, Kochi; FMNH - Field Museum, Chicago.

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**Author Contribution:** AA, ND, SP, KK & RR carried out the field work and collected the specimens; RR studied museum specimens; AA performed morphometry, ND carried out the extraction of DNA and related molecular laboratory work; SP carried out the phylogenetic analysis; AA, SP, ND & RR wrote the manuscript.

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## INTRODUCTION

The cyprinid genus, *Neolissochilus* Rainboth, 1985, comprises of 25 species of medium to large sized barbs, of which 22 are known to occur in Southeast Asia (see Kottelat 2013) and seven in the Indian subcontinent (Table 1). They are important game fishes in parts of South and Southeast Asia (Jhingran 1977; Khaironizam 2010) and are also known to occur in the aquarium pet trade (Khaironizam 2010). Sixteen species of *Neolissochilus* have been assessed for their conservation status, of which, two species have been assessed as 'Critically Endangered', two as 'Vulnerable', three as 'Near Threatened', four as 'Least Concern' and five as 'Data Deficient' (see Table 1; and also species specific accounts on IUCN Red List of Threatened Species at [www.iucnredlist.org](http://www.iucnredlist.org)).

The Wayanad Mahseer, *Neolissochilus wynaadensis* (Day, 1873) is one of two species within the genus that occurs in peninsular India; the other being *N. bovanicus*, found in the Bhavani River. Day (1873; p528) described *Barbus (Barbodes) wynaadensis*, from Vythiri, Wayanad and reported it to be a common species in the larger streams of the region, growing up to a length of 200 mm (also see Day 1878, p 568; 1889, p 313). The species was considered to be endemic to the streams in the Wayanad region of Kerala, until Manimekalan (1998) and subsequently, Yazdani et al. (2001) recorded it from Mudumalai, Tamil Nadu and Arunachalam et al. (2005) recorded it from Abbey Falls near Madikeri, Kodagu, Karnataka.

*Neolissochilus wynaadensis* has been considered to be a rare species with several surveys in and around the type locality, failing to collect this species, and very few records available in the recent ichthyological literature which are backed by voucher specimens (see Abraham 2011). Due to its restricted distribution and severe population declines (up to 80%) in the last decade, *N. wynaadensis* has been listed as 'Critically Endangered' in the IUCN Red List of Threatened Species (Abraham 2011).

As part of the on-going project on the 'Lost fishes of Western Ghats', which aims to document the status and distribution of the region's rarest species (see Ali et al. 2013 a,b,c) we obtained specimens of *N. wynaadensis* (Image 1 a,b,c) from its type locality (Wayanad) as well as several locations in Kodagu District, Karnataka. This paper serves to document these records, and discuss the current distribution, threats and conservation status of this species. In the wake of this new information, we also propose a revised Red List status for *N. wynaadensis*.

**Table 1. List of valid species within the genus *Neolissochilus* Rainboth 1985, their distribution and IUCN threat status**

Species	Distribution	IUCN Status
<i>Neolissochilus baoshanensis</i> (Chen & Yang, 1999)	China	Data Deficient
<i>Neolissochilus benasi</i> (Pellegrin & Chevey, 1936)	China, Vietnam	Data Deficient
<i>Neolissochilus blanci</i> (Pellegrin & Fang, 1940)	Cambodia, Laos, Thailand, Vietnam	Near Threatened
<i>Neolissochilus blythi</i> (Day, 1870)	Myanmar	Data Deficient
<i>Neolissochilus bovanicus</i> *(Day, 1877)	India	Critically Endangered
<i>Neolissochilus compressus</i> (Day, 1870)	Uncertain - probably Myanmar	Not Assessed
<i>Neolissochilus dukai</i> (Day, 1878)	India	Data Deficient
<i>Neolissochilus hendersoni</i> (Herre, 1940)	Malay Peninsula	Not Assessed
<i>Neolissochilus heterostomus</i> (Chen & Yang, 1999)	China	Not Assessed
<i>Neolissochilus hexagonolepis</i> (McClelland, 1839)	Bangladesh, China, India, Indonesia, Malaysia, Myanmar, Nepal, Thailand	Not Assessed
<i>Neolissochilus hexastichus</i> (McClelland, 1839)	India, Myanmar	Near Threatened
<i>Neolissochilus longipinnis</i> (Weber & Beaufort, 1916)	Sumatra and Java	Not Assessed
<i>Neolissochilus nigrovittatus</i> (Boulenger, 1893)	Myanmar	Data Deficient
<i>Neolissochilus paucisquamatus</i> (Smith, 1945)	Myanmar, Thailand	Least Concern
<i>Neolissochilus soro</i> (Valenciennes, 1842)	Indonesia	Not Assessed
<i>Neolissochilus soroides</i> (Duncker, 1904)	Cambodia, Malaysia, Thailand	Least Concern
<i>Neolissochilus spinulosus</i> (McClelland, 1845)	India	Data Deficient
<i>Neolissochilus stevensonii</i> (Day, 1870)	Myanmar	Data Deficient
<i>Neolissochilus stracheyi</i> (Day, 1871)	Cambodia, Myanmar, India, Thailand	Least Concern
<i>Neolissochilus subterraneus</i> Vidthayanon & Kottelat, 2003	Thailand	Vulnerable
<i>Neolissochilus sumatranus</i> (Weber & Beaufort, 1916)	Indonesia, Thailand	Not Assessed
<i>Neolissochilus thienemmani</i> (Ahl, 1933)	Indonesia	Vulnerable
<i>Neolissochilus tweediei</i> (Herre & Myers, 1937)	Malaysia	Not Assessed
<i>Neolissochilus vittatus</i> (Smith, 1945)	Myanmar, Thailand	Least Concern
<i>Neolissochilus wynaadensis</i> (Day, 1873)	India	Critically Endangered

\*generic status as per Pethiyagoda et al. (2012)

