



International Journal of Fisheries and Aquatic Studies

E-ISSN: 2347-5129

P-ISSN: 2394-0506

(ICV-Poland) Impact Value: 5.62

(GIF) Impact Factor: 0.549

IJFAS 2017; 5(5): 402-407

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www.fisheriesjournal.com

Received: 11-07-2017

Accepted: 12-08-2017

Asha Rayamajhi

Fisheries Research Division,
Godawari, Nepal Agricultural
Research Council, Kathmandu,
Nepal

Arunachalam M

(A). Sri Paramakalyani Centre
for Environmental Sciences,
Manonmaniam Sundaranar
University, Alwarkurichi, Tamil
Nadu, India.

(B). Current address:

Department of Animal Science,
School of Biological Sciences,
Central University of Kerala,
Riverside Transit Campu,
Nileshwar, Kasargod, Kerala,
India

Correspondence

Asha Rayamajhi

(A). Sri Paramakalyani Centre
for Environmental Sciences,
Manonmaniam Sundaranar
University, Alwarkurichi-627
412, Tamil Nadu, India.

(B). Current address:

Department of Animal Science,
School of Biological Sciences,
Central University of Kerala,
Riverside Transit Campu,
Nileshwar, Kasargod- 671 314,
Kerala, India

A new species of *Garra* (Cyprinidae: Cypriniformes) from Western Nepal

Asha Rayamajhi and Arunachalam M

Abstract

Seven species of *Garra* have been reported from Nepal, and recently a collection of fishes from Mardi River (Kaligandaki River basin), Mardi village, Kaski district, Western Nepal showed that there is an undescribed species of *Garra* and hereby described as *Garra nepalensis* sp. nov. It is distinguished from its sympatric congeners (except *Garra rupecula*) by having a greater number of lateral line scales (35-36 vs. 31-34). It can be further distinct from *G. rupecula* by the absence of a W-shaped band on the caudal fin. *G. nepalensis* sp. nov. is distinguished from *G. khawbungii* a closely related species by having snout tip not marked off by a transverse groove (vs. snout with weakly developed transverse groove) and the absence of W-shaped band on caudal fin (vs. present).

Keywords: freshwater fish, cyprinidae, *Garra*, taxonomic study, Nepal, Asia

Introduction

The cyprinid fish genus *Garra* Hamilton 1822 (*Garrinae* subfamily) is widely distributed in fresh waters of the world usually found in fast flowing streams. Its high diversity in Asia may be due to its affinity for swift waters, which are incredibly abundant throughout the Himalaya and its foothills, where populations can potentially become isolated, enabling divergence (Kangrang *et al.*, 2016) [1]. Most species of *Garra* are uniformly brownish to blackish, with sparse, insignificant markings. The genus *Garra* can be diagnosed by the presence of a suctorial disc of semi-cartilaginous pad on the chin as well as lateral line complete with 30-40 scales. The genus *Garra* is widely distributed in southern China, Nepal, India, across Southeast Asia and the Middle East to northern and central Africa (Getahun, 2000) [2]. Within Asia about 40 species of *Garra* are reported (Kullander and Fang, 2004) [3]. Menon (1964) [4] recognized 38 species. In India, the genus *Garra* Hamilton (1822) contains 36 species (Talwar and Jhingran, 1991) [5]. Diversity of *Garra* is particularly high in India and Southeast Asia (Kangrang *et al.*, 2016) [1]. Though till date seven species of *Garra* listed from Nepal were *G. lissorhynchus*, *G. annandalei*, *G. gotyla*, *G. mullya*, *G. lamta*, *G. nasuta* and *G. rupecula* (Rajbanshi, 2012) [6] of which two species; *G. annandalei* and *G. lamta* were reported from Eastern Nepal (Talwar and Jhingran, 1991) [5] as well as reported in central, mid-western and far-western Nepal (Shrestha, 2008) [7]. Moreover, Shrestha (2008) [7] has reported *G. gotyla*, *G. mullya* and *G. rupecula* from central and eastern Nepal. Recently an additional species *Garra khawbungii* was described from Mizoram India (Arunachalam *et al.*, 2014) [8]. It appears to be a close relative of *Garra* species collected during present study.