## MATERIALS AND METHODS

### Materials examined

*Neolissochilus wynaadensis*, CRG-SAC.2013.109-110, 07.x.2013, 2 ex., 126.45–139.83 mm SL, off the road from Mukkodlu to Surlabi, Kodagu, 12.501°N & 75.757°E, Cauvery River, Karnataka, India, coll. Raghavan



**Image 1.** *Neolissochilus wynaadensis* from Kodagu and Wayanad; (a) freshly preserved adult specimen from Thirunelli, Wayanad [CRG-SAC.2013.113; 83.97 mm SL]; (b) live adult specimen from near Mukkodlu, Kodagu [CRG-SAC.2013.109; 126.45mm SL]; (c) live juvenile specimen from near Bhagamandala, Kodagu [not preserved] [images not to scale]

et al.; *Neolissochilus wynaadensis*, 08.x.2013, CRG-SAC.2013.111-112, 2 ex., 114.85–130.03 mm SL, off the road from Bhagamandala to Napoklu, 12.329°N & 75.659°E, Cauvery River, Karnataka, India, coll. R. Raghavan et al.; *Neolissochilus wynaadensis*, CRG-SAC.2013.113-114, 11.x.2013, 2 ex., 83.97–84.48 mm SL, Thirunelli, 11.902°N & 75.998°E, Kalindi Stream of Kabini River, Wayanad, Kerala, India, coll. A. Ali & K. Krishnakumar.

**Photographs:** *Barbus wynaadensis*, F. Day, BMNH 1889.2.1.571, 1 ex, Vythiri, Wayanad, India; *Barbus wynaadensis*, F. Day, FMNH 2318, 1 ex, Vythiri, Wayanad,

India (both paralectotypes) (Image 2 a,b).

#### Biometrics

Counts and measurements follow Pethiyagoda et al. (2008, 2012). Measurements were taken using a digital calliper to the nearest 0.1mm. Subunits of body are presented as percent of standard length (SL) and subunits of head are provided as percent of head length (HL) (see Table 2).

#### DNA isolation and molecular phylogeny

Fin clips were extracted from fresh specimens



Image 2. Paralectotypes and or Day's specimens of *Neolissochilus wynaadensis*; (a) FMNH 2318 and (b) 1889.2.1.571

collected from three different locations (one of which was from the type locality) in the Cauvery drainage (see Table 3) and was preserved in absolute ethanol. Laboratory protocols for DNA isolation, PCR amplification of *co1* and *cytb* genes, and molecular phylogeny are similar to those detailed in Ali et al. (2013a,c).

Table 2. Morphometric characters and meristics of *Neolissochilus wynaadensis* from various locations in the Western Ghats

Morphometric characters	CRG.SAC.2013. 109	CRG.SAC.2013. 110	CRG.SAC.2013. 111	CRG.SAC.2013. 112	CRG.SAC.2013. 113	CRG.SAC.2013. 114
Standard Length (SL) in mm	139.8	126.5	130.0	114.9	84.5	84.0
% SL						
Head length (HL)	28.1	28.7	26.0	29.2	28.1	28.6
Head depth	18.8	19.2	18.8	20.8	19.2	20.1
Pre dorsal length	51.0	50.3	48.6	49.0	49.7	49.8
Pre anal length	76.3	75.8	75.2	76.8	74.8	75.3
Pre pelvic length	52.9	52.2	50.8	55.0	50.9	51.8
Body depth	26.5	26.2	25.9	25.1	26.9	27.1
Caudal peduncle length	18.0	17.5	18.2	18.8	19.1	19.6
Caudal peduncle depth	10.9	10.9	10.7	10.7	11.1	11.5
Dorsal fin height	22.5	23.4	22.8	22.4	23.2	23.4
Pectoral fin length	20.7	19.7	18.9	19.7	20.2	20.0
Pelvic fin length	17.6	16.9	16.4	16.9	18.2	18.4
Anal fin length	20.3	20.0	18.0	18.6	20.0	19.4
Dorsal hypural distance	53.3	53.0	55.0	53.7	56.2	56.4
Anal fin base length	8.8	9.2	8.0	8.8	7.8	8.3
Dorsal fin base length	15.1	15.7	14.9	14.2	16.3	15.5
% HL						
Snout length	37.0	38.3	40.9	39.4	36.2	35.9
Head depth	66.9	67.0	72.4	71.0	68.5	70.3
Eye diameter	24.3	25.7	27.5	26.0	28.5	28.3
Maxillary barbel length	26.8	27.4	30.0	27.7	26.7	27.4
Internarial width	20.8	18.8	20.4	18.6	20.7	18.3
Inter orbital width	35.0	34.5	36.5	36.0	36.2	33.7
<b>Meristics</b>						
Dorsal fin rays	iv 9	iv 9	iv 9	iv 9	iv 9	iv 9
Pectoral fin rays	i 14	i 14	i 14	i 14	i 14	i 14
Ventral fin rays	i 8	i 8	i 8	i 8	i 8	i 8
Anal fin rays	iii 5	iii 5	iii 5	iii 5	iii 5	iii 5
Lateral line scales	28+1	28+1	28+1	29+1	26+1	26+1
Lateral transverse scales	½ 4 2 ½	½ 4 2 ½	½ 4 2 ½	½ 4 2 ½	½ 4 2 ½	½ 4 2 ½
Pre-dorsal scales	10	9	9	9	9	9
Circumpeduncular scales	12	12	12	12	12	12



## RESULTS AND DISCUSSION

### Taxonomy and generic status

*Neolissochilus wynaadensis* has been placed in different genera, viz.: *Barbus* (Barbodes) (Day 1873, 1878, 1889), *Barbus* (Puntius) (Hora & Law 1941), *Puntius* (Tonapi & Mulherkar 1963; Jayaram 1981; Manimekalan 1998), *Neolissochilus* (Rainboth 1985; Talwar & Jhingran 1991; Devi et al. 1996; Pethiyagoda et al. 2012), and *Barbodes* (Wu 1977; Zhu 1995; Chen et al. 1999).