During the present inventory survey to collecting fishes from the Mardi River (Kaligandaki River basin) Kaski district, specimens of *Garra* were obtained and determined to be a new species based on several morphometric and meristic characters and this new species is formally described herein as *Garra nepalensis*.

Materials and methods

Abbreviation used herein include SL=standard length, HL=head length, FRDFM= Fisheries Research Division Fish Museum in Godawari, Kathmandu Nepal, MSUMNH=Manonmaniam Sundaranar University Museum of Natural History, in Alwarkurichi, India and CMA= collections of M. Arunachalam.

Morphometric measurements were made point to point using digital caliper (0.01 mm accuracy). Counts and measurements were made on the left side of specimens. Measurements

taken followed by Hubbs and Lagler [9], with additional characters of disc length, disc width, central-pad length and central-pad width are from Kullander and Fang (2004) [3]. Disc width is measured as the widest portion of the lower lip and disc length is taken from the corneous margin of the lower jaw to the posterior margin of the lower lip. Central-pad length and central-pad width are taken as the greatest distances obtainable.

Pre-anal scales were counted from anus to isthmus [3]. Body measurements are expressed as percentage of standard length (%SL) and head measurements as percentage of head length (%HL). Comparison materials were from MSUMHH and CMA.

At collection site, temperature (°C), pH, dissolved oxygen (mg/l), conductivity (ms) and total dissolved solids (ppt) were measured using mercury thermometer, pH meter, dissolved oxygen meter, conductivity meter and TDS meter respectively. Altitude, latitude are measured with GPS recorder.

***Garra nepalensis* sp. nov.**

(Figures 1-4, Tables 1-2)

Holotype: FRDFM-3, 93.45 mm SL; Western Nepal, Kaski District, Mardi Village, Hemja Village Development Committee, Mardi River upstream from Kaligandaki River, near hanging foot bridge (N 28° 17. 847' E 083° 55. 826', 1040 msl), collected by Asha Rayamajhi 11 April 2014.

Paratypes: FRDFM-3, 2 ex. 70.18-72.37 mm SL deposited at Fisheries Research Division Fish Museum in Godawari, Kathmandu Nepal; FRDFM-3, 4 ex. 59.84-67.54 mm SL deposited in Natural History Museum of Nepal. All other details same as holotype.

Diagnosis

Garra nepalensis can be distinguished from *G. lissorhynchus* in having more lateral line scales (35-36 vs. 33-34), more pre-anal scales (anus to isthmus) (20-22 vs. 9-12), and absence of a W-shaped band on the caudal fin (vs. presence). *G. nepalensis* is distinct from *G. anmandalei* in having a greater number of lateral line scales (35-36 vs. 33), a greater number of pre-dorsal scale rows (11-12 vs. 9-10) and greater number of pre anal scale rows (20-22 vs. 18). *G. nepalensis* is distinguished from *G. gotyla* in having a greater number of lateral-line scales (35-36 vs. 31-32) and shorter disk (26.09-29.10 vs. 36.9-42.6 % HL), shorter disk width (38.48- 45.66 vs. 48.7-60.9) and its central pad (15.64-17.17 vs. 21.0-25.8 %HL). *G. nepalensis* is distinguished from *G. mullya* in having more lateral line scales (35-36 vs. 32-34) and a shorter dorsal-fin base (11.17-13.47 vs. 15.2-18.6 %SL). *G. nepalensis* is distinguished from *G. lamta* in having a greater number of lateral line scales rows (35-36 vs. 33), a greater interorbital width (44.40-48.31 vs. 38.7-43.3 %SL) and a longer head (20.60-25.01 vs. 10.0-15.3 %SL). *G. nepalensis* is distinguished from *G. nasuta* in lacking a proboscis (vs. presence of a prominent trilobed proboscis) and having more lateral line scales (35-36 vs. 33-34). *G. nepalensis* is distinct from *G. rupecula* in the absence of a W-shaped band on the caudal fin (vs. presence). *G. nepalensis* is distinguished from *G. khawbungii* in having a smooth snout (vs. weakly developed transverse groove on snout), a shorter snout (38.48-48.00 vs. 49.2-59.8 %HL) and more pre dorsal scales (11-12 vs. 10).