Our study shows that the correct generic allocation of the species is *Neolissochilus* (see Fig. 1) and not *Barbodes* s.s. (after Kottelat 2013) as mentioned in public databases like Catalog of Fishes (Eschmeyer 2014) and FishBase (Froese & Pauly 2014). The *N. wynaadensis* sequences (co1 and cytb) formed a distinct clade closely related to other *Neolissochilus* species such as *N. hexagonolepis*, *N. hexastichus* and *N. stracheyi*. The closest genus related to *Neolissochilus* is *Tor* (Fig. 1a,b). Endemic large barbs of the Western Ghats (*Hypselobarbus* and *Lepidopygopsis*) also formed a monophyletic group along with *Tor* and *Neolissochilus*.

Rainboth (1985) suggested the possibility of the presence of more than one species of *Neolissochilus* per drainage based on the information available from the eastern part (i.e., Southeast Asia) of its distribution. However, our results on the biometrics as well as mitochondrial co1 and cytb gene sequences of *N. wynaadensis* collected from Wayanad (type locality) and two locations in Kodagu (=Coorg) are similar (see Table 2, 4 and Fig 1a,b) and suggest that there is only one species within the upper Cauvery drainage (Wayanad and Kodagu). The morphometric characters of the fish analysed in the present paper, are also consistent with those recorded by Arunachalam et al. (2005) from Abbey Falls. It is to be noted here that, similar to other large barbs of Western Ghats (see Knight et al. 2013 a,b; Ali et al. 2013 a,b), *N. wynaadensis* also has a wide range of lateral line scale counts (26–29).

Currently, only two species of *Neolissochilus* are known from peninsular India and the Western Ghats, *N. bovanicus* and *N. wynaadensis*. The following names, viz., *Neolissochilus tamiraparaniensis*, *N. acutirostris*, *N. microphthalmus*, *N. capudelphinus*, *N. minimus* and *N. anamalaiensis*, which are mentioned in some scientific and non-scientific literature, are unavailable and represent 'nomina nuda' (for details see Raghavan et al. 2013).

### Distribution

*Neolissochilus wynaadensis* is endemic to the

Western Ghats of India (Dahanukar & Raghavan 2013). The species has a restricted distribution (an area of occupancy of 1000km<sup>2</sup>) occurring in the east flowing streams and rivers part of the larger Cauvery drainage, i.e., Kalindi Stream of Kabini River in Thirunelli; Noolpuzha Stream of Kabini River inside the Wayanad Wildlife Sanctuary, Kakkanhalla and Moyar tributaries inside the Mudumalai Wildlife Sanctuary, as well as streams near Vythiri in Wayanad, and Muvathoklu, Mukkodlu, Surlabi, Bhagamandala and Abbey falls in Kodagu (see Image 3; Table 5). In Kodagu, *N. wynaadensis* has also been recorded in Hamyala (Images 4, 5) and Kakkehole (Steven Lockett, pers. comm. 2013). However, no voucher specimens are available. The species is currently known between the altitudinal range 400–1100 m.

The fact that the species has a very restricted distribution, and is confined to only a few tributaries/streams in its range is additionally evident from the studies of Johnson & Arunachalam (2009) (studies conducted in 2001–2002) where they did not record *N. wynaadensis* from two tributaries (Thalipuzha and Bavalipuzha) of the east flowing Cauvery in Wayanad District.

Abraham (2011), mentions that the fish also occurs in the Chooralmala and Kanthampara areas in Wayanad (part of the west flowing Chaliyar River system), without providing any reference. The author also mentions (a personal communication; see <http://www.iucnredlist.org/details/172429/0>) that the species occurs in the Periya Forest Range near Mananthavady, Wayanad. It is to be noted that, in a comprehensive study of the fishes of Nilgiri Biosphere Reserve including parts of Wayanad and upper reaches of Chaliyar (Easa & Basha 1995; Easa & Shaji 1997), not a single specimen of *N. wynaadensis* was collected from Chooralmala and Kanthampara (see Easa & Basha 1995; Table 10; p 29), suggesting that the species could be restricted to only the east flowing drainages (Easa & Shaji 1997). Therefore, in the absence of any references to the records, and actual voucher specimens, it is premature to conclude that *N. wynaadensis* occurs in the west flowing drainages as suggested by Abraham (2011).

Arunachalam et al. (2005) mentioned that *N. wynaadensis* occurs in Vattapoil in Wayanad District by citing Gopi (2000). This record may however be based on the personal examination of voucher specimens (ZSI/WRS Calicut 6868) collected from this location, rather than as mentioned by Gopi (2000). This is because, Gopi (2000), in his review on the fishes of Kerala, does not mention such a location and only records this species from Thirunelli and Vythiri (see p 62 and 71).

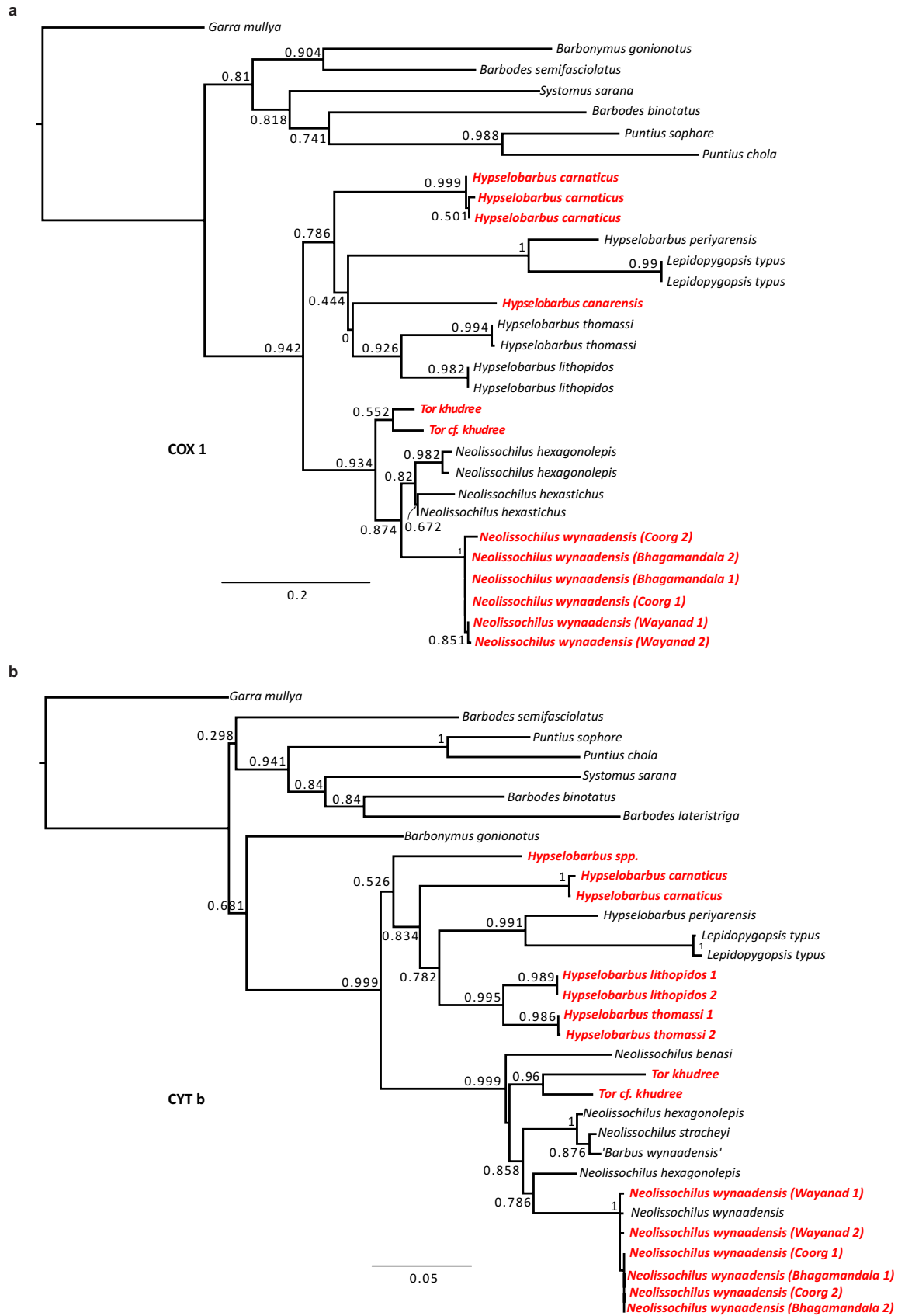


Figure 1. Maximum Likelihood tree using (a) mitochondrial co1 and (b) cytb gene sequences showing the identity and phylogenetic position of *Neolissochilus wynaadensis*

Table 3. Details of co1 and cytb sequences used for the phylogenetic analyses presented in Fig. 1a and b.

Genbank Accession Number	Species	Location	Remarks
<b>Co1</b>			
KJ702313	<i>Neolissochilus wynaadensis</i>	Thirunelli, Kabini River, India	Putative topotype
KJ702314	<i>Neolissochilus wynaadensis</i>	Thirunelli, Kabini River, India	Putative topotype
KJ702312	<i>Neolissochilus wynaadensis</i>	Mukkodlu, Cauvery River, Kodagu, India	
KJ702317	<i>Neolissochilus wynaadensis</i>	Mukkodlu, Cauvery River, Kodagu, India	
KJ702315	<i>Neolissochilus wynaadensis</i>	Bhagamandala, Cauvery River, Kodagu, India	
KJ702316	<i>Neolissochilus wynaadensis</i>	Bhagamandala, Cauvery River, Kodagu, India	
EU714098	<i>Neolissochilus hexagonolepis</i>	Ziyavarali River, Arunachal Pradesh, India	
JX127231	<i>Neolissochilus hexagonolepis</i>	India	
JX127239	<i>Neolissochilus hexastichus</i>	India	
KF410988	<i>Neolissochilus hexastichus</i>	India	
NC_008655	<i>Barbonymus gonionotus</i>	Mekong, Thailand	
NC_020096	<i>Puntius semifasciolatus</i>	Taiwan	
JX983460	<i>Systomus sarana</i>	Narmada River	
JN646096	<i>Puntius binotatus</i>	Malaysia	
HM057185	<i>Puntius saphore</i>	India	
JN815309	<i>Puntius chola</i>	India	
KJ702311	<i>Hypselobarbus carnaticus</i>	Cauvery, India	Putative topotype
KJ702319	<i>Hypselobarbus carnaticus</i>	Cauvery, India	Putative topotype
KJ702320	<i>Hypselobarbus carnaticus</i>	Cauvery, India	Putative topotype
KF113559	<i>Hypselobarbus periyarensis</i>	Periyar, India	Putative topotype
KF113553	<i>Lepidopygopsis typus</i>	Periyar, India	Putative topotype
KF113554	<i>Lepidopygopsis typus</i>	Periyar, India	Putative topotype
KJ702321	<i>Hypselobarbus canarensis</i>	Kumaradhara, Karnataka, India	Putative topotype
KF955536	<i>Hypselobarbus thomassi</i>	Vettilapara, Chalakudy River, India	
KF955539	<i>Hypselobarbus thomassi</i>	Rosemalai, Kallada River, India	
KF955537	<i>Hypselobarbus lithopidos</i>	Chandragiri River, India	Putative topotype
KF955538	<i>Hypselobarbus lithopidos</i>	Chandragiri River, India	Putative topotype
KJ702318	<i>Tor khudree</i>	Pune, India	Putative topotype
KJ702322	<i>Tor cf. khudree</i>	Chalakudy, India	
JX074155	<i>Garra mullya</i>	India	
<b>Cytb</b>			
KJ702324	<i>Neolissochilus wynaadensis</i>	Thirunelli, Kabini River, India	Putative topotype
KJ702325	<i>Neolissochilus wynaadensis</i>	Thirunelli, Kabini River, India	Putative topotype
KJ702323	<i>Neolissochilus wynaadensis</i>	Mukkodlu, Cauvery River, Kodagu, India	
KJ702328	<i>Neolissochilus wynaadensis</i>	Mukkodlu, Cauvery River, Kodagu, India	
KJ702326	<i>Neolissochilus wynaadensis</i>	Bhagamandala, Cauvery River, Kodagu, India	
KJ702327	<i>Neolissochilus wynaadensis</i>	Bhagamandala, Cauvery River, Kodagu, India	
JN863594	<i>Neolissochilus wynaadensis</i>	India	
JX097077	<i>Neolissochilus hexagonolepis</i>	Not mentioned	
KC696525	<i>Neolissochilus hexagonolepis</i>	Not mentioned	
EF588164	<i>Neolissochilus stracheyi</i>	Not mentioned	
KC696524	<i>Barbus wynaadensis</i>	Not mentioned	Misidentification <sup>1</sup>