Description

Counts and measurements are from 7 specimens (Table 1, Table 2). Images of *G. nepalensis* sp. nov. are shown in Fig. 1 and a line drawing is provided in Fig. 2.

Body is elongate and cylindrical. Dorsal profile convex from nape to dorsal-fin origin and body deeper between occiput to dorsal fin origin then gradually decreases from dorsal fin origin toward caudal fin base. Ventral profile from pectoral-fin origin to pelvic-fin origin is slightly convex. Body depth is 18.76-21.73 %SL (7). Head ventrally flattened and moderately short, its length 20.60-25.01 %SL (7) and width 67.07-79.43 %HL (7). Head width at nostril 35.90-39.79 %HL (7), at pupil 50.99-59.39 %HL (7) and at occiput 61.19-67.49 %HL (7). Inter-orbital space is somewhat convex; its width broader than nasal width. Width of interorbital is 44.40-48.31 %HL (7) and inter nasal width 15.30-33.30 %SL (7). Snout is smooth with rounded tip, its length 38.48-48.00 %HL (7). Tip of snout not marked off by a transverse groove. Tubercles small and soft arranged in two rows; one from snout tip to under orbit beyond crossing end of orbit but not reaching interorbital space, 2nd row from snout tip to under nostril beyond nostril but not reaching inter-nostril space. Orbit is in middle of head, its width 15.33-22.57 %HL (7). Two nostril pores separated by a curved nostril flap. Two pairs of barbels; rostral barbel located antero-laterally, maxillary barbel located at corner of mouth, both barbels are almost equal in length. Length of maxillary barbel is 5.19-9.14 %HL (7) and length of rostral barbel is 7.64-10.13 %HL (7). Rostral cap well-developed and covered by numerous tiny papillae; curved ventrally and connected with lower lip at the corners of mouth. Upper jaw entirely covered by rostral cap. Central-pad elliptical; its width greater than length. Width of central pad is 24.68-27.74 %HL (7) and length of central pad 15.64-17.14 %HL (7). Disc width is greater than its length; width of disc is 38.48-45.66 %HL (7) and length of disc is 25.77-29.10 %HL (7) (Table 1).

Fin counts: dorsal fin rays ii-8 (7); anal fin rays ii-5 (7); pelvic fin rays i-8 (7); pectoral fin rays i-13 (7); caudal fin rays 10+9 (7) including principal rays (Table 2). Dorsal fin inserted anterior to pelvic fin. First and second branched rays of dorsal fin longer, extending slightly beyond its last ray and posterior margin of dorsal fin slightly concave. Pectoral-fin with rounded tips, its fifth branched ray is longest but not extending to the base of pelvic-fin origin. Pectoral-fin separated from pelvic-fin insertion by 8 scales. Posterior tip of pelvic-fin is extending beyond anus but not reaching anal-fin origin, pelvic fin separated from anal fin by a distance of 4 scales and third branched pelvic-fin rays greatest in length. Anal-fin short with rounded tip and having straight posterior margin. Posterior terminus of anal-fin is not reaching base of caudal fin. A distance of five scales between vent and pelvic fin insertion and 4-5 scales between vent and anal fin. Caudal fin rays forked and both lobes are rounded and equal in length. Distance between pectoral-fin and vent is 42.89-47.98 %SL and distance between pelvic-fin and vent is 12.87-29.06 %SL.

Lateral-line distinct and complete, lateral line scales 35 (4), 36 (3); upper transverse scale rows 4.5 (7); scale rows from lateral-line to pelvic fin 3.5 (7); scale rows between lateral-line to anal-fin origin 4.5 (7); circumpeduncular scale rows 16 (7); circumferential scale rows 20 (3), 21 (3), 22 (1); pre-dorsal scales 11 (4), 12 (3); transverse breast rows (7); anal-scales (anus to anal fin origin) 4 (4), 5 (3); pre anal scales (anus to isthmus) 20 (2), 21 (4), 22 (1) (Table 2). Body fully

covered with well-developed large-sized scale rows except breast scale rows, scales between pectoral fin insertion and outer margin of adhesive apparatus having deeply embedded scales in skin (subcutaneous scales) (Figs. 1 and 2).

Coloration

Color in 10% formalin: Dorsum of head and body brown, ventrally light brown. Fins are hyaline with dark brown rays. Central disc is pale brown.

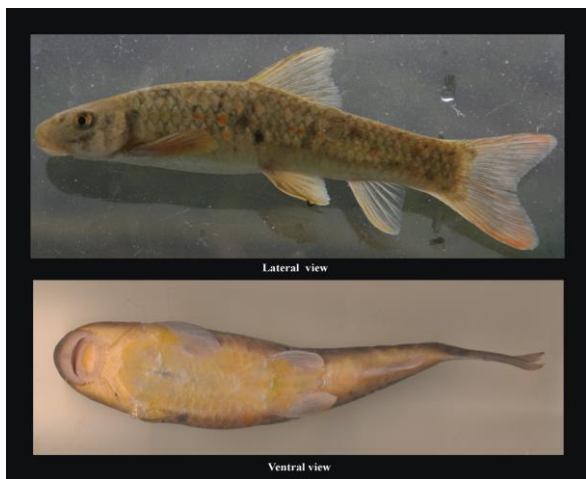
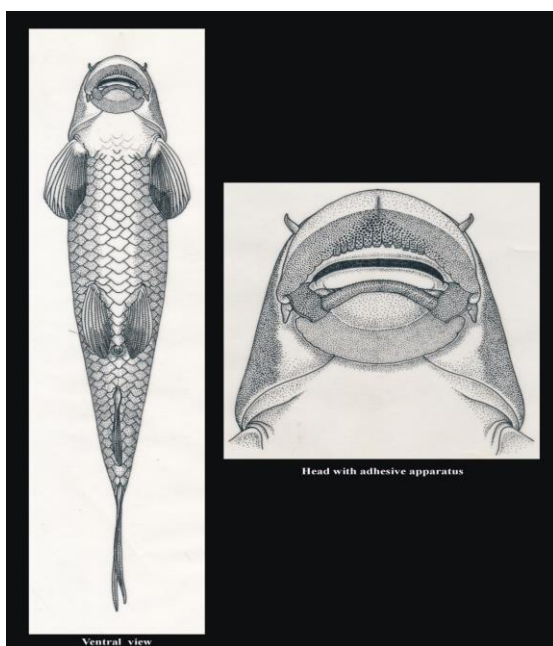
Color in life: Dorsum of head and body brownish olive; ventrally white from outer margin of central disk to anus, afterwards cream-brown up to caudal fin base. Some lateral line scales (9-11 scales) having reddish tinge on brownish-olive ground scales between operculum and caudal fin base (Fig. 1) and 2-4 scales just above and below lateral line with reddish tinge on brownish-olive ground scales. Fins brownish-red with pinkish tinge; outer margin of fin tips are hyaline.

Table 1: Morphometric data of *Garra nepalensis* sp. nov. from the Mardi River, Mardi village, Kaski District, western Nepal (n=7).