Genbank Accession Number	Species	Location	Remarks
KC696527	<i>Neolissochilus benasi</i>	Not mentioned	
NC_008655	<i>Barbonymus gonionotus</i>	Mekong, Thailand	
FJ667563	<i>Puntius semifasciolatus</i>	China: Hueidong	
GU826667	<i>Barbodes lateristiga</i>	Not mentioned	
GU826629	<i>Barbodes binotatus</i>	Not mentioned	
HM010726	<i>Systemus sarana</i>	Narmada River	
EU241461	<i>Puntius sophore</i>	India	
JQ795436.1	<i>Puntius chola</i>	India	
KJ702329	<i>Hypselobarbus carnaticus</i>	Cauvery, India	Putative topotype
KJ702331	<i>Hypselobarbus carnaticus</i>	Cauvery, India	Putative topotype
KF113565	<i>Hypselobarbus periyarensis</i>	Periyar, India	Putative topotype
KF113567	<i>Lepidopygopsis typus</i>	Periyar, India	Putative topotype
KF113569	<i>Lepidopygopsis typus</i>	Periyar, India	Putative topotype
KJ702333	<i>Hypselobarbus thomassi</i>	Vettilapara, Chalakudy River, India	
KJ702334	<i>Hypselobarbus thomassi</i>	Rosemalai, Kallada River, India	
KJ702335	<i>Hypselobarbus lithopidos</i>	Chandragiri River, India	Putative topotype
KJ702336	<i>Hypselobarbus lithopidos</i>	Chandragiri River, India	Putative topotype
KJ702330	<i>Tor khudree</i>	Pune, India	Putative topotype
KJ702337	<i>Tor cf. khudree</i>	Chalakudy, India	
KJ702332	<i>Hypselobarbus sp.</i>	Kumaradhara, South Canara	
JX074237	<i>Garra mullya</i>	India	

Abraham (2011) mentions about a record of *N. wynaadensis* from Bhadra River, citing Shahnawaz et al. (2009 *sic*) (note that the correct year should have been 2010). However a perusal of the original paper by Shahnawaz et al. (2010) reveals no such record. Similarly, although Pillai (1929) and Hora & Law (1941) recorded *Barbus wynaadensis* from Travancore in southern Kerala, it is highly unlikely that the species occurs in the region. The record by Pillai (1929) from Tenmalai was also doubted by Menon (2004). In all probability, the specimen misidentified as *Barbus wynaadensis* from Travancore could be the fish currently known as '*Barbodes*' *carnaticus*.

*Neolissochilus wynaadensis* was reported from Mula-Mutha River of Pune by Tonapi & Mulherkar (1963). However, this record was doubted by Kharat et al. (2001, p 47). Similarly, the records of *N. wynaadensis* from China (Wu 1964, cited in Talwar & Jhingran 1991), especially from the Yunnan region (Wu 1977, cited in Chen et al. 1999; Yang & Chen 1994; Jing et al. 2013; also see cytb sequence KC696524 in GenBank) are 'at best' misidentifications, and may in all probability be *N. hexagonolepis*, *N. stracheyi* (see Fig 1) or an undescribed species similar to it. The examination of the specimen,

KIZ8110101 (see Yang & Chen 1994) at the Kunming Institute of Zoology, China will help clear the exact identity of the '*Barbodes wynaadensis*' recorded from the rivers in Yunnan.

Further studies are, however, required to understand the diversity of this genus especially from the southern regions of the Western Ghats from where many 'nomina nuda' under the genus *Neolissochilus* (see Raghavan et al. 2013) as well as previous records (Pillai 1929; Hora & Law 1941) of *N. wynaadensis* are available. There is specifically a need to examine specimens identified and catalogued in various museums, as *Tor* species/Mahseer from various regions south of the Palakkad Gap.

#### Population status

*Neolissochilus wynaadensis* has been considered to be a very rare species (Gopi 2000; Easa & Shaji 1997), as it was not recorded in many collections from Wayanad during 1999–2004 and in 2008 (Abraham 2011). Although not backed by any scientific data, global populations of this species were considered to have reduced by 80% during 2000–2010, and are still declining (See Abraham 2011).

Our field surveys in Thirunelli in April 2004



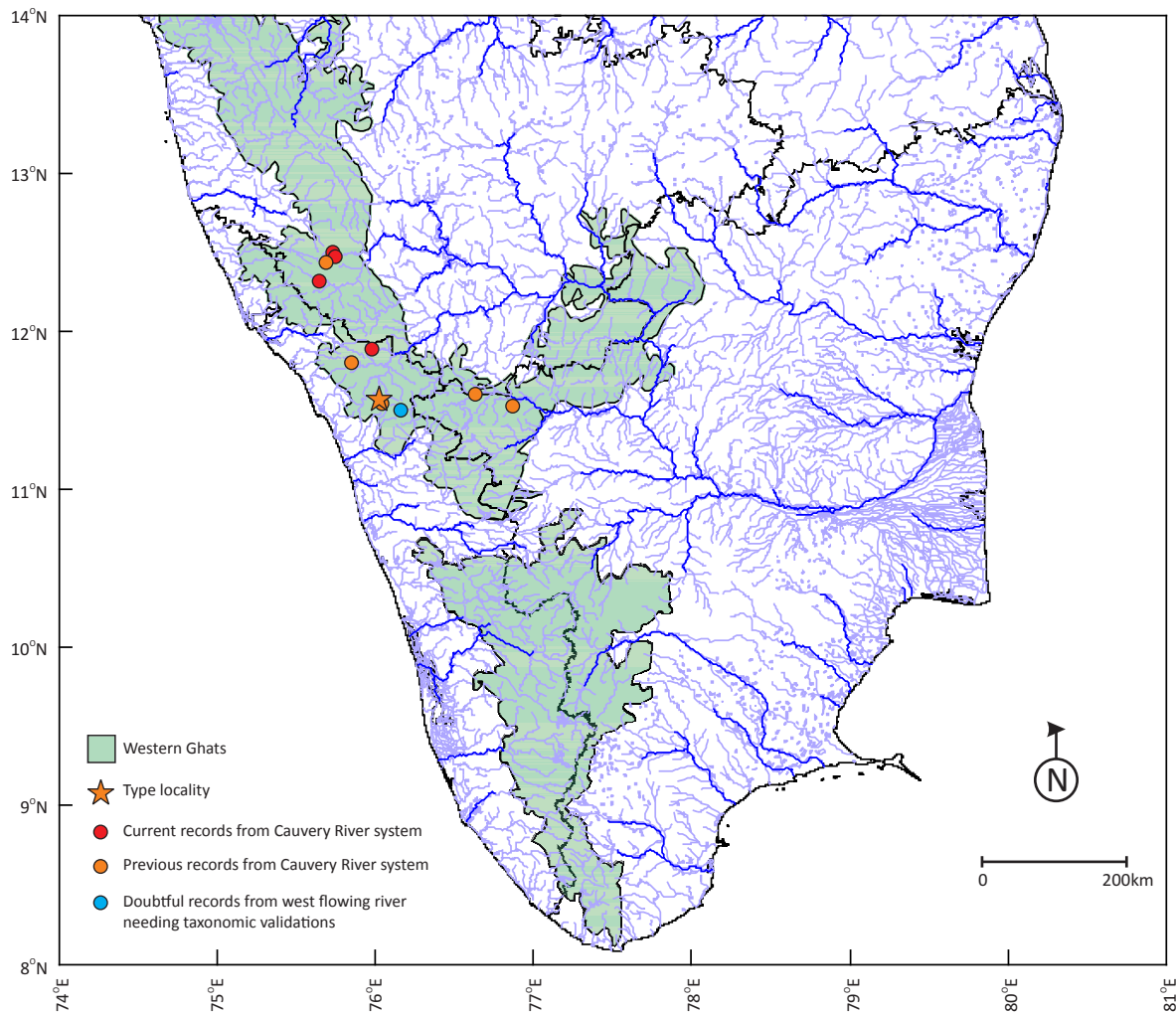


Image 3. Distribution of *Neolissochilus wynaadensis* in Western Ghats

Table 4. Table showing the ‘raw’ genetic distances between the specimens of *Neolissochilus wynaadensis* collected from different locations; The values for genetic distances with *co1* is shown above diagonals (lighter shade) and *cytb* is shown below diagonals (darker shade).

	KJ702312	KJ702317	KJ702315	KJ702316	KJ702313	KJ702314	<i>co1</i>
KJ702323	--	0.007	0	0	0.002	0.003	KJ702312
KJ702328	0	--	0.007	0.007	0.008	0.010	KJ702317
KJ702326	0	0	--	0	0.002	0.002	KJ702315
KJ702327	0	0	0	--	0.002	0.002	KJ702316
KJ702324	0.003	0.003	0.003	0.003	--	0.002	KJ702313
KJ702325	0.004	0.004	0.004	0.004	0	--	KJ702314
<i>cytb</i>	KJ702323	KJ702328	KJ702326	KJ702327	KJ702324	KJ702325	

(Unpublished), and recently in October 2013 (vouchers mentioned in the present paper) led to the collection of only three specimens, while those in Vythiri in April 2004 did not yield any. Nevertheless, there are fairly good populations in Kodagu District of Karnataka State

as evident from large shoals inhabiting the streams and rivers where they were occur. A large group (probably in hundreds) of *N. wynaadensis* were seen in a single splash pool near Muvathoklu where they are protected in a sacred grove (Devarkaadu).

**Table 5. Previous records of *Neolissochilus wynaadensis* from the Western Ghats**

Location/River	References
Vythiri, Wayanad	Day (1873, 1878, 1889); Easa & Basha (1995); Shaji & Easa (1995); Kurup et al. (2004)
Tenmalai, Travancore <sup>1</sup>	Pillai (1929)
Travancore <sup>1</sup>	Hora & Law (1941)
Pune <sup>1</sup>	Tonapi & Mulherkar (1963)
Kakkanhalla, Mudumalai	Manimekalan (1998), Yazdani et al. (2001)
Moyar, Mudumalai	Manimekalan (1998), Yazdani et al. (2001)
Arunagiri, Wayanad	Kurup et al. (2004)
Abbey falls, Madikeri, Kodagu	Arunachalam et al. (2005)
Kunumbatta, Wayanad	Euphrasia et al. (2006)
Kattikunnu, Wayanad	Euphrasia et al. (2006)
C.C. Puzha, Wayanad	Euphrasia et al. (2006)
Appenkappa, Wayanad	Euphrasia et al. (2006)
Hamyala, Kodagu	Steven Lockett (2013) <sup>1</sup>
Kakehole, Kodagu	Steven Lockett (2013) <sup>1</sup>
Chooralmala, Wayanad	Abraham (2011) <sup>2</sup>
Kanthampara, Wayanad	Abraham (2011) <sup>2</sup>