No		Holotype	Range	Mean \pm SD
	Standard length (SL)	93.45	59.84-93.45	70.68 \pm 10.81
	% Standard Length			
1	Snout to urocentrum	93.24	89.78-93.24	91.70 \pm 1.26
2	Pre anal length	72.34	71.74-76.73	74.03 \pm 1.76
3	Pre dorsal-fin length	47.33	45.92-49.38	47.42 \pm 1.25
4	Pre pelvic-fin length	49.91	47.13-53.97	51.87 \pm 2.53
5	Pre pectoral-fin length	19.54	19.54-22.41	21.41 \pm 1.05
6	Peduncle length	14.06	10.82-15.24	13.18 \pm 1.67
7	Dorsal-fin origin to pelvic-fin insertion	20.39	18.60-22.01	20.58 \pm 1.11
8	Anal-fin height	15.55	14.79-18.19	16.31 \pm 1.09
9	Peduncle depth	11.04	11.04-11.99	11.55 \pm 0.35
10	Caudal-fin length	24.37	24.37-28.46	26.89 \pm 1.26
11	Dorsal-fin height	19.91	19.88-22.44	20.89 \pm 0.89
12	Pectoral-fin length	17.90	17.90-20.91	19.47 \pm 1.03
13	Pelvic-fin length	16.03	16.03-18.42	17.43 \pm 0.79
14	Occiput to dorsal-fin origin	29.50	24.74-29.50	27.10 \pm 1.80
15	Occiput to pectoral-fin insertion	15.48	15.48-18.47	17.06 \pm 1.18
16	Occiput to pelvic-fin insertion	39.54	38.55-41.08	39.81 \pm 1.05
17	Dorsal-fin insertion to pelvic-fin insertion	16.96	16.01-17.95	16.91 \pm 0.66
18	Dorsal-fin origin to pectoral-fin insertion	29.23	25.53-29.23	26.92 \pm 1.13
19	Dorsal-fin origin to anal-fin origin	30.39	30.39-34.47	32.18 \pm 1.60
20	Dorsal-fin insertion to caudal-fin base	43.01	37.87-43.01	40.07 \pm 1.88
21	Dorsal-fin insertion to anal-fin origin	21.07	19.44-23.84	21.40 \pm 1.42
22	Dorsal-fin insertion to anal-fin insertion	24.63	13.28-30.13	23.68 \pm 5.10
23	Dorsal-fin base length	11.17	11.17-13.47	12.10 \pm 0.70
24	Anal-fin base length	7.32	6.57-7.75	7.22 \pm 0.41
25	Pectoral-fin insertion to pelvic insertion	30.19	29.01-31.62	30.07 \pm 0.83
26	Pectoral-fin insertion to anal-fin origin	48.05	43.63-51.69	48.22 \pm 2.55
27	Pelvic-fin insertion to anal-fin origin	19.99	16.43-20.30	19.08 \pm 1.61
28	Head length	20.60	20.60-25.01	23.86 \pm 1.54
29	Post dorsal length	47.74	36.03-47.74	42.76 \pm 3.90
30	Body depth	18.96	18.76-21.73	20.22 \pm 1.18
31	Distance between pectoral-fin to vent	46.14	42.89-47.98	45.77 \pm 2.02
32	Distance between pelvic-fin to vent	22	12.87-29.06	18.76 \pm 5.99
	% Head Length			
33	Pre occipital length	90.29	79.83-90.29	83.43 \pm 3.56
34	Snout to opercle	99.84	90.23-99.84	95.44 \pm 3.01
35	Upper jaw length	35.25	27.46-35.86	32.18 \pm 3.17
36	Snout length	48.00	38.48-48.00	45.21 \pm 3.84
37	Pre nasal length	28.83	28.00-32.15	30.12 \pm 1.41
38	Orbit width	17.09	15.33-22.57	18.42 \pm 2.35
39	Inter orbital width	48.31	44.40-48.31	46.14 \pm 1.34
40	Inter nasal width	33.30	15.30-33.30	27.63 \pm 6.27
41	Head width	79.43	67.07-79.43	73.11 \pm 3.71
42	Head depth at nostril	39.79	35.90-39.79	37.54 \pm 1.22
43	Head depth at pupil	58.03	50.99-59.39	55.29 \pm 2.93
44	Head depth at occiput	64.88	61.19-67.49	63.81 \pm 2.0
45	Maxillary barbel length	7.74	5.19-9.14	7.35 \pm 1.37
46	Rostral barbel length	10.13	7.64-10.13	8.28 \pm 0.88
47	Disc length	28.36	25.77-29.10	27.17 \pm 1.17
48	Disc width	45.66	38.48-45.66	41.51 \pm 2.28
49	Central pad length	15.84	15.64-17.14	16.20 \pm 0.60
50	Central pad width	26.60	24.68-27.74	25.86 \pm 1.01

Table 2: Meristic characters of *Garra nepalensis* sp. nov. from the Mardi River, Mardi village, Kaski District, western Nepal (n-7).