<sup>1</sup> doubtful records; <sup>2</sup> personal communications

### Habitat and Ecology

*Neolissochilus wynaadensis* prefers fast flowing upland streams and rivers where they occur in both rocky pools (Abraham 2011) as well as riffles (Kurup et al. 2004). The pool-riffle habitats have a moderate flow velocity and provide good hiding places for the species. These habitats are also frequented by riffle beetles and chironomids that form the major food for *N. wynaadensis* (Manojkumar & Kurup 2002). Kurup et al. (2004) provides information on several microhabitat variables in the locations frequented by *N. wynaadensis*. Habitats in the sites from where *N. wynaadensis* was recorded in the present study are shown in Images 6, 7 and 8. It has also been suggested that *N. wynaadensis* are long range migrants that travel to the upper reaches of rivers for spawning (Menon 2004).

### Phylogenetic position

The *Neolissochilus* from peninsular India (*N. wynaadensis*) forms a monophyletic grouping with other *Neolissochilus* species from northeastern India and Southeast Asia (Fig 1a,b). Also, the specimens of *Neolissochilus* found in various locations in Kodagu (=Coorg, in Bhagamandala and Mukkodlu), were genetically similar to those that occur in the type locality of the species (i.e., Wayanad) (also see Table 4). The



Image 4. *Neolissochilus wynaadensis* at Hamyala, Kodagu



Image 5. *Neolissochilus wynaadensis* at Hamyala, Kodagu

discontinuous distribution of the genus *Neolissochilus* (Sundaland, Indo Burma, Eastern Himalaya and Western Ghats) could also form the basis for interesting biogeographic hypothesis testing; for instance, to check the scenario of 'true disjuncts' (see Dahanukar et al. 2013 and references therein). On the other hand, detailed anatomical and morphological analysis is needed to ascertain if the Western Ghats representatives of the genus are 'false disjuncts' and need a separate generic allocation. Such biogeographic and evolutionary questions should however be validated with larger multi-locus datasets.

### Threats and conservation

Anthropogenic threats including habitat destruction as well as pollution caused by the discharge of fertilizers, pesticides and other chemical effluents from surrounding plantations and sand mining have been reported from the habitats frequented by the species (Abraham 2011). There is no data to show that this species is being





Image 6. Habitat of *Neolissochilus wynaadensis* near Mukkodlu, Kodagu, Karnataka [Image taken on 07.x.2013]



Image 7. Habitat of *Neolissochilus wynaadensis* near Surlabi, Kodagu, Karnataka [Image taken on 10.ix.2013]



Image 8. Habitat of *Neolissochilus wynaadensis* near Thirunelli, Wayanad, Kerala [Image taken in April 2004]

exploited as a food fish (Abraham 2011), but given its size, it is likely to be harvested by local communities. Overall, there is a need for greater understanding of the specific threats, their intensity and the impacts they have on the survival of the species.

Much of the known range of *N. wynaadensis* is outside protected areas. Currently, Wayanad Wildlife Sanctuary in Kerala and Mudumalai Wildlife Sanctuary in Tamil Nadu are the only protected areas where the species occur. However, an alternate protected area system in the form of sacred groves, (Devarkaadu) exists in Kodagu, Karnataka. Streams flowing through these sacred groves harbour good populations of *N. wynaadensis* which are protected (for e.g., in Mukkodlu, Muvathoklu and Surlabi regions) by the local communities.

Currently, *N. wynaadensis* has been listed as 'Critically Endangered' (Abraham 2011) in the IUCN Red List of Threatened Species. Additional information on distribution and threats as documented in the present

paper has led to a scenario where the conservation status of the species needs to be revised. The proposed Red List Status of the species has been provided in Appendix 1.

## CONCLUSIONS

Large cyprinids of the genus *Tor*, *Neolissochilus*, *Hypselobarbus* and '*Barbodes*' comprise one of the most poorly known freshwater fishes of the Western Ghats, with very little information available on their diversity (both generic and specific) and distribution. Recent studies have helped to improve our knowledge on some genera (for e.g., *Hypselobarbus*) (see Ali et al. 2013a,b; Knight et al. 2013a,b,c), while others (*Tor*, *Neolissochilus* and *Barbodes*) remain understudied. Future research should be directed on these large barbs to understand in detail their taxonomy, diversity, distribution, population dynamics and stock structure and conservation. There is particularly a need to understand the identity of the barb described by Day (1877) as *Barbus bovanicus*, from the Bhavani River in the southern Western Ghats, which is currently considered to be a species of *Neolissochilus* (see Pethiyagoda et al. 2012).

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**Appendix 1. Proposed Red List Status for *Neolissochilus wynaadensis***

**Current Status:** Critically Endangered A2ace

**Proposed Status:** Vulnerable B1ab(iii)+2ab(iii)

**Taxonomy**

Scientific name: *Neolissochilus wynaadensis* Day (1873)

Common names: Wayanad Mahseer, Copper Mahseer (English); Wayanadan Kuyil, Manja Kadanna (Malayalam); Maara Meenu, Katli (Kannada)

Synonyms: *Barbus wynaadensis*, *Puntius wynaadensis*, *Barbodes wynaadensis*

Taxonomic notes: *Neolissochilus wynaadensis* was described by Day (1873) from the streams near Vythiri, Wayanad, Kerala State, India. The fish has been placed under different genera viz., *Barbus*, *Puntius* and *Barbodes* in the ichthyological literature. A detailed phylogenetic analysis (see present paper) revealed its affinity to, and supports its placement in the genus *Neolissochilus*.

**Assessment Information**

Red List category and criteria: Vulnerable B1ab(iii)+2ab(iii)

Justification: *Neolissochilus wynaadensis* is assessed as Vulnerable (B1ab(iii)+2ab(iii)) as it has an estimated EOO of not more than 8000km<sup>2</sup>, an AOO of not more than 1000km<sup>2</sup>, and a restricted distribution as it occurs in only seven locations. The habitats where the species is known to occur is also greatly affected by deforestation, ongoing siltation and pollution caused by the discharge of fertilizers, pesticides and other chemical effluents from coffee and other plantations.

**Geographic range**

Range description: Endemic to the Western Ghats (Dahanukar & Raghavan 2013), where they are currently known from the Cauvery river system in Wayanad (Kabini) and Kodagu (Manimekalan 1998; Yazdani et al. 2001; Kurup et al. 2004; Arunachalam et al. 2005; present paper) as well as streams in Mudumalai (Moyar and Kakanhalla). Its occurrence in the west flowing Chaliyar River in Kerala is likely, but needs confirmation. All other records, i.e. China (Wu 1964, cited in Talwar & Jhingran 1991; Wu 1977, cited in Chen et al. 1999; Yang & Chen 1994; Jing et al. 2013), Pune (Tonapi & Mulherkar 1963), Travancore (Pillai 1929; Hora & Law 1941) are considered to be misidentifications. The estimated (approximate) current extent of occurrence (EOO) is less than 8000km<sup>2</sup> and current (approximate) area of occupancy (AOO) no more than 1000km<sup>2</sup> (see map next page).

Countries: India (states of Karnataka, Kerala and Tamil Nadu)

Range Map: see Image 3

**Habitat and Ecology**

Habitat and Ecology: Known to occur in fast to moderately flowing streams and rivers flowing through low to mid elevation evergreen forests, where they are found in pool-riffle habitats with sand as the dominant substrate (Manojkumar & Kurup 2002). The fish is known to attain sizes up to 250mm (Menon 1999) but individuals above 170mm are rare (Manojkumar 2006).

Systems: Freshwater

**Threats**

Major Threats: Habitat alteration and destruction as well as pollution caused by the discharge of fertilizers, pesticides and other chemical effluents from plantations are the most important threats to the species. Although, there is no data to show that this species is being exploited as a food fish, given its size, it is likely to be harvested by local (especially tribal) communities. In Kodagu, many of the streams in which *N. wynaadensis* occurs pass through coffee plantations and are likely to be under the threat of pesticide run-off.

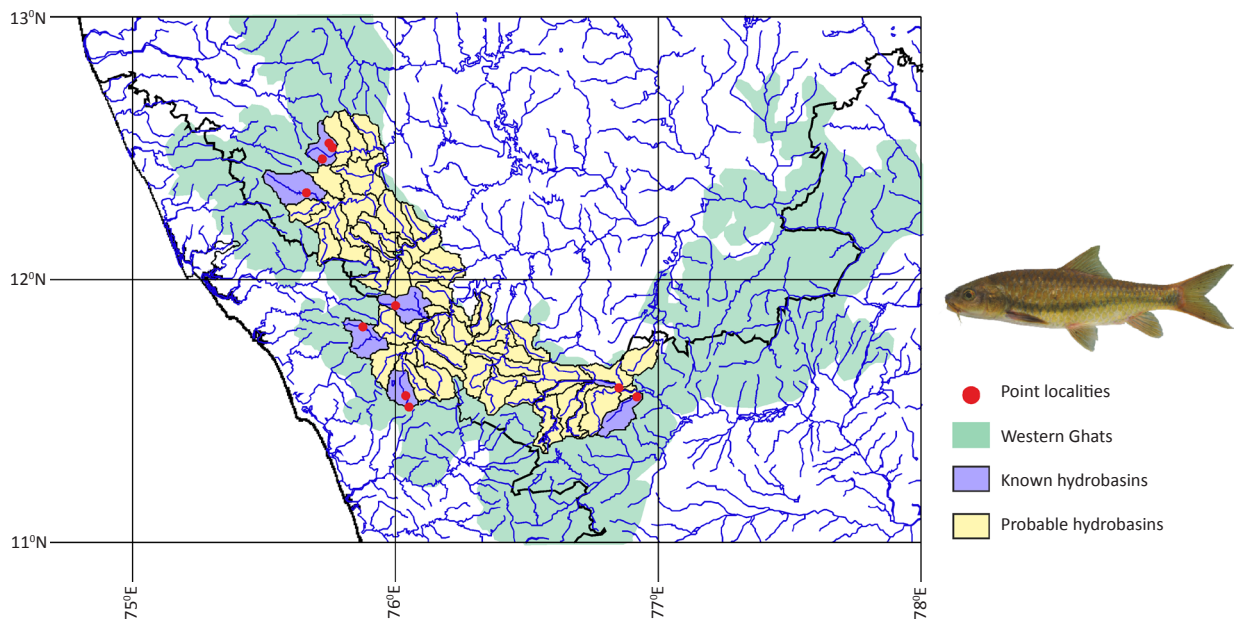
**Population**

Population: No reliable estimates of the status or trends in populations are available. Streams flowing through the sacred groves in Kodagu are known to harbour high numbers of the species (Ali et al. 2014).

Population trend: Unknown

**Conservation**

Conservation action: No species specific conservation actions are currently in place. Except for the populations inside the Wayanad Wildlife Sanctuary in Kerala, and the Mudumalai Wildlife Sanctuary in Tamil Nadu, much of the range of this species (especially in Kodagu) is outside formal protected areas. However, many of the streams in Kodagu are part of sacred groves (*Devarkaadu*) or village temples, and so are protected. The project on 'Lost fishes of the Western Ghats' is involved in research, education and awareness on poorly known species of the region including *N. wynaadensis*. Increased survey efforts are needed in various parts of Kodagu as well as in the upper reaches of Chaliyar in the Chooralmala area of Kerala to confirm whether undiscovered populations exist. Education and awareness programs need to be carried out in close cooperation with the local self governments (Panchayath) in Kodagu.



**Map. Estimated extent of occurrence (EOO) and area of occupancy (AOO) of *Neolissochilus wynaadensis***

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- Point localities
- Western Ghats
- Known hydrobasins
- Probable hydrobasins

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