No	Meristic counts	Holotype	Paratypes (n=6)					
1	Unbranched dorsal fin rays	2	2	2	2	2	2	2
2	Branched dorsal fin rays	8	8	8	8	8	8	8
3	Unbranched anal fin rays	2	2	2	2	2	2	2
4	Branched anal fin rays	5	5	5	5	5	5	5
5	Unbranched pelvic fin rays	1	1	1	1	1	1	1
6	Branched pelvic fin rays	8	8	8	8	8	8	8
7	Unbranched pectoral fin rays	1	1	1	1	1	1	1
8	Branched pectoral fin rays	13	13	13	13	13	13	13
9	Caudal fin rays in upper lobe	10	10	10	10	10	10	10
10	Caudal fin rays in lower lobe	9	9	9	9	9	9	9
11	Lateral line- scales	36	35	36	35	35	35	36
12	Pre- dorsal scales	12	11	11	11	11	12	12
13	Upper transverse scale rows	4.5	4.5	4.5	4.5	4.5	4.5	4.5
14	Lateral line to pelvic scales	3.5	3.5	3.5	3.5	3.5	3.5	3.5
15	Lower transverse rows (anus)	4.5	4.5	4.5	4.5	4.5	4.5	4.5
16	Circumpeduncular scales	16	16	16	16	16	16	16
17	Circumferential scales	20	20	22	21	20	21	21
18	Anal scale row (anus to anal fin)	4	5	4	5	4	5	4
19	Pre- anal scales	21	20	22	21	21	20	21
20	Transverse breast rows	7	7	7	7	7	7	7
21	Anus to pelvic fin- insertion scales	5	5	5	5	5	5	5

**Fig 1:** Lateral and ventral view of *Garra nepalensis* sp. nov.; Holotype, FRDFM- 3, 93.45 mm SL; Mardi River, Kaski District, western, Nepal.**Fig 2:** Line drawings; ventral view and head of *Garra nepalensis* sp. nov. Holotype, FRDFM-3, 93.45 mm SL; Mardi River, western Nepal.

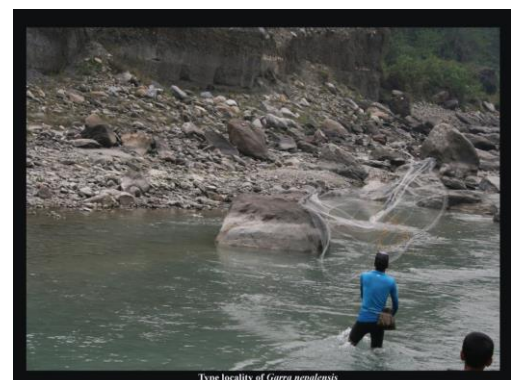
Distribution and Habitat

G. nepalensis is represented by one population collected from Mardi River (Kaligandaki River basin) situated at Mardi village, near the hanging foot bridge, Hemja village development committee, Kaski District, 12 km away from Pokhara city, western Nepal (N 28°, 17. 847' E 83° 55. 826' at 1040 msl) (Figs. 3 and 4). The Mardi River drains into the Kaligandaki River which join with Trishuli River at Dev Ghat, Chitwan District, Narayani Zone, Central Nepal and the junction of these two Rivers are the origin point of Narayani River (Gandak River) which receives numerous tributaries of high mountainous areas with glaciers and snow melt finally drain into Ganges River.

The locality where the holotype and paratypes were collected had clear, bluish, moderately flowing water (0.61 mean depth and average width 10 meter) with a mixed substrate of sand, silt, gravel, pebbles, boulders and bedrock. The river appeared to be relatively undisturbed and unpolluted. During fish sampling, other fish species were also collected namely *Schizothorax richardsonii* (Gray), *Barilius bendelisis* (Hamilton), *Naziritor cheilynoides* (McClelland) and *Tor tor* (Hamilton). In the site (11 April 2014), air temperature was 20°C, water temperature 23°C, pH 7.2, dissolved oxygen 7.9 mg/l, conductivity 021 µs, and total dissolved solids 163 ppm in 2 pm at noon.

Etymology

Named after the country (Nepal) where it was collected.

**Fig 3:** Type locality of *Garra nepalensis* Mardi River, Kaski District, western Nepal

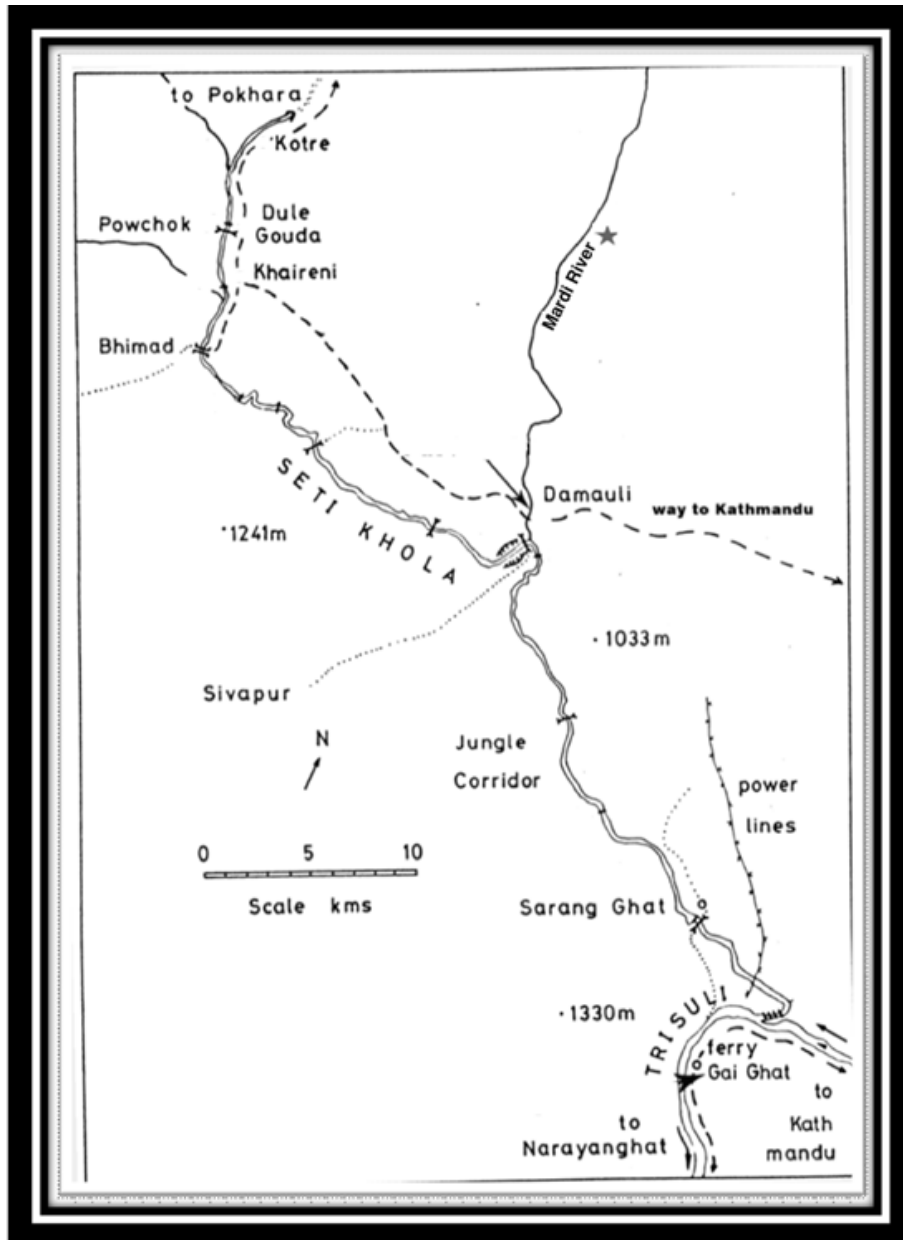


Fig 4: Map showing Mardi River (marked as star) in Kaski District, western Nepal.

Discussion

Lip and mouth structure are considered to be important diagnostic tools for phylogenetic analyses (Kullander and Fang, 2004) [3] and during diagnosis of new species of *Garra nepalensis* snout structure, absence of groove on snout, colour pattern, fin ray and lateral line scale rows as well as other morphometric and meristic characters were considered important.

Recently, Arunachalam, *et al.* (2014) [8] diagnosed the India species of *Garra khaubnagi* from type locality Tuipui River, Khawbung Village-Champhai District, Mizoram, India (N 22° 38'14.8" E 94° 07' 44.0") based on some of considerable characters such as snout rounded in dorsal profile with weakly developed transverse groove; and lateral-line scale rows 36-37 and more recently new species of *Garra* of Nepal shows similarity with *Garra khubangi* in its snout structure and having overlapping lateral line scale rows (35-36 vs. 36-37).

But *G. nepalensis* was distinctly different from *G. khawbung* with the absence of a W-shaped band on the caudal fin (vs. caudal-fin with indistinct "W"-shaped band). Lateral line scale rows was the most considerable character for diagnosis

and differentiating the *Garra nepalensis* from sympatric congeners (except *Garra rupecula*) namely *G. lissorhynchus*, *G. annandalei*, *G. gotyla*, *G. mullya*, *G. lamta* and *G. nasuta* by having greater number of lateral line scales (35-36 vs. 31-34) and it is also distinguished from *Garra rupecula* by lack of W-shaped band on caudal fin. Further some additional characters differentiating the *Garra nepalensis* from its congeners such as it is distinct with *G. lissorhynchus* by absence of a transverse groove on the snout (vs. presence of a deep transverse groove on the snout) and distinguished from *G. nasuta* in lacking a proboscis. Further *G. nepalensis* is distinguished from *G. gotyla* in absence of a proboscis on the snout (vs. presence of a well-developed median proboscis).

Comparison Materials

1. *G. khawbung* : MSUMNH 63, 4 ex., 77.86-98.32 mm SL; CMA 21, 3 ex., 75.07-88.65 mm SL, Collectors: Arunachalam M, Raja M, Vijayakumar C, Nandagopal S. 11 May 2012.
2. *G. annandalei*: MSUMNH-C16: 4 ex., 61.41-79.28 mm SL, Kaljani River, Tabsiktha village, West Bengal, India,

- collected by Arunachalam M and team, 8 Mar. 2013.
3. *G. gotyla*: MSUMNH-C13, 10 ex., 66.6-99.5 mm SL, old Sarawathi River, Punjab, India, collected by Arunachalam M and team, 6 Oct. 2011
 4. *G. mullya*: MSUMNH-C2: 19 ex., 62.6-145.9 mm SL, Gadana River, Tamiraparani River basin, Tamil Nadu, India, collected by Arunachalam M and team, 2 Feb. 2007.
 5. *G. nasuta*: Data from Arunachalam *et al.* 2014.
 6. *G. lamta*: MSUMNH-C15, 10 ex., 38.1-57.6 mm SL, Darbanda River, Pasidava village, New Jalpaguri, West Bengal, India, collected by Arunachalam M and team, 29 Nov. 2012.
 7. *G. rupecula*: Data from Arunachalam M, Nandagopal S, Mayden RL (2014).
 8. *G. lissorhynchus*: MSUMNH-C14, 14 ex., 35.81–66.61 mm SL, Ranga River at Betapul colony, Lower Subanshri District, Arunachal Pradesh, India, collected by Arunachalam M and team. 17 Jun. 2011.

Acknowledgment

The authors acknowledge the help of Mr. S. Mariappan, temporary draughtsman, Sri Paramkalyani Centre for Environmental Sciences, Manonmaniam Sundaranar University, Alwarkurichi-627 412, Tamil Nadu, India for line drawings of *G. nepalensis*.

